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Preface

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Preface

This year's *TutORials in Operations Research* is the seventh volume in the series published by INFORMS. As this preface is being written, a major topic of debate is the analysis and quantification of risk. This topic pertains to discussions in the financial area (e.g., the housing crisis), in the engineering sector (e.g., the Gulf of Mexico), and in health care. Although it was not intentional, a major theme running through both the tutorial papers and the presentations is handling risk in complex systems. By my accounting, at least five of the chapters and two additional presentations focus on risk and/or decision analysis. Of course, optimization has also always been a cornerstone of operations research, and three chapters analyze optimization under different assumptions on future uncertainty. Rounding out this volume are two chapters on optimization of stochastic systems and a chapter on procurement auctions. The tutorials in this book, as well as nine other tutorials, will be presented at the 2010 INFORMS Annual Meeting in Austin, Texas.

In Chapter 1, Nedialko B. Dimitrov and Lauren Ancel Meyers analyze models of infectious diseases spreading through human populations. As our social and business networks become ever more interconnected and globalized, we have seen the importance of modeling and controlling the spread of infectious diseases. Dimitrov and Meyers' work is partially motivated by the recent spread of the H1N1 influenza strain. They introduce a new contact network model to mimic the spread of such diseases. More accurate models of such epidemics (or pandemics) allow policy makers to respond more effectively to outbreaks and to create more robust contingency plans.

The next chapter examines the assessment of risk in a much more localized, but still enormously complex system—a commercial nuclear reactor. Ernie Kee and Elmira Popova give a detailed overview of a years' long project to enhance the methodology of probabilistic risk assessment (PRA) in nuclear safety systems. PRA is used to analyze both production risks and public safety risks in reactors. I find this a particularly interesting area of risk assessment because it is one in which the federal government both checks PRA models and places probabilistic constraints on various risks. In light of the issues mentioned in the tutorial's introduction, we might ask ourselves if more intensive scrutiny of commercial PRA models is warranted in other sectors.

Chapters 3, 4, and 5 focus on extending decision-making methodology. In Chapter 3, Ali E. Abbas proposes methods to extend classical von Neumann–Morgenstern utility theory. In this theory, the typical scenario is that we are given several prospects whose payoff is represented by single attribute such as wealth. For prospects with one attribute, the decision process is required to adhere to the axioms of decision analysis: the rules of probability, order, equivalence, substitution, and choice. Abbas examines more complex decision scenarios in which each potential prospect may have multiple attributes such as health and wealth. He provides a number of methods for extending the standard framework to construct multiattribute utility functions. Chapter 4, authored by Matthew J. Sobel, has one of the more interesting titles in this volume: "The Trojan Horse of Time–Risk Preference Representations." Sobel's contribution is in some sense more philosophical than many of the contributions, yet he grounds his philosophical musings in the real-world needs of decision analysis practitioners. This chapter considers two major factors in evaluating alternatives: "the logic of preferences among risks, and the logic of preferences with regard to timing." Sobel notes that investigations of these two issues have often been developed separately, and the interaction between them has not been thoroughly examined. He finds the logical

representation of timing and risk to be contradictory and proposes a framework to resolve these issues. He wraps up the tutorial by providing a concrete example in supply chain contracts. Chapter 5 rounds out this volume's investigation of decision analysis, by examining a different aspect than the previous chapters: group decision making and ranking. As both OR theorists and practitioners know well, translating individual preferences or rankings into an aggregate decision is a persistently thorny problem. In her chapter, Dorit S. Hochbaum examines different methods for providing aggregate rankings. She suggests that scorewise methods can be flawed and suggests a methodology based on pairwise comparisons of rankings. This seemingly more academic approach has a wide impact on a range of practical problems such as the ranking of Web pages and National Science Foundation proposals, and determining credit risks.

Chapters 6 through 8 deal with a theme, optimization under uncertainty, whose importance in the OR community has continued to grow over the past several years. These chapters complement each other nicely in providing different approaches to the problem. In Chapter 6, Patrick Jaillet and Michael R. Wagner review the field of online optimization. Jaillet and Wagner divide optimization methods into three groups, depending on how they deal with future uncertainty. First, there is stochastic optimization, which assumes that future uncertainty is known via a probability distribution. Second, robust optimization eschews distributions but instead takes uncertainty sets as an uncertainty primitive. Finally, online optimization does away with both the previous constructs and makes the minimal assumptions about future data, assuming only that it is revealed incrementally over time. Jaillet and Wagner review the fundamental algorithms and theory of online optimization and give an in-depth example that is a variant of the celebrated traveling salesman problem (TSP). Chapter 7 is closely related in that it examines vehicle routing problems (VRPs), which are extensions of the TSP, in the framework of robust optimization. In this chapter, Fernando Ordóñez provides a comprehensive review of stochastic vehicle routing problems that can take many forms, depending on what is assumed to be uncertain and on what kind of route updating is allowed as uncertainty is revealed. A particularly nice feature of this chapter is a section that compares various modeling and solution approaches in stochastic VRPs. The debate over the right approach to uncertainty modeling is one which again has important practical ramifications. Apropos to these effects, Ordóñez provides an example of the use of his methodology for the development of routing plans in large-scale bioterrorism emergencies. The modeling framework in Chapter 8, authored by Retsef Levi, is stochastic optimization. Levi investigates multistage stochastic optimization problems, which are notoriously difficult to solve exactly the computational difficulties arising with modest increases in the number of stages. In particular, this chapter develops approximation algorithms to solve problems with more than two stages. Such algorithms, which were first developed in the computer science context, have gained increased importance in difficult stochastic optimization problems. Levi's methods can be applied to a range of problems, including inventory control and revenue management.

The next two chapters address the issues of optimizing stochastic systems. In Chapter 9, renowned simulation expert Barry L. Nelson takes a broad look at optimization via simulation (OvS). He notes that while significant advances have been made in the area of optimizing over continuous decision variables, the techniques for optimizing over discrete variables are more scattered. His article surveys the issues, methods, and software available in the discrete OvS regime. In Chapter 10, Robert C. Hampshire and William A. Massey tackle the problem of optimizing queuing systems. Their approach is unique compared to common optimization models in the queuing literature. First, they focus on systems with time-varying demand rates. Second, they provide a sweeping optimization framework by making connections among mathematical methods that have been developed over centuries. Specifically, they examine the relationship among Lagrangians, Hamiltonians, and Bellman value functions for solving dynamic optimization problems arising in queuing models.

In Chapter 11, the closing chapter in the book, Damian R. Beil provides an overview of procurement auctions. Firms that rely heavily on external suppliers are faced with complex decisions on where to acquire goods and services and at what price. Competitive bidding among suppliers provides one solution to streamline this process. Beil analyzes and contrasts the characteristics of various types of auctions and examines their effects on the firm and its suppliers.

For most academics and practitioners in operations research, the field's enduring appeal is the range of applications and mathematical techniques involved. This bricolage of knowledge is often distilled most strikingly in the tutorials at the annual INFORMS meetings. This year, the range can be seen from both the tutorial papers and oral presentations. The applications include Internet fraud detection, risk management in nuclear reactors, disease control, power grid management, and epidemiology. Analytical techniques included methods developed in physics, computer science, and social network theory. And, as mentioned above, there is always a soupçon of philosophy in OR discussions: How should uncertainty be modeled? What is the relationship between time and risk? What is the true meaning of statistical statements? What should I make for dinner? I hope this volume provides evidence to all generations of OR adherents that the field is still fascinating, vibrant, and enduring.

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