

# Evolutionary Game Theory

- Classical Game Theory suffers from a number of conceptual weaknesses (hyper-rational players, selection problem of strategy, static theory)
- Evolutionary Game Theory introduces evolutionary dynamics for **strategy** selection, i.e. the evolutionary most stable strategy dominates the system dynamics
- Players are rational about their own decisions but do not need to know the strategies (and reasoning) of all other players!
- Very suited for agent-based modeling approaches as it allows for learning and adaption of agents!

# Evolutionary Game Theory Evolutionary Game Theory

**Jorgen W. Weibull**



## **Evolutionary Game Theory Evolutionary Game Theory:**

Evolutionary Game Theory, Natural Selection, and Darwinian Dynamics Thomas L. Vincent, Joel S. Brown, 2005-05-23 All of life is a game and evolution by natural selection is no exception The evolutionary game theory developed in this 2005 book provides the tools necessary for understanding many of nature's mysteries including co evolution speciation extinction and the major biological questions regarding fit of form and function diversity procession and the distribution and abundance of life Mathematics for the evolutionary game are developed based on Darwin's postulates leading to the concept of a fitness generating function  $G$  function  $G$  function is a tool that simplifies notation and plays an important role developing Darwinian dynamics that drive natural selection Natural selection may result in special outcomes such as the evolutionarily stable strategy ESS An ESS maximum principle is formulated and its graphical representation as an adaptive landscape illuminates concepts such as adaptation Fisher's Fundamental Theorem of Natural Selection and the nature of life's evolutionary game

**Evolutionary Games in Natural, Social, and Virtual Worlds** Daniel Friedman, Barry Sinervo, 2016 Authors Daniel Friedman and Barry Sinervo show how to use theoretical developments in evolutionary game theory to build useful models describing parts of the worlds we live in the natural world of biology the social world of politics and economics and the virtual world that is emerging from our connected electronic devices

**Evolutionary Game Theory** Jörgen W. Weibull, 1997 Introduces current evolutionary game theory where ideas from evolutionary biology and rationalistic economics meet emphasizing the links between static and dynamic approaches and noncooperative game theory This text introduces current evolutionary game theory where ideas from evolutionary biology and rationalistic economics meet emphasizing the links between static and dynamic approaches and noncooperative game theory Much of the text is devoted to the key concepts of evolutionary stability and replicator dynamics The former highlights the role of mutations and the latter the mechanisms of selection Moreover set valued static and dynamic stability concepts as well as processes of social evolution are discussed Separate background chapters are devoted to noncooperative game theory and the theory of ordinary differential equations There are examples throughout as well as individual chapter summaries Because evolutionary game theory is a fast moving field that is itself branching out and rapidly evolving Jörgen Weibull has judiciously focused on clarifying and explaining core elements of the theory in an up to date comprehensive and self contained treatment The result is a text for second year graduate students in economic theory other social sciences and evolutionary biology The book goes beyond filling the gap between texts by Maynard Smith and Hofbauer and Sigmund that are currently being used in the field Evolutionary Game Theory will also serve as an introduction for those embarking on research in this area as well as a reference for those already familiar with the field Weibull provides an overview of the developments that have taken place in this branch of game theory discusses the mathematical tools needed to understand the area describes both the motivation and intuition for the concepts involved and explains why and how it is relevant to economics

**Fundamentals of**

**Evolutionary Game Theory and its Applications** Jun Tanimoto, 2015-10-23 This book both summarizes the basic theory of evolutionary games and explains their developing applications giving special attention to the 2 player 2 strategy game This game usually termed a 2 2 game in the jargon has been deemed most important because it makes it possible to posit an archetype framework that can be extended to various applications for engineering the social sciences and even pure science fields spanning theoretical biology physics economics politics and information science The 2 2 game is in fact one of the hottest issues in the field of statistical physics The book first shows how the fundamental theory of the 2 2 game based on so called replicator dynamics highlights its potential relation with nonlinear dynamical systems This analytical approach implies that there is a gap between theoretical and reality based prognoses observed in social systems of humans as well as in those of animal species The book explains that this perceived gap is the result of an underlying reciprocity mechanism called social viscosity As a second major point the book puts a sharp focus on network reciprocity one of the five fundamental mechanisms for adding social viscosity to a system and one that has been a great concern for study by statistical physicists in the past decade The book explains how network reciprocity works for emerging cooperation and readers can clearly understand the existence of substantial mechanics when the term network reciprocity is used In the latter part of the book readers will find several interesting examples in which evolutionary game theory is applied One such example is traffic flow analysis Traffic flow is one of the subjects that fluid dynamics can deal with although flowing objects do not comprise a pure fluid but rather are a set of many particles Applying the framework of evolutionary games to realistic traffic flows the book reveals that social dilemma structures lie behind traffic flow

**Evolutionary Game Theory** Nikolaos Karagiannis, 2014-05-25 The evolution of game theory

*Game-Theoretical Models in Biology* Mark Broom, Jan Rychtar, 2013-03-27 Covering the major topics of evolutionary game theory *Game Theoretical Models in Biology* presents both abstract and practical mathematical models of real biological situations It discusses the static aspects of game theory in a mathematically rigorous way that is appealing to mathematicians In addition the authors explore many applications of game theory to biology making the text useful to biologists as well The book describes a wide range of topics in evolutionary games including matrix games replicator dynamics the hawk dove game and the prisoner s dilemma It covers the evolutionarily stable strategy a key concept in biological games and offers in depth details of the mathematical models Most chapters illustrate how to use MATLAB to solve various games Important biological phenomena such as the sex ratio of so many species being close to a half the evolution of cooperative behavior and the existence of adornments for example the peacock s tail have been explained using ideas underpinned by game theoretical modeling Suitable for readers studying and working at the interface of mathematics and the life sciences this book shows how evolutionary game theory is used in the modeling of these diverse biological phenomena

**Evolutionary Games and Population Dynamics** Josef Hofbauer, Karl Sigmund, 1998-05-28 Every form of behaviour is shaped by trial and error Such stepwise adaptation can occur through individual learning or through natural

selection the basis of evolution Since the work of Maynard Smith and others it has been realised how game theory can model this process Evolutionary game theory replaces the static solutions of classical game theory by a dynamical approach centred not on the concept of rational players but on the population dynamics of behavioural programmes In this book the authors investigate the nonlinear dynamics of the self regulation of social and economic behaviour and of the closely related interactions between species in ecological communities Replicator equations describe how successful strategies spread and thereby create new conditions which can alter the basis of their success i e to enable us to understand the strategic and genetic foundations of the endless chronicle of invasions and extinctions which punctuate evolution In short evolutionary game theory describes when to escalate a conflict how to elicit cooperation why to expect a balance of the sexes and how to understand natural selection in mathematical terms

### **The Stability Concept of Evolutionary Game Theory** Ross

Cressman,2013-03-09 These Notes grew from my research in evolutionary biology specifically on the theory of evolutionarily stable strategies ESS theory over the past ten years Personally evolutionary game theory has given me the opportunity to transfer my enthusiasm for abstract mathematics to more practical pursuits I was fortunate to have entered this field in its infancy when many biologists recognized its potential but were not prepared to grant it general acceptance This is no longer the case ESS theory is now a rapidly expanding in both applied and theoretical directions force that no evolutionary biologist can afford to ignore Perhaps to continue the life cycle metaphor ESS theory is now in its late adolescence and displays much of the optimism and exuberance of this exciting age There are dangers in writing a text about a theory at this stage of development A comprehensive treatment would involve too many loose ends for the reader to appreciate the central message On the other hand the current central message may soon become obsolete as the theory matures Although the restricted topics I have chosen for this text reflect my own research bias I am confident they will remain the theoretical basis of ESS theory Indeed I feel the adult maturity of ESS theory is close at hand and I hope the text will play an important role in this achievement

*Evolutionary Game Theory* Jorgen W. Weibull,1995

*Evolutionary Games and Equilibrium Selection* Larry

Samuelson,1997 The author examines the interplay between evolutionary game theory and the equilibrium selection problem in noncooperative games Evolutionary game theory is one of the most active and rapidly growing areas of research in economics Unlike traditional game theory models which assume that all players are fully rational and have complete knowledge of details of the game evolutionary models assume that people choose their strategies through a trial and error learning process in which they gradually discover that some strategies work better than others In games that are repeated many times low payoff strategies tend to be weeded out and an equilibrium may emerge Larry Samuelson has been one of the main contributors to the evolutionary game theory literature In *Evolutionary Games and Equilibrium Selection* he examines the interplay between evolutionary game theory and the equilibrium selection problem in noncooperative games After providing an overview of the basic issues of game theory and a presentation of the basic models the book addresses

evolutionary stability the dynamics of sample paths the ultimatum game drift noise backward and forward induction and strict Nash equilibria

**Game Theory and Animal Behavior** Lee Alan Dugatkin, Hudson Kern Reeve, 2000-03-23 Game theory has revolutionized the study of animal behavior The fundamental principle of evolutionary game theory that the strategy adopted by one individual depends on the strategies exhibited by others has proven a powerful tool in uncovering the forces shaping otherwise mysterious behaviors In this volume the first since 1982 devoted to evolutionary game theory leading researchers describe applications of the theory to diverse types of behavior providing an overview of recent discoveries and a synthesis of current research The volume begins with a clear introduction to game theory and its explanatory scope This is followed by a series of chapters on the use of game theory to understand a range of behaviors social foraging cooperation animal contests communication reproductive skew and nepotism within groups sibling rivalry alternative life histories habitat selection trophic level interactions learning and human social behavior In addition the volume includes a discussion of the relations among game theory optimality and quantitative genetics and an assessment of the overall utility of game theory to the study of social behavior Presented in a manner accessible to anyone interested in animal behavior but not necessarily trained in the mathematics of game theory the book is intended for a wide audience of undergraduates graduate students and professional biologists pursuing the evolutionary analysis of animal behavior

*Game Theory in Action* Stephen Schecter, Herbert Gintis, 2016-04-05 The essential textbook for learning game theory strategies Game Theory in Action is a textbook about using game theory across a range of real life scenarios From traffic accidents to the sex lives of lizards Stephen Schecter and Herbert Gintis show students how game theory can be applied in diverse areas including animal behavior political science and economics The book's examples and problems look at such fascinating topics as crime control strategies climate change negotiations and the power of the Oracle at Delphi The text includes a substantial treatment of evolutionary game theory where strategies are not chosen through rational analysis but emerge by virtue of being successful This is the side of game theory that is most relevant to biology it also helps to explain how human societies evolve Aimed at students who have studied basic calculus and some differential equations Game Theory in Action is the perfect way to learn the concepts and practical tools of game theory Aimed at students who have studied calculus and some differential equations Examples are drawn from diverse scenarios ranging from traffic accidents to the sex lives of lizards A substantial treatment of evolutionary game theory Useful problem sets at the end of each chapter

Evolutionary Game Theory J. McKenzie Alexander, 2023-03-23 Evolutionary game theory originated in population biology from the realisation that frequency dependent fitness introduced a strategic element into evolution Since its development evolutionary game theory has been adopted by many social scientists and philosophers to analyse interdependent decision problems played by boundedly rational individuals Its study has led to theoretical innovations of great interest for the biological and social sciences For example theorists have developed a number of dynamical models which can be used to

study how populations of interacting individuals change their behaviours over time In this introduction this Element covers the two main approaches to evolutionary game theory the static analysis of evolutionary stability concepts and the study of dynamical models their convergence behaviour and rest points This Element also explores the many fascinating and complex connections between the two approaches      Game-Theoretical Models in Biology Mark Broom, Jan Rychtář, 2022-08-03

Covering the major topics of evolutionary game theory *Game Theoretical Models in Biology* Second Edition presents both abstract and practical mathematical models of real biological situations It discusses the static aspects of game theory in a mathematically rigorous way that is appealing to mathematicians In addition the authors explore many applications of game theory to biology making the text useful to biologists as well The book describes a wide range of topics in evolutionary games including matrix games replicator dynamics the hawk dove game and the prisoner s dilemma It covers the evolutionarily stable strategy a key concept in biological games and offers in depth details of the mathematical models Most chapters illustrate how to use Python to solve various games Important biological phenomena such as the sex ratio of so many species being close to a half the evolution of cooperative behaviour and the existence of adornments for example the peacock s tail have been explained using ideas underpinned by game theoretical modelling Suitable for readers studying and working at the interface of mathematics and the life sciences this book shows how evolutionary game theory is used in the modelling of these diverse biological phenomena In this thoroughly revised new edition the authors have added three new chapters on the evolution of structured populations biological signalling games and a topical new chapter on evolutionary models of cancer There are also new sections on games with time constraints that convert simple games to potentially complex nonlinear ones new models on extortion strategies for the Iterated Prisoner s Dilemma and on social dilemmas and on evolutionary models of vaccination a timely section given the current Covid pandemic Features Presents a wide range of biological applications of game theory Suitable for researchers and professionals in mathematical biology and the life sciences and as a text for postgraduate courses in mathematical biology Provides numerous examples exercises and Python code      *Game Theory in Biology* John M. McNamara, Olof Leimar, 2020-09-24 The principles of game theory apply to a wide range of topics in biology This book presents the central concepts in evolutionary game theory and provides an authoritative and up to date account The focus is on concepts that are important for biologists in their attempts to explain observations This strong connection between concepts and applications is a recurrent theme throughout the book which incorporates recent and traditional ideas from animal psychology neuroscience and machine learning that provide a mechanistic basis for behaviours shown by players of a game The approaches taken to modelling games often rest on idealized and unrealistic assumptions whose limitations and consequences are not always appreciated The authors provide a novel reassessment of the field highlighting how to overcome limitations and identifying future directions *Game Theory in Biology* is an advanced textbook suitable for graduate level students as well as professional researchers both empiricists and theoreticians in the fields of behavioural ecology and

evolutionary biology It will also be of relevance to a broader interdisciplinary audience including psychologists and neuroscientists

Evolutionary Dynamics and Extensive Form Games Ross Cressman, 2003 Evolutionary game theory attempts to predict individual behavior whether of humans or other species when interactions between individuals are modeled as a noncooperative game Most dynamic analyses of evolutionary games are based on their normal forms despite the fact that many interesting games are specified more naturally through their extensive forms Because every extensive form game has a normal form representation some theorists hold that the best way to analyze an extensive form game is simply to ignore the extensive form structure and study the game in its normal form representation This book rejects that suggestion arguing that a game's normal form representation often omits essential information from the perspective of dynamic evolutionary game theory

*Game Theoretical Foundations of Evolutionary Stability* Immanuel M. Bomze, Benedikt M. Pötscher, 2013-12-19 These Lecture Notes arose from discussions we had over a working paper written by the first author in fall 1987 We decided then to write a short paper about the basic structure of evolutionary stability and found ourselves ending up with a book manuscript Parts of the material contained herein were presented in a seminar at the Department of Mathematics at the University of Vienna as well as at a workshop on evolutionary game theory in Bielefeld The final version of the manuscript has certainly benefitted from critical comments and suggestions by the participants of both the seminar and the workshop Thanks are also due to S Bomze de Barba R Burger G Danninger J Hofbauer R Selten K Sigmund G Stiastry and F Weising The co operation of W Muller from Springer Verlag Heidelberg is gratefully acknowledged Vienna November 1988 Immanuel M Bomze Benedikt M Pötscher III Contents 1 Introduction 1 2 Strategies and payoffs 5 2 1 A general setting for evolutionary game theory 6 2 2 Mixed strategies and population games 8 2 3 Finite number of strategies 13 2 4 Infinitely many pure strategies 15 2 5 Structured populations asymmetric contests and multitype games 17 2 6 Additional remarks 21 3 Evolutionary stability 25 3 1 Definition of evolutionary stability 25 3 2 Evolutionary stability and solution concepts in classical game theory 30 3 3 Conditions for evolutionary stability based on the normal cone 31 3 4

Introduction to Evolutionary Game Theory The Open The Open Courses Library, 2019-11-21 Introduction to evolutionary game theory Evolutionary Game Theory EGT is a branch of a more general discipline called game theory Therefore to understand what EGT is about it is useful to get familiar with the basic ideas underlying game theory first Chapter Outline What is game theory Traditional game theory Evolutionary Game Theory The Open Courses Library introduces you to the best Open Source Courses

**Game Theory Evolving** Herbert Gintis, 2009-01-26 Since its original publication in 2000 Game Theory Evolving has been considered the best textbook on evolutionary game theory This completely revised and updated second edition of Game Theory Evolving contains new material and shows students how to apply game theory to model human behavior in ways that reflect the special nature of sociality and individuality The textbook continues its in depth look at cooperation in teams agent based simulations experimental economics the evolution and diffusion of preferences and



the connection between biology and economics Recognizing that students learn by doing the textbook introduces principles through practice Herbert Gintis exposes students to the techniques and applications of game theory through a wealth of sophisticated and surprisingly fun to solve problems involving human and animal behavior The second edition includes solutions to the problems presented and information related to agent based modeling In addition the textbook incorporates instruction in using mathematical software to solve complex problems Game Theory Evolving is perfect for graduate and upper level undergraduate economics students and is a terrific introduction for ambitious do it yourselfers throughout the behavioral sciences Revised and updated edition relevant for courses across disciplines Perfect for graduate and upper level undergraduate economics courses Solutions to problems presented throughout Incorporates instruction in using computational software for complex problem solving Includes in depth discussions of agent based modeling *Evolutionary Game Dynamics* American Mathematical Society. Short Course, 2011-10-27 This volume is based on lectures delivered at the 2011 AMS Short Course on Evolutionary Game Dynamics held January 4-5 2011 in New Orleans Louisiana Evolutionary game theory studies basic types of social interactions in populations of players It combines the strategic viewpoint of classical game theory independent rational players trying to outguess each other with population dynamics successful strategies increase their frequencies A substantial part of the appeal of evolutionary game theory comes from its highly diverse applications such as social dilemmas the evolution of language or mating behaviour in animals Moreover its methods are becoming increasingly popular in computer science engineering and control theory They help to design and control multi agent systems often with a large number of agents for instance when routing drivers over highway networks or data packets over the Internet While these fields have traditionally used a top down approach by directly controlling the behaviour of each agent in the system attention has recently turned to an indirect approach allowing the agents to function independently while providing incentives that lead them to behave in the desired way Instead of the traditional assumption of equilibrium behaviour researchers opt increasingly for the evolutionary paradigm and consider the dynamics of behaviour in populations of agents employing simple myopic decision rules

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