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Optimization in Economic Theory Oxford University Press on Demand A new edition of a student text which provides a broad study of optimization methods. It builds on the base of simple economic theory, elementary linear algebra and calculus, and reinforces each new mathematical idea by relating it to its economic application. Mathematical Optimization and Economic Theory SIAM A classic account of mathematical programming and control techniques and their applications to static and dynamic problems in economics. Mathematical Optimization and Economic Analysis Springer Science & Business Media "Mathematical Optimization and Economic Analysis" is a self-contained introduction to various optimization techniques used in economic modeling and analysis such as geometric, linear, and convex programming and data envelopment analysis. Through a systematic approach, this book demonstrates the usefulness of these mathematical tools in quantitative and qualitative economic analysis. The book presents specific examples to demonstrate each technique's advantages and applicability as well as numerous applications of these techniques to industrial economics, regulatory economics, trade policy, economic sustainability, production planning, and environmental policy. Key Features include: - A detailed presentation of both single-objective and multiobjective optimization; - An in-depth exposition of various applied optimization problems; - Implementation of optimization tools to improve the accuracy of various economic models; - Extensive resources suggested for further reading. This book is intended for graduate and postgraduate students studying quantitative economics, as well as economics researchers and applied mathematicians. Requirements include a basic knowledge of calculus and linear algebra, and a familiarity with economic modeling. Mathematics for Stability and Optimization of Economic Systems Academic Press Economic Theory and Mathematical Economics: Mathematics for Stability and Optimization of Economic Systems provides information pertinent to the stability aspects and optimization methods relevant to various economic systems. This book presents relevant mathematical theorems sufficient to develop important economic systems, including Leontief input-output systems, Keynesian dynamic models, the Ramsey optimal accumulation systems, and von Neumann expanding economic systems. Organized into two parts encompassing nine chapters, this book begins with an overview of useful theorems on matrices, eigenvalue problems, and matrices with dominant diagonals and P-matrices. This text then explores the linear transformations on vector spaces. Other chapters consider the Hawkins–Simon theorem concerning non-negative linear systems. This book discusses as well the dual linear relations and optimization methods applicable to inequality economic systems. The final chapter deals with powerful optimal control method for dynamical systems. This book is a valuable resource for mathematicians, economists, research workers, and graduate students. Approximation, Optimization and Mathematical Economics With 14 Tables ; [Proceedings of the Fifth International Conference on "Approximation and Optimization in the Caribbean" which Met at the Université Des Antilles Et de la Guyane (Guadeloupe, French West Indies) During the Week March 29 to April 2, 1999] Springer Science & Business Media The articles in this proceedings volume reflect the current trends in the theory of approximation, optimization and mathematical economics, and include numerous applications. The book will be of interest to researchers and graduate students involved in functional analysis, approximation theory, mathematical programming and optimization, game theory, mathematical finance and economics. Mathematical Analysis and Optimization for Economists CRC Press In Mathematical Analysis and Optimization for Economists, the author aims to introduce students of economics to the power and versatility of traditional as well as contemporary methodologies in mathematics and optimization theory; and, illustrates how these techniques can be applied in solving microeconomic problems. This book combines the areas of intermediate to advanced mathematics, optimization, and microeconomic decision making, and is suitable for advanced undergraduates and first-year graduate students. This text is highly readable, with all concepts fully defined, and contains numerous detailed example problems in both mathematics and microeconomic applications. Each section contains some standard, as well as more thoughtful and challenging, exercises. Solutions can be downloaded from the CRC Press website. All solutions are detailed and complete. Features Contains a whole spectrum of modern applicable mathematical techniques, many of which are not found in other books of this type. Comprehensive and contains numerous and detailed example problems in both mathematics and economic analysis. Suitable for economists and economics students with only a minimal mathematical background. Classroom-tested over the years when the author was actively teaching at the University of Hartford. Serves as a beginner text in optimization for applied mathematics students. Accompanied by several electronic chapters on linear algebra and matrix theory, nonsmooth optimization, economic efficiency, and distance functions available for free on www.routledge.com/9780367759018. Mathematical Optimization and Economic Theory Approximation, Optimization and Mathematical Economics Springer Science & Business Media The articles in this proceedings volume reflect the

current trends in the theory of approximation, optimization and mathematical economics, and include numerous applications. The book will be of interest to researchers and graduate students involved in functional analysis, approximation theory, mathematical programming and optimization, game theory, mathematical finance and economics. Extrema of Smooth Functions With Examples from Economic Theory Springer Science & Business Media It is not an exaggeration to state that most problems dealt with in economic theory can be formulated as problems in optimization theory. This holds true for the paradigm of "behavioral" optimization in the pursuit of individual self interests and societally efficient resource allocation, as well as for equilibrium paradigms where existence and stability problems in dynamics can often be stated as "potential" problems in optimization. For this reason, books in mathematical economics and in mathematics for economists devote considerable attention to optimization theory. However, with very few exceptions, the reader who is interested in further study is left with the impression that there is no further place to go to and that what is in these second hand sources is all these is available as far as the subject of optimization theory is concerned. On the other hand the main results from mathematics are often carelessly stated or, more often than not, they do not get to be formally stated at all. Furthermore, it should be well understood that economic theory in general and, mathematical economics in particular, must be classified as special types of applied mathematics or, more precisely, of motivated mathematics since tools of mathematical analysis are used to prove theorems in an economics context in the manner in which probability theory may be classified. Hence, rigor and correct scholarship are of utmost importance and can not be subject to compromise. A First Course in Optimization Theory Cambridge University Press This book, first published in 1996, introduces students to optimization theory and its use in economics and allied disciplines. The first of its three parts examines the existence of solutions to optimization problems in Rn, and how these solutions may be identified. The second part explores how solutions to optimization problems change with changes in the underlying parameters, and the last part provides an extensive description of the fundamental principles of finite- and infinite-horizon dynamic programming. Each chapter contains a number of detailed examples explaining both the theory and its applications for first-year master's and graduate students. 'Cookbook' procedures are accompanied by a discussion of when such methods are guaranteed to be successful, and, equally importantly, when they could fail. Each result in the main body of the text is also accompanied by a complete proof. A preliminary chapter and three appendices are designed to keep the book mathematically self-contained. Theory of Vector Optimization Springer Science & Business Media These notes grew out of a series of lectures given by the author at the Univer sity of Budapest during 1985-1986. Additional results have been included which were obtained while the author was at the University of Erlangen-Niirnberg under a grant of the Alexander von Humboldt Foundation. Vector optimization has two main sources coming from economic equilibrium and welfare theories of Edgeworth (1881) and Pareto (1906) and from mathemat ical backgrounds of ordered spaces of Cantor (1897) and Hausdorff (1906). Later, game theory of Borel (1921) and von Neumann (1926) and production theory of Koopmans (1951) have also contributed to this area. However, only in the fifties, after the publication of Kuhn-Tucker's paper (1951) on the necessary and sufficient conditions for efficiency, and of Deubreu's paper (1954) on valuation equilibrium and Pareto optimum, has vector optimization been recognized as a mathematical discipline. The stretching development of this field began later in the seventies and eighties. Today there are a number of books on vector optimization. Most of them are concerned with the methodology and the applications. Few of them offer a systematic study of the theoretical aspects. The aim of these notes is to pro vide a unified background of vector optimization,with the emphasis on nonconvex problems in infinite dimensional spaces ordered by convex cones. The notes are arranged into six chapters. The first chapter presents prelim inary material. Dynamic Optimization and Mathematical Economics Springer Science & Business Media 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 optimiza tion, 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, exploita tion, and pricing of extractive natural resources. Finally, in Part III, some recent advances in large-scale systems and decentralized control appear. Optimal Control Theory and Static Optimization in Economics Cambridge University Press 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. Mathematical Methods of Game and Economic Theory Newnes This book presents a unified treatment of optimization theory, game theory and a general equilibrium theory in economics in the framework of nonlinear functional analysis. It not only provides powerful and versatile tools for solving specific problems in economics and the social sciences but also serves as a unifying theme in the mathematical theory of these subjects as well as in pure mathematics itself. Mathematical Optimization and Economic Theory Mathematical Theory of Optimization Springer Science & Business Media This book provides an introduction to the mathematical theory of optimization. It emphasizes the convergence theory of nonlinear optimization algorithms and applications of nonlinear optimization to combinatorial optimization. Mathematical Theory of Optimization includes recent developments in global convergence, the Powell conjecture, semidefinite programming, and relaxation techniques for designs of approximation solutions of combinatorial optimization problems. Mathematical Methods of Game and Economic Theory Courier Corporation Mathematical economics and game theory approached with the fundamental mathematical toolbox of nonlinear functional analysis are the central themes of this text. Both optimization and equilibrium theories are covered in full detail. The book's central application is the fundamental economic problem of allocating scarce resources among competing agents, which leads to considerations of the interrelated applications in game theory and the theory of optimization. Mathematicians, mathematical economists, and operations research specialists will find that it provides a solid foundation in nonlinear functional analysis. This text begins by developing linear and convex analysis in the context of optimization theory. The treatment includes results on the existence and stability of solutions to optimization problems as well as an introduction to duality theory. The second part explores a number of topics in game theory and mathematical economics, including two-person games, which provide the framework to study theorems of nonlinear analysis. The text concludes with an introduction to non-linear analysis and optimal control theory, including an array of fixed point and subjectivity theorems that offer powerful tools in proving existence theorems. Optimization in Economics and Finance Some Advances in Non-Linear, Dynamic, Multi-Criteria and Stochastic Models Springer Science & Business Media 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. Mathematical Methods and Models for Economists Cambridge University Press A textbook for a first-year PhD course in mathematics for economists and a reference for graduate students in economics. Generalized Convexity and Optimization Theory and Applications Springer Science & Business Media The authors have written a rigorous yet elementary and self-contained book to present, in a unified framework, generalized convex functions. The book also includes numerous exercises and two appendices which list the findings consulted. Mathematical Optimization Theory and Operations Research 18th International Conference, MOTOR 2019, Ekaterinburg, Russia, July 8-12, 2019, Proceedings Springer This book constitutes the proceedings of the 18th International Conference on Mathematical Optimization Theory and Operations Research, MOTOR 2019, held in Ekaterinburg, Russia, in July 2019. The 48 full papers presented in this volume were carefully reviewed and selected from 170 submissions. MOTOR 2019 is a successor of the well-known International and All-Russian conference series, which were organized in Ural, Siberia, and the Far East for a long time. The selected papers are organized in the following topical sections: mathematical programming; bi-level optimization; integer programming; combinatorial optimization; optimal control and approximation; data mining and computational geometry; games and mathematical economics. Mathematical Optimization Theory and Operations Research 19th International Conference, MOTOR 2020, Novosibirsk, Russia, July 6–10, 2020, Revised Selected Papers Springer Nature This book constitutes refereed proceedings of the 19th International Conference on Mathematical Optimization Theory and Operations Research, MOTOR 2020, held in Novosibirsk, Russia, in July 2020. Due to the COVID-19 pandemic the conference was held online. The 25 full papers and 8 short papers presented in this volume were carefully reviewed and selected from a total of 102 submissions. The papers in the volume are organised according to the following topical headings: combinatorial optimization; mathematical programming; global optimization; game theory and mathematical economics; heuristics and metaheuristics; machine learning and data analysis. Elements of Numerical Mathematical Economics with Excel Static and Dynamic Optimization Academic Press Elements of Numerical Mathematical Economics with Excel: Static and Dynamic Optimization shows readers how to apply static and dynamic optimization theory in an easy and practical manner, without requiring the mastery of specific programming languages that are often difficult and expensive to learn. Featuring user-friendly numerical discrete calculations developed within the Excel worksheets, the book includes key examples and economic applications solved step-by-step and then replicated in Excel. After introducing the fundamental tools of mathematical economics, the book explores the classical static optimization theory of linear and nonlinear programming, applying the core concepts of microeconomics and some portfolio theory. This provides a background for the more challenging worksheet applications of the dynamic optimization theory. The book also covers special complementary topics such as inventory modelling, data analysis for business and economics, and the essential elements of Monte Carlo analysis. Practical and accessible, Elements of Numerical Mathematical Economics with Excel: Static and Dynamic Optimization increases the computing power of economists worldwide. This book is accompanied by a companion website that includes Excel examples presented in the book, exercises, and other supplementary materials that will further assist in understanding this useful framework. Explains how Excel provides a practical numerical approach to optimization theory and analytics Increases access to the economic applications of this universally-available, relatively simple software program Encourages readers to go to the core of theoretical continuous calculations and learn more about optimization processes Mathematical Optimization and Economic Analysis Springer Science & Business Media "Mathematical Optimization and Economic Analysis" is a self-contained

introduction to various optimization techniques used in economic modeling and analysis such as geometric, linear, and convex programming and data envelopment analysis. Through a systematic approach, this book demonstrates the usefulness of these mathematical tools in quantitative and qualitative economic analysis. The book presents specific examples to demonstrate each technique's advantages and applicability as well as numerous applications of these techniques to industrial economics, regulatory economics, trade policy, economic sustainability, production planning, and environmental policy. Key Features include: - A detailed presentation of both single-objective and multiobjective optimization; - An in-depth exposition of various applied optimization problems; - Implementation of optimization tools to improve the accuracy of various economic models; - Extensive resources suggested for further reading. This book is intended for graduate and postgraduate students studying quantitative economics, as well as economics researchers and applied mathematicians. Requirements include a basic knowledge of calculus and linear algebra, and a familiarity with economic modeling. An Introduction to Mathematical Analysis for Economic Theory and Econometrics Princeton University Press Providing an introduction to mathematical analysis as it applies to economic theory and econometrics, this book bridges the gap that has separated the teaching of basic mathematics for economics and the increasingly advanced mathematics demanded in economics research today. Dean Corbae, Maxwell B. Stinchcombe, and Juraj Zeman equip students with the knowledge of real and functional analysis and measure theory they need to read and do research in economic and econometric theory. Unlike other mathematics textbooks for economics, An Introduction to Mathematical Analysis for Economic Theory and Econometrics takes a unified approach to understanding basic and advanced spaces through the application of the Metric Completion Theorem. This is the concept by which, for example, the real numbers complete the rational numbers and measure spaces complete fields of measurable sets. Another of the book's unique features is its concentration on the mathematical foundations of econometrics. To illustrate difficult concepts, the authors use simple examples drawn from economic theory and econometrics. Accessible and rigorous, the book is self-contained, providing proofs of theorems and assuming only an undergraduate background in calculus and linear algebra. Begins with mathematical analysis and economic examples accessible to advanced undergraduates in order to build intuition for more complex analysis used by graduate students and researchers Takes a unified approach to understanding basic and advanced spaces of numbers through application of the Metric Completion Theorem Focuses on examples from econometrics to explain topics in measure theory Mathematics for Economists Emerald Group Publishing Focuses on two key components of microeconomics - optimization subject to constraints and the development of comparative statics. The book assumes familiarity with calculus of one variable and basic linear algebra, allowing coverage of additional topics like the chain rule and Taylor's theorem. Approximation, Optimization and Mathematical Economics Physica The articles in this proceedings volume reflect the current trends in the theory of approximation, optimization and mathematical economics, and include numerous applications. The book will be of interest to researchers and graduate students involved in functional analysis, approximation theory, mathematical programming and optimization, game theory, mathematical finance and economics. Optimisation and Stability Theory for Economic Analysis Cambridge University Press This text presents a coherent and systematic exposition of the mathematical theory of the problems of optimization and stability, both of which are central to economic analysis. Through extensive use of economic examples, the authors provide the economist with a feel for the kinds of mathematical techniques most useful for dealing with particular economic problems. Although the text deals with fairly advanced material, the mathematical prerequisites are minimized by the inclusion of an integrated mathematical review designed to make the text self-contained and accessible to the reader with only an elementary knowledge of calculus and linear algebra. Mathematical Analysis, Approximation Theory and Their Applications Springer Designed for graduate students, researchers, and engineers in mathematics, optimization, and economics, this self-contained volume presents theory, methods, and applications in mathematical analysis and approximation theory. Specific topics include: approximation of functions by linear positive operators with applications to computer aided geometric design, numerical analysis, optimization theory, and solutions of differential equations. Recent and significant developments in approximation theory, special functions and q-calculus along with their applications to mathematics, engineering, and social sciences are discussed and analyzed. Each chapter enriches the understanding of current research problems and theories in pure and applied research. Mathematical Optimization Theory and Operations Research 20th International Conference, MOTOR 2021, Irkutsk, Russia, July 5–10, 2021, Proceedings Springer This book constitutes the proceedings of the 20th International Conference on Mathematical Optimization Theory and Operations Research, MOTOR 2021, held in Irkutsk, Russia, in July 2021. The 29 full papers and 1 short paper presented in this volume were carefully reviewed and selected from 102 submissions. Additionally, 2 full invited papers are presented in the volume. The papers are grouped in the following topical sections: combinatorial optimization; mathematical programming; bilevel optimization; scheduling problems; game theory and optimal control; operational research and mathematical economics; data analysis. Foundations of Optimization Springer Science & Business Media This book covers the fundamental principles of optimization in finite dimensions. It develops the necessary material in multivariable calculus both with coordinates and coordinate-free, so recent developments such as semidefinite programming can be dealt with. Subgame Consistent Economic Optimization An Advanced Cooperative Dynamic Game Analysis Springer Science & Business Media Various imperfections in existing market systems prevent the free market from serving as a truly efficient allocation mechanism, but optimization of economic activities provides an effective remedial measure. Cooperative optimization claims that socially optimal and individually rational solutions to decision problems involving strategic action over time exist. To ensure that cooperation will last throughout the agreement period, however, the stringent condition of subgame consistency is required. This textbook presents a study of subgame consistent economic optimization, developing game-theoretic optimization techniques to establish the foundation for an effective policy menu to tackle the suboptimal behavior that the conventional market mechanism fails to resolve. Stochastic Optimization and Economic Models Springer This book presents the main applied aspects of stochas tic optimization in

economic models. Stochastic processes and control theory are used under optimization to illustrate the various economic implications of optimal decision rules. Unlike econometrics which deals with estimation, this book emphasizes the decision-theoretic basis of uncertainty specified by the stochastic point of view. Methods of ap plied stochastic control using stochastic processes have now reached an exciti~g phase, where several disciplines like systems engineering, operations research and natural reso- ces interact along with the conventional fields such as mathematical economics, finance and control systems. Our objective is to present a critical overview of this broad terrain from a multidisciplinary viewpoint. In this attempt we have at times stressed viewpoints other than the purely economic one. We believe that the economist would find it most profitable to learn from the other disciplines where stochastic optimization has been successfully applied. It is in this spirit that we have discussed in some detail the following major areas: A. Portfolio models in ·:finance, B. Differential games under uncertainty, c. Self-tuning regulators, D. Models of renewable resources under uncertainty, and ix x PREFACE E. Nonparametric methods of efficiency measurement. Stochastic processes are now increasingly used in economic models to understand the various adaptive behavior implicit in the formulation of expectation and its application in decision rules which are optimum in some sense. Mathematical Methods in Economics and Social Choice Studies in Economic Theory In recent years, the usual optimization techniques, which have proved so useful in microeconomic theory, have been extended to incorporate more powerful topological and differential methods, and these methods have led to new results on the qualitative behavior of general economic and political systems. These developments have necessarily resulted in an increase in the degree of formalism in the publications in the academic journals. This formalism can often deter graduate students. The progression of ideas presented in this book will familiarize the student with the geometric concepts underlying these topological methods, and, as a result, make mathematical economics, general equilibrium theory, and social choice theory more accessible. Finite Dimensional Convexity and Optimization Springer Science & Business Media This book discusses convex analysis, the basic underlying structure of argumentation in economic theory. Convex analysis is also common to the optimization of problems encountered in many applications. The text is aimed at senior undergraduate students, graduate students, and specialists of mathematical programming who are undertaking research into applied mathematics and economics. The text consists of a systematic development in eight chapters, and contains exercises. The book is appropriate as a class text or for self-study. Functional Analysis, Optimization, and Mathematical Economics A Collection of Papers Dedicated to the Memory of Leonid Vitalʹevich Kantorovich Oxford University Press on Demand This is a collection of papers on the work of Leonid Kantorovich, a Russian mathematician and economist, and a leading contributor to the fields of optimization and mathematical economics. Kantorovich invented linear programming then applied this theory to optimal macroeconomic planning in a socialist economy, for which he received the Nobel Prize. The book is dedicated to the memory of Kantorovich, who died in 1986. It contains original contributions from several researchers in the USSR never before available in the U.S. It is organized in a logical sequence, from mathematics to the applications of the theories to concrete problems. The work is fully illustrated. Mathematical Economics Prelude to the Neoclassical Model Springer Nature This textbook provides a one-semester introduction to mathematical economics for first year graduate and senior undergraduate students. Intended to fill the gap between typical liberal arts curriculum and the rigorous mathematical modeling of graduate study in economics, this text provides a concise introduction to the mathematics needed for core microeconomics, macroeconomics, and econometrics courses. Chapters 1 through 5 builds students' skills in formal proof, axiomatic treatment of linear algebra, and elementary vector differentiation. Chapters 6 and 7 present the basic tools needed for microeconomic analysis. Chapter 8 provides a quick introduction to (or review of) probability theory. Chapter 9 introduces dynamic modeling, applicable in advanced macroeconomics courses. The materials assume prerequisites in undergraduate calculus and linear algebra. Each chapter includes in-text exercises and a solutions manual, making this text ideal for self-study. Practical Mathematical Optimization An Introduction to Basic Optimization Theory and Classical and New Gradient-Based Algorithms Springer Science & Business Media This book presents basic optimization principles and gradient-based algorithms to a general audience, in a brief and easy-to-read form. It enables professionals to apply optimization theory to engineering, physics, chemistry, or business economics. Optimization—Theory and Practice Springer Science & Business Media Optimization is a field important in its own right but is also integral to numerous applied sciences, including operations research, management science, economics, finance and all branches of mathematics-oriented engineering. Constrained optimization models are one of the most widely used mathematical models in operations research and management science. This book gives a modern and well-balanced presentation of the subject, focusing on theory but also including algorithims and examples from various real-world applications. Detailed examples and counter-examples are provided--as are exercises, solutions and helpful hints, and Matlab/Maple supplements. Multiple Criteria Decision Making Theory and Application Proceedings of the Third Conference Hagen/Königswinter, West Germany, August 20-24, 1979 Springer Science & Business Media He consider a cone dominance problem: given a "preference" cone IP and a set n X ~ R of available, or feasible, alternatives, the problem is to identify the non dominated elements of X. The nonzero elements of IP are assumed to model the do- nance structure of the problem so that y s X dominates x s X if Y = x + P for some nonzero p S IP. Consequently, x S X is nondominated if, and only if, ({x} + IP) n X = {x} (1.1) He will also refer to nondominated points as efficient points (in X with respect to IP) and we will let EF(XJP) denote the set of such efficient points. This cone dominance problem draws its roots from two separate, but related, ori gins. The first of these is multi-attribute decision making in which the elements of the set X are endowed with various attributes, each to be maximized or minimized.