

# Dynamic Programming In Economics

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*Elements of Dynamic Optimization* - Alpha C. Chiang 1999-12-22

In this text, Dr. Chiang introduces students to the most important methods of dynamic optimization used in economics. The classical calculus of variations, optimal control theory, and dynamic programming in its discrete form are explained in the usual Chiang fashion, with patience and thoroughness. The economic examples, selected from both classical and recent literature, serve not only to illustrate applications of the mathematical methods, but also to provide a useful glimpse of the development of thinking in several areas of economics.

**Numerical Methods in Economics** - Kenneth L. Judd 1998-09-28

To harness the full power of computer technology, economists need to use a broad range of mathematical techniques. In this book, Kenneth Judd presents techniques from the numerical analysis and applied mathematics literatures and shows how to use them in economic analyses. The book is divided into five parts. Part I provides a general introduction. Part II presents basics from numerical analysis on  $R^n$ , including linear equations, iterative methods, optimization, nonlinear equations, approximation methods, numerical integration and differentiation, and Monte Carlo methods. Part III covers methods for dynamic problems, including finite difference methods, projection methods, and numerical dynamic programming. Part IV covers perturbation and asymptotic solution methods. Finally, Part V covers applications to dynamic equilibrium analysis, including solution methods for perfect foresight models and rational expectation models. A website contains supplementary material including programs and answers to exercises.

Forward-Looking Decision Making - Robert E. Hall 2010-02-08

Individuals and families make key decisions that impact many aspects of financial stability and determine the future of the economy. These decisions involve balancing current sacrifice against future benefits. People have to decide how much to invest in health care, exercise, their diet, and insurance. They must decide how much debt to take on, and how much to save. And they make choices about jobs that determine employment and unemployment levels. Forward-Looking Decision Making is about modeling this individual or family-based decision making using an optimizing dynamic programming model. Robert Hall first reviews ideas about dynamic programs and introduces new ideas about numerical solutions and the representation of solved models as Markov processes. He surveys recent research on the parameters of preferences- the intertemporal elasticity of substitution, the Frisch elasticity of labor supply, and the Frisch cross-elasticity. He then examines dynamic programming models applied to health spending, long-term care insurance, employment, entrepreneurial risk-taking, and consumer debt. Linking theory with data and applying them to real-world problems, Forward-Looking Decision Making uses dynamic optimization programming models to shed light on individual behaviors and their economic implications.

**Dynamic Programming in Economics** - Cuong Van 2003-04-30

Dynamic Programming in Economics is an outgrowth of a course intended for students in the first year PhD program and for researchers in Macroeconomics Dynamics. It can be used by students and researchers in Mathematics as well as in Economics. The purpose of Dynamic Programming in Economics is twofold: (a) to provide a rigorous, but not too complicated, treatment of optimal growth models in infinite discrete time horizon, (b) to train the reader to the use of optimal growth models and hence to help him to go further in his research. We are convinced that there is a place for a book which stays somewhere between the "minimum tool kit" and specialized monographs leading to the frontiers of research on optimal growth.

**Optimization in Economics and Finance** - Bruce D. Craven 2006-03-30

Some recent developments in the mathematics of optimization, including the concepts of invexity and quasimax, have not yet been applied to models of economic growth, and to finance and investment. Their

applications to these areas are shown in this book.

**Dynamic Economics** - Gregory C. Chow 1997

This work presents the optimization framework for dynamic economics and treats a number of topics in economics, including growth, macroeconomics, microeconomics, finance and dynamic games. The book also teaches by examples, using concepts to solve simple problems, moving on to general propositions.

**Optimal Control Theory and Static Optimization in Economics** - Daniel Léonard 1992-01-31

Optimal control theory is a technique being used increasingly by academic economists to study problems involving optimal decisions in a multi-period framework. This textbook is designed to make the difficult subject of optimal control theory easily accessible to economists while at the same time maintaining rigour. Economic intuitions are emphasized, and examples and problem sets covering a wide range of applications in economics are provided to assist in the learning process. Theorems are clearly stated and their proofs are carefully explained. The development of the text is gradual and fully integrated, beginning with simple formulations and progressing to advanced topics such as control parameters, jumps in state variables, and bounded state space. For greater economy and elegance, optimal control theory is introduced directly, without recourse to the calculus of variations. The connection with the latter and with dynamic programming is explained in a separate chapter. A second purpose of the book is to draw the parallel between optimal control theory and static optimization. Chapter 1 provides an extensive treatment of constrained and unconstrained maximization, with emphasis on economic insight and applications. Starting from basic concepts, it derives and explains important results, including the envelope theorem and the method of comparative statics. This chapter may be used for a course in static optimization. The book is largely self-contained. No previous knowledge of differential equations is required.

**Dynamic Optimization and Economic Applications** - Ronald E. Miller 1979

**Mathematical Methods in Dynamic Economics** - A. Simonovits 2000-06-05

This book contains a concise description of important mathematical methods of dynamics and suitable economic models. It covers discrete as well as continuous-time systems, linear and nonlinear models. Mixing traditional and modern materials, the study covers dynamics with and without optimization, naive and rational expectations, respectively. In addition to standard models of growth and cycles, the book also contains original studies on control of a multisector economy and expectations-driven multicohort economy. Numerous examples, problems (with solutions) and figures complete the book.

Numerical Dynamic Programming in Economics - John Rust 1994

Dynamic Programming and Mathematical Economics - Richard Bellman 1963

**Reinforcement Learning and Dynamic Programming Using Function Approximators** - Lucian Busoniu 2017-07-28

From household appliances to applications in robotics, engineered systems involving complex dynamics can only be as effective as the algorithms that control them. While Dynamic Programming (DP) has provided researchers with a way to optimally solve decision and control problems involving complex dynamic systems, its practical value was limited by algorithms that lacked the capacity to scale up to realistic problems. However, in recent years, dramatic developments in Reinforcement Learning (RL), the model-free counterpart of DP, changed our understanding of what is possible. Those developments led to the creation of reliable methods that can be applied even when a mathematical model of the system is unavailable, allowing researchers to solve challenging control problems in engineering, as well as in a variety

of other disciplines, including economics, medicine, and artificial intelligence. Reinforcement Learning and Dynamic Programming Using Function Approximators provides a comprehensive and unparalleled exploration of the field of RL and DP. With a focus on continuous-variable problems, this seminal text details essential developments that have substantially altered the field over the past decade. In its pages, pioneering experts provide a concise introduction to classical RL and DP, followed by an extensive presentation of the state-of-the-art and novel methods in RL and DP with approximation. Combining algorithm development with theoretical guarantees, they elaborate on their work with illustrative examples and insightful comparisons. Three individual chapters are dedicated to representative algorithms from each of the major classes of techniques: value iteration, policy iteration, and policy search. The features and performance of these algorithms are highlighted in extensive experimental studies on a range of control applications. The recent development of applications involving complex systems has led to a surge of interest in RL and DP methods and the subsequent need for a quality resource on the subject. For graduate students and others new to the field, this book offers a thorough introduction to both the basics and emerging methods. And for those researchers and practitioners working in the fields of optimal and adaptive control, machine learning, artificial intelligence, and operations research, this resource offers a combination of practical algorithms, theoretical analysis, and comprehensive examples that they will be able to adapt and apply to their own work. Access the authors' website at [www.dsc.tudelft.nl/rlbook/](http://www.dsc.tudelft.nl/rlbook/) for additional material, including computer code used in the studies and information concerning new developments. *Estimation of Dynamic Programming Models with Censored Dependent Variables* - Victor Aguirregabiria 1997

**Foundations of Dynamic Economic Analysis** - Michael R. Caputo 2005-01-10

Foundations of Dynamic Economic Analysis presents a modern and thorough exposition of the fundamental mathematical formalism used to study optimal control theory, i.e., continuous time dynamic economic processes, and to interpret dynamic economic behavior. The style of presentation, with its continual emphasis on the economic interpretation of mathematics and models, distinguishes it from several other excellent texts on the subject. This approach is aided dramatically by introducing the dynamic envelope theorem and the method of comparative dynamics early in the exposition. Accordingly, motivated and economically revealing proofs of the transversality conditions come about by use of the dynamic envelope theorem. Furthermore, such sequencing of the material naturally leads to the development of the primal-dual method of comparative dynamics and dynamic duality theory, two modern approaches used to tease out the empirical content of optimal control models. The stylistic approach ultimately draws attention to the empirical richness of optimal control theory, a feature missing in virtually all other textbooks of this type.

[Dynamic Programming and Its Application to Variational Problems in Mathematical Economics](#) - Richard Bellman 1956

The purpose of this paper is to discuss some variational problems arising from mathematical economics, and some of the methods that can be used to treat these questions both analytically and computationally. The discussion is limited to important and interesting classes of processes, allocation and smoothing processes, and to a discussion of the application of the theory of dynamic programming to those processes. (Author).

[Stochastic Economics](#) - Gerhard Tintner 2014-05-10

Stochastic Economics: Stochastic Processes, Control, and Programming presents some aspects of economics from a stochastic or probabilistic point of view. The application of stochastic processes to the theory of economic development, stochastic control theory, and various aspects of stochastic programming is discussed. Comprised of four chapters, this book begins with a short survey of the stochastic view in economics, followed by a discussion on discrete and continuous stochastic models of economic development. The next chapter focuses on methods of stochastic control and their application to dynamic economic models, with emphasis on those aspects connected especially with the theory of quantitative economic policy. Some basic operational problems of applying stochastic control, particularly in economic systems and organizations for problems such as dynamic resource allocation, growth planning, and economic coordination are considered. The last chapter is devoted to stochastic programming, paying particular attention to the decision rule theory of operations research under the chance-constrained

model and a method of incorporating reliability measures into a systems reliability model. This book will be of interest to economists, statisticians, applied mathematicians, operations researchers, and systems engineers.

**Dynamic Programming and Inverse Optimal Problems in Mathematical Economics** - Richard Bellman 1968

**Dynamic Macroeconomic Theory** - Thomas J. Sargent 2009-06-01

The tasks of macroeconomics are to interpret observations on economic aggregates in terms of the motivations and constraints of economic agents and to predict the consequences of alternative hypothetical ways of administering government economic policy. General equilibrium models form a convenient context for analyzing such alternative government policies. In the past ten years, the strengths of general equilibrium models and the corresponding deficiencies of Keynesian and monetarist models of the 1960s have induced macroeconomists to begin applying general equilibrium models. This book describes some general equilibrium models that are dynamic, that have been built to help interpret time-series of observations of economic aggregates and to predict the consequences of alternative government interventions. The first part of the book describes dynamic programming, search theory, and real dynamic capital pricing models. Among the applications are stochastic optimal growth models, matching models, arbitrage pricing theories, and theories of interest rates, stock prices, and options. The remaining parts of the book are devoted to issues in monetary theory; currency-in-utility-function models, cash-in-advance models, Townsend turnpike models, and overlapping generations models are all used to study a set of common issues. By putting these models to work on concrete problems in exercises offered throughout the text, Sargent provides insights into the strengths and weaknesses of these models of money. An appendix on functional analysis shows the unity that underlies the mathematics used in disparate areas of rational expectations economics. This book on dynamic equilibrium macroeconomics is suitable for graduate-level courses; a companion book, Exercises in Dynamic Macroeconomic Theory, provides answers to the exercises and is also available from Harvard University Press.

**Computational Methods for the Study of Dynamic Economies** - Ramon Marimon 1999-03-04

Macroeconomics increasingly uses stochastic dynamic general equilibrium models to understand theoretical and policy issues. Unless very strong assumptions are made, understanding the properties of particular models requires solving the model using a computer. This volume brings together leading contributors in the field who explain in detail how to implement the computational techniques needed to solve dynamic economics models. A broad spread of techniques are covered, and their application in a wide range of subjects discussed. The book provides the basics of a toolkit which researchers and graduate students can use to solve and analyse their own theoretical models.

**Dynamic Optimization, Second Edition** - Morton I. Kamien 2013-04-17

Since its initial publication, this text has defined courses in dynamic optimization taught to economics and management science students. The two-part treatment covers the calculus of variations and optimal control. 1998 edition.

**Dynamic Economics** - Jerome Adda 2003-08-29

An integrated approach to the empirical application of dynamic optimization programming models, for students and researchers. This book is an effective, concise text for students and researchers that combines the tools of dynamic programming with numerical techniques and simulation-based econometric methods. Doing so, it bridges the traditional gap between theoretical and empirical research and offers an integrated framework for studying applied problems in macroeconomics and microeconomics. In part I the authors first review the formal theory of dynamic optimization; they then present the numerical tools and econometric techniques necessary to evaluate the theoretical models. In language accessible to a reader with a limited background in econometrics, they explain most of the methods used in applied dynamic research today, from the estimation of probability in a coin flip to a complicated nonlinear stochastic structural model. These econometric techniques provide the final link between the dynamic programming problem and data. Part II is devoted to the application of dynamic programming to specific areas of applied economics, including the study of business cycles, consumption, and investment behavior. In each instance the authors present the specific optimization problem as a dynamic programming problem, characterize the optimal policy functions, estimate the parameters, and use models for policy evaluation.

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**Recursive Macroeconomic Theory, fourth edition** - Lars Ljungqvist 2018-09-11

The substantially revised fourth edition of a widely used text, offering both an introduction to recursive methods and advanced material, mixing tools and sample applications. Recursive methods provide powerful ways to pose and solve problems in dynamic macroeconomics. *Recursive Macroeconomic Theory* offers both an introduction to recursive methods and more advanced material. Only practice in solving diverse problems fully conveys the advantages of the recursive approach, so the book provides many applications. This fourth edition features two new chapters and substantial revisions to other chapters that demonstrate the power of recursive methods. One new chapter applies the recursive approach to Ramsey taxation and sharply characterizes the time inconsistency of optimal policies. These insights are used in other chapters to simplify recursive formulations of Ramsey plans and credible government policies. The second new chapter explores the mechanics of matching models and identifies a common channel through which productivity shocks are magnified across a variety of matching models. Other chapters have been extended and refined. For example, there is new material on heterogeneous beliefs in both complete and incomplete markets models; and there is a deeper account of forces that shape aggregate labor supply elasticities in lifecycle models. The book is suitable for first- and second-year graduate courses in macroeconomics. Most chapters conclude with exercises; many exercises and examples use Matlab or Python computer programming languages.

*Dynamic Programming* - John O.S. Kennedy 2012-12-06

Humans interact with and are part of the mysterious processes of nature. Inevitably they have to discover how to manage the environment for their long-term survival and benefit. To do this successfully means learning something about the dynamics of natural processes, and then using the knowledge to work with the forces of nature for some desired outcome. These are intriguing and challenging tasks. This book describes a technique which has much to offer in attempting to achieve the latter task. A knowledge of dynamic programming is useful for anyone interested in the optimal management of agricultural and natural resources for two reasons. First, resource management problems are often problems of dynamic optimization. The dynamic programming approach offers insights into the economics of dynamic optimization which can be explained much more simply than can other approaches. Conditions for the optimal management of a resource can be derived using the logic of dynamic programming, taking as a starting point the

usual economic definition of the value of a resource which is optimally managed through time. This is set out in Chapter I for a general resource problem with the minimum of mathematics. The results are related to the discrete maximum principle of control theory. In subsequent chapters dynamic programming arguments are used to derive optimality conditions for particular resources.

*Mathematical Economics* - Kelvin Lancaster 2012-10-10

Graduate-level text provides complete and rigorous expositions of economic models analyzed primarily from the point of view of their mathematical properties, followed by relevant mathematical reviews. Part I covers optimizing theory; Parts II and III survey static and dynamic economic models; and Part IV contains the mathematical reviews, which range from linear algebra to point-to-set mappings.

*The Infinite-horizon, Dynamic Programming Model of Economic Development* - Peter A. Stephan 1985

*Dynamic Programming Solutions for Economic Models Requiring Little Information about the Future* - Hans Ulrich Buhl 1983

*Dynamic Programming in Computational Economics* - 1999

**Economic Dynamics** - John Stachurski 2009-01-16

A rigorous and example-driven introduction to topics in economic dynamics, with an emphasis on mathematical and computational techniques for modeling dynamic systems. This text provides an introduction to the modern theory of economic dynamics, with emphasis on mathematical and computational techniques for modeling dynamic systems. Written to be both rigorous and engaging, the book shows how sound understanding of the underlying theory leads to effective algorithms for solving real world problems. The material makes extensive use of programming examples to illustrate ideas. These programs help bring to life the abstract concepts in the text. Background in computing and analysis is offered for readers without programming experience or upper-level mathematics. Topics covered in detail include nonlinear dynamic systems, finite-state Markov chains, stochastic dynamic programming, stochastic stability and computation of equilibria. The models are predominantly nonlinear, and the emphasis is on studying nonlinear systems in their original form, rather than by means of rudimentary approximation methods such as linearization. Much of the material is new to economics and improves on existing techniques. For graduate students and those already working in the field, *Economic Dynamics* will serve as an essential resource.

*Mathematical Programming for Economics and Business* - Roger C. Pfaffenberger 1976

Characteristics and types of models; Linear programming; Nonlinear programming; Nonlinear programming algorithms; Quadratic programming; Integer programming; Dynamic programming; Recursive; Calculus of variations; Stochastic programming.

*Dynamic Programming and Its Application in Economics and Finance* - Cai Yongyang 2009

Multistage decision problems are numerically challenging. Typically the work to solve such problems is an exponential function with respect to both the number of stages and the number of decision parameters. The problems have been researched extensively and a wide variety of methods to solve them have been proposed. Inevitably all methods are limited in the size of problem they can solve. The purpose of our work is to develop a new more efficient algorithm and one that can run on parallel architectures, thereby extending significantly the size of problems that are tractable. We present a numerical dynamic programming algorithm that has three components: optimization, approximation, and integration. A key feature of the approximation methods we use is to preserve mathematical features such as convexity and differentiability, which enables us to use powerful optimization methods. To illustrate the efficiency of the new method we present extensive results on optimal growth models and dynamic portfolio problems, using our implementation of the algorithm on the Condor Master-Worker system.

*Recursive Methods in Economic Dynamics* - Nancy L. Stokey 1989-10-10

This rigorous but brilliantly lucid book presents a self-contained treatment of modern economic dynamics. Stokey, Lucas, and Prescott develop the basic methods of recursive analysis and illustrate the many areas where they can usefully be applied.

**Dynamic Programming of Economic Decisions** - Martin F. Bach 2013-11-11

Dynamic Programming is the analysis of multistage decision in the

sequential mode. It is now widely recognized as a tool of great versatility and power, and is applied to an increasing extent in all phases of economic analysis, operations research, technology, and also in mathematical theory itself. In economics and operations research its impact may someday rival that of linear programming. The importance of this field is made apparent through a growing number of publications. Foremost among these is the pioneering work of Bellman. It was he who originated the basic ideas, formulated the principle of optimality, recognized its power, coined the terminology, and developed many of the present applications. Since then mathematicians, statisticians, operations researchers, and economists have come in, laying more rigorous foundations [KARLIN, BLACKWELL], and developing in depth such application as to the control of stochastic processes [HOWARD, JEWELL]. The field of inventory control has almost split off as an independent branch of Dynamic Programming on which a great deal of effort has been expended [ARROW, KARLIN, SCARF], [WIDTIN], [WAGNER]. Dynamic Programming is also playing an increasing role in modern mathematical control theory [BELLMAN, Adaptive Control Processes (1961)]. Some of the most exciting work is going on in adaptive programming which is closely related to sequential statistical analysis, particularly in its Bayesian form. In this monograph the reader is introduced to the basic ideas of Dynamic Programming.

Comparative Statics in Dynamic Programming Models of Economics - Harald Lang 1986

**Dynamic Economics** - Gregory C. Chow 1997-02-13

This work provides a unified and simple treatment of dynamic economics using dynamic optimization as the main theme, and the method of Lagrange multipliers to solve dynamic economic problems. The author presents the optimization framework for dynamic economics in order that readers can understand the approach and use it as they see fit. Instead of using dynamic programming, the author chooses instead to use the method of Lagrange multipliers in the analysis of dynamic optimization because it is easier and more efficient than dynamic programming, and allows readers to understand the substance of dynamic economics better. The author treats a number of topics in economics, including economic growth, macroeconomics, microeconomics, finance and dynamic games. The book also teaches by examples, using concepts to solve simple problems; it then moves to general propositions.

**Applied Dynamic Programming** - Richard E. Bellman 2015-12-08

This comprehensive study of dynamic programming applied to numerical solution of optimization problems. It will interest aerodynamic, control,

and industrial engineers, numerical analysts, and computer specialists, applied mathematicians, economists, and operations and systems analysts. Originally published in 1962. The Princeton Legacy Library uses the latest print-on-demand technology to again make available previously out-of-print books from the distinguished backlist of Princeton University Press. These editions preserve the original texts of these important books while presenting them in durable paperback and hardcover editions. The goal of the Princeton Legacy Library is to vastly increase access to the rich scholarly heritage found in the thousands of books published by Princeton University Press since its founding in 1905.

**Convexity and Steady State Policies in Dynamic Programming, with Application to Optimal Economic Growth** - James Flynn 1974

**Dynamic Programming of Economic Decisions** - Martin J. Beckmann 1968

**Dynamic Optimization and Mathematical Economics** - Pan-Tai Liu 2013-03-09

As an outgrowth of the advancement in modern control theory during the past 20 years, dynamic modeling and analysis of economic systems has become an important subject in the study of economic theory. Recent developments in dynamic utility, economic planning, and profit optimization, for example, have been greatly influenced by results in optimal control, stabilization, estimation, optimization under conflicts, multi criteria optimization, control of large-scale systems, etc. The great success that has been achieved so far in utilizing modern control theory in economic systems should be attributed to the effort of control theorists as well as economists. Collaboration between the two groups of researchers has proven to be most successful in many instances; nevertheless, the gap between them has existed for some time. Whereas a control theorist frequently sets up a mathematically feasible model to obtain results that permit economic interpretations, an economist is concerned more with the fidelity of the model in representing a real world problem, and results that are obtained (through possibly less mathematical analysis) are due largely to economic insight. The papers appearing in this volume are divided into three parts. In Part I there are five papers on the application of control theory to economic planning. Part II contains five papers on exploration, exploitation, and pricing of extractive natural resources. Finally, in Part III, some recent advances in large-scale systems and decentralized control appear.

Some Applications of Dynamic Programming in Agricultural Economics - C. D. Throsby 1967