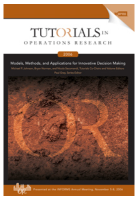

INFORMS TutORials in Operations Research

Preface

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Preface

This volume of *Tutorials in Operations Research*, subtitled "Models, Methods, and Applications for Innovative Decision Making," is the third in a series that started with the volume edited by Harvey Greenberg and published by Springer in 2004. Like the previous volume of *TutORials* (which was edited by J. Cole Smith, published by INFORMS, and made available at the 2005 INFORMS meeting in San Francisco, CA), the present volume continues an innovative tradition in scholarship and academic service. First, all of the chapters in this volume correspond to tutorial presentations made at the 2006 INFORMS meeting held in Pittsburgh, PA. This conveys a sense of immediacy to the volume: readers have the opportunity to gain knowledge on important topics in OR/MS quickly, through presentations and the written chapters to which they correspond. Second, the chapters in this volume span the range of OR/MS sectors that make this field exciting and relevant to academics and practitioners alike: analytic methods (deterministic and dynamic math programming and math programming under risk and uncertainty), application areas (production and inventory management, interactions between supply chain actors, and supply chain network design), and OR/MS practice (spreadsheet modeling and analysis).

We believe that this volume, like its predecessors, will serve as a reference guide for best practices and cutting-edge research in OR/MS: It is a "go-to" guide for operations researchers. Moreover, the topics covered here are consistent with the theme of the current conference: a "renaissance" in operations research that has resulted in new theory, computational models, and applications that enable public and private organizations to identify new business models and develop competitive advantages.

The administrative challenges of producing a volume of tutorials to coincide with the conference at which the tutorials are presented has been significant. The three Volume Editors, who are also the Tutorials Co-Chairs of the conference presentations, are fortunate to have relied on the excellent model of last year's volume, as well as the guidance of Paul Gray, Series Editor. We now review the topics and findings of the nine chapters that comprise this volume.

Linear programming is one of the fundamental tools of operations research and has been at the core of operations research applications since the middle of the last century. Since the initial introduction of the simplex method, many ideas have been introduced to improve problem solution times. Additionally, the advent of interior point methods has provided an alternative method for solving linear programs that has drawn considerable interest over the last 20 years. In Chapter 1, "Linear Equations, Inequalities, Linear Programs, and a New Efficient Algorithm," Katta G. Murty discusses the history of linear programming, including both the simplex method and interior point methods, and discusses current and future directions in solving linear programs more efficiently.

Math programming contains a number of extensions to conventional modeling frameworks that allow the solution of otherwise intractable real-world problems. One example of this is semidefinite and second-order cone programming, examined by Farid Alizadeh in "Semidefinite and Second-Order Cone Programming and Their Application to Shape-Constrained Regression and Density Estimation." Using the fundamental definitions of positive semidefinite matrices and membership in cones and second-order cones, Alizadeh shows that semidefinite programs (SDP) and second-order cone programs (SOCP) have a number of the duality, complementarity, and optimality properties associated with conventional linear programs. In addition, there are interior point algorithms for both SDP and SOCP that enable the solution of realistically sized instances of SDP and SOCP. Alizadeh applies SOCP to parametric and nonparametric shape-constrained regression and applies a hybrid of SDP and SOCP to parametric and nonparametric density function estimation. Finally, Alidazeh describes a promising real-world application of SDP and SOCP: approximation of the arrival rate of a nonhomogenous Poisson process with limited arrivals data.

Many operations research methods are based on knowing problem data with certainty. However, in many real applications, problem data such as resource levels, cost information, and demand forecasts are not known with certainty. Many stochastic optimization methods have been developed to model problems with stochastic problem data. These methods are limited by the assumption that problem uncertainty can be characterized by a distribution with known parameters, e.g., demand follows a normal distribution with a given mean and variance. In "Model Uncertainty, Robust Optimization, and Learning" Andrew E. B. Lim, J. George Shanthikumar, and Z. J. Max Shen discuss methods that can be applied to problems where the problem uncertainty is more complex. The authors propose robust optimization approaches that can be applied to these more general problems. The methods are discussed from a theoretical perspective and are applied in inventory and portfolio selection problems.

In the next chapter, Dimitris Bertsimas and Aurélie Thiele ("Robust and Data-Driven Optimization: Modern Decision Making Under Uncertainty") consider an important aspect of decision making under uncertainty: robust optimization approaches. Many approaches to solving this problem result in very conservative policies because the policy is based on considering the worst-case scenario. Bertsimas and Thiele provide a framework that provides a more comprehensive approach that goes beyond just considering the worst-case scenario. Moreover, this approach can incorporate the decision maker's risk preferences in determining an operating policy. Bertsimas and Thiele discuss the theory underlying their methods and present applications to portfolio and inventory management problems.

Many operations research problems involve the allocation of resources over time or under conditions of uncertainty. In "Approximate Dynamic Programming for Large-Scale Resource Allocation Problems," Warren B. Powell and Huseyin Topaloglu present modeling and solution strategies for the typical large-scale resource allocation problems that arise in these contexts. Their approach involves formulating the problem as a dynamic program and replacing its value function with tractable approximations, which are obtained by using simulated trajectories of the system and iteratively improving on some initial estimates. Consequently, the original complex problem decomposes into time-staged subproblems linked by value function approximations. The authors illustrate their approach with computational experiments, which indicate that the proposed strategies yield high-quality solutions, and compare it with conventional stochastic programming methods.

Spreadsheets are ubiquitous in business and education for data management and analysis. However, there is often a tension between the need for quick analyses, which may result in errors and use of only a small fraction of a spreadsheet software's features, and the need for sophisticated understanding of the capabilities and features of spreadsheets, which may require time-intensive training. In "Enhance Your Own Research Productivity Using Spreadsheets," Janet M. Wagner and Jeffrey Keisler remind us of the high stakes of many "mission-critical" spreadsheet-based applications and the significant likelihood of errors in these applications. In response to these identified needs, Wagner and Keisler argue for the importance of spreadsheet-based methods and tools for data analysis, user interface design, statistical modeling, and math programming that may be new even to experienced users. The authors' presentation of important features of Microsoft Excel relevant to OR/MS researchers and practitioners is framed by four case studies drawn from education and business and available online.

The theory on multiechelon production/inventory systems lies at the core of supply chain management. It provides fundamental insights that can be used to design and manage supply chains, both at the tactical and operational planning levels. In "Multiechelon Production Inventory Systems: Optimal Policies, Heuristics, and Algorithms," Geert-Jan van Houtum presents the main concepts underlying this theory. He illustrates those systems for which the structure of the optimal policy is known, emphasizing those features of the system that are necessary to obtain such a structure, and discusses appropriate heuristic methods for those systems for which the structure of the optimal policy is unknown. Special attention is given to describing the class of basestock policies and conditions that make such policies, or generalizations thereof, optimal.

While tactical and operational considerations are clearly important in managing a supply chain, recent years have witnessed increased attention by operations management researchers to applying game-theoretic concepts to analyze strategic interactions among different players along a supply chain. The next chapter, written by Gérard P. Cachon and Serguei Netessine ("Game Theory in Supply Chain Analysis"), provides a detailed survey of this literature. Cachon and Netessine illustrate the main game-theoretic concepts that have been applied, but also point out those concepts that have potential for future applications. In particular, they carefully discuss techniques that can be used to establish the existence and uniqueness of equilibrium in noncooperative games. The authors employ a newsvendor game throughout the chapter to illustrate the main results of their analysis.

Many important extensions to basic models of supply chain management address demand uncertainty—the possibility that fluctuations in demand for goods provided by a supply chain could result in service disruptions. In "Planning for Disruptions in Supply Chain Networks," Lawrence V. Snyder, Maria P. Scaparra, Mark S. Daskin, and Richard L. Church develop planning models that address uncertainty in the supply of goods and services arising from disruptions that might close product facilities. Their key insight is that models accounting for demand uncertainty use results in risk pooling effects to argue for fewer distribution centers, while those that account for supply uncertainty generally result in more distribution facilities to preserve the robustness of the network. The authors present models that address the location of facilities alone versus the construction of entire distribution networks, distinguish between supply chain design de novo and fortification of existing systems, and address uncertainty through minimizing worst-case outcomes, expected cost, and maximum regret.

We hope that you find this collection of tutorials stimulating and useful. *TutORials* represents the best that INFORMS has to offer: theory, applications, and practice that are grounded in problems faced by real-world organizations, fortified by advanced analytical methods, enriched by multidisciplinary perspectives, and useful to end-users, be they teachers, researchers, or practitioners.

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