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运筹学导论（第10版）

[美] 弗雷德里克·S. 希利尔 (Frederick S. Hillier) 著
杰拉尔德·J. 利伯曼 (Gerald J. Lieberman)

Introduction to Operations Research (Tenth Edition)

清华大学出版社



根据中国工商管理本科大纲要求、教学实践进行详细精简的本科英文教材

适合中国国情及国际化双轨要求的双语教学英文教材

为中国应用型商科教育发展奠定教学模式及基础的英文版商科教材

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本书是运筹学经典著作，在美国高校有很高的采用率。两位作者是运筹学领域的大师。本书内容丰富，覆盖运筹学各个分支，主要内容包括：运筹学建模方法、线性规划、对偶理论与灵敏度分析、网络优化模型、动态规划、整数规划、决策分析等。书中有大量案例，可供自学及复习。

本书可作为管理类及工科类本科生的运筹学教材。

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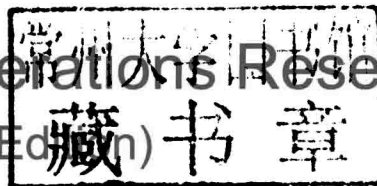
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出 版 说 明

为了适应经济全球化的发展趋势，满足国内广大读者了解、学习和借鉴国外先进经济管理理论和管理经验的需要，清华大学出版社与国外著名出版公司 McGraw-hill 教育出版集团合作影印出版了一系列商科英文版教材。鉴于大部分外版教材篇幅过长，且其中部分内容与我国的教学需要不符，我们请专家学者结合国内教学的实际要求，对所选图书进行了必要的删节。我们所选择的图书，基本上是在国外深受欢迎、并被广泛采用的优秀教材的缩减版，其主教材均是该领域中较具权威性的经典之作。

为有效控制定价以便减轻学生购买教材的负担，本书删去了原书的第 13~15 章、第 17~20 章以及附录 1~3。为方便读者阅读，本书采取双页码方式编排。在本书的选书和删节的过程中，我们得到了哈尔滨工业大学胡运权教授的支持、帮助和鼓励，在此表示谢意！

读者在阅读过程中可能会发现按照原书的页码有漏页、跳页的现象，而且文中提到的页码或内容有可能已被删掉从而无法找到，由此给读者带来的诸多不便，我们深表歉意。

由于原作者所处国家的政治、经济和文化背景等与我国不同，对书中所持观点，敬请广大读者在阅读过程中注意加以分析和鉴别。

我们期望这套影印书的出版对我国经济管理科学的发展能有所帮助，对我国商科的教学，尤其是商学本科的教学能有所促进。

欢迎广大读者给我们提出宝贵的意见和建议；同时也欢迎有关专业人士向我们推荐您所接触到的国外优秀图书。

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中国的学生要不要使用英文版的教材，一直有争议。有人认为，我们应该使用自己编写的教材，这样才能更准确地反映我们在课堂上所要表述的观点。用国外的原版教材，有些隔靴搔痒，不能解决中国的实际问题。持不同意见的观点认为，尽管各国在管理体制上有意识、制度、文化等差异，但管理本身是在国际环境下具有共同性的问题。特别是，中国的企业在经济全球化的环境下，需要更多地了解国外的管理理论与现状。在这种情况下，就需要引进一些外版的教材。一则，用于满足我们教学的部分需求；二则，更好地了解外版教材的教学服务体系；三则，为我们的师生创造英语教学的环境。

在进行 2004 年本科教指委的工作规划时，我曾特别谈及，要加强对本科教育中教书“育人”、服务于学生的使命的认识，继续优化专业课程设计，扩大精品课程建设，增加专业导向课程，尤其要加强对国际商科与经济管理学科教学进展的研究，并引进最新的教学成果，包括教材及教学资源。这一切都是为了更好地为国家与社会培养更好的人才。

为此，清华大学出版社与美国麦格劳-希尔教育出版公司的合作，引进出版这套“精编版”的英文工商管理教材，也是体现这一理念。这套教材吸收国际最新教学成果，提供全方位的教学资源，并借助英语的语言媒介，将会大力提升与发展中国工商管理教学水平，提高学生使用英语语言和网络手段获得长久的终生学习的能力和兴趣，进而提高我国工商界的国际竞争力。这是一件具有重大意义的工作。

在讨论引进国际上在工商管理教学的最新成果时，确定了引进本套教材及教学资源的基本格调，即对“国际最新教学成果”的几个共同认识：一是国际上教学技术的进展究竟走到了哪一步，我们就引进到哪一步。二是要注意教学技术的发展给教学及教材带来了的影响，我们要借鉴新的教学辅助手段。

最近几年，我在美国授课的过程中，注意到教学网络技术：课程管理系统（Course Management System, CMS）。通过这个教学辅助系统，教师可以将所要讲授的课程内容简单地张贴到一个系统化的网页上，包括教学演示文件 PPT、章节提要（Lecture Notes）、在线阅读资料，以及问答题、简答题还有课后大作业等，还可以很简单地开设自己课程的在线论坛 BBS。学生在注册后，便成为在线学生，通过该平台与教师交互，完成习题，在线提交作业，在线考试，自动出评测分析报告。这一切是以教师为中心，完全解决了教师对于自己教学内容以及对学​​生及教学过程的网络化数字化管理的问题，并可多次复用、异地复用。这个在线学习系统（BlackBoard, WebCT, eCollege）等不同于国内各高校自己研发的以学籍管理或居于录像、课件的远程教学为中心的校园管理平台，直接解决大学的核心问题：即“大师”们对课程教学内容的管理问题，成为对教师授课最好的在线数字化辅助支持平台。

2004 年的春季学期，中国人民大学商学院 247 位教师，所有 364 门课程全面上线，2000 多名学生在线注册学习，引发了人大商学院一场真正意义上的“教学革命”。教师与学生实现了很好地沟通与互动，

学生之间也有了很好地学习谈论的天地。目前，我校商学院的经验，已经成为赛尔毕博支持国内院校教学上线发展的典范，成为 BlackBoard 在国内的示范教学网站。

课堂教学同网络平台结合之后，又给教学带来了新的挑战，也给教材和教材的出版商们带来了新的机遇。历史悠久的麦格劳-希尔教育出版公司积极适应这种挑战，在商科及经管教材的出版上做了战略性的调整：即将教材本身做“薄”，出版一批新型的、跨媒介的教材：将研讨性、探索性、展开式的学习内容放到网上，将动态交互性的内容放到网上；印刷版的教材从过去强调各章节内容全面，呈现教学过程、学习环节，转向注重概念性及引导性，展现学习的核心内容。同时，他们将教材配套的教学资源做得更“全”，将更多的内容上线后全面依托网络，更加动态地呈现教学内容及教学过程；并为不同的教学平台提供完全解决方案，提供跨平台的不同版本的内容“子弹”。无论采用 BlackBoard 或 WebCT 等平台，教师们都可以从出版商处获得标准的教学资源包，为自己采用的教材轻松搭建课程网站，实现教学的在线革命。

总之，教学在革命，教学的手段也在革命。我们要看到工商管理教学在国际上的各种变化，努力跟上时代的发展变化，使我们的学生真正获得国际水准的教育。为此，我衷心地感谢这批教材的国外作者们，正是他们不懈的教学实践，给我们学科的发展带来源源的活力；同时感谢国内外的出版界的人们，感谢他们对教材、教材市场的永恒的追求，不断地帮助我们提升教学的水准；衷心希望这批适应新的教学需要的国际最新教材的出版能抛砖引玉，再次带动整个工商管理教育无论是本科、高职高专教学，还是 MBA、EMBA 教学的发展。

子曰：“学而时习之，不亦悦乎。”在这场教学革命中，我们有更大的勇气面临新的教学的挑战，将中国的工商管理教育推向世界一流！

徐二明
中国人民大学

ABOUT THE AUTHORS

Frederick S. Hillier was born and raised in Aberdeen, Washington, where he was an award winner in statewide high school contests in essay writing, mathematics, debate, and music. As an undergraduate at Stanford University, he ranked first in his engineering class of over 300 students. He also won the McKinsey Prize for technical writing, won the Outstanding Sophomore Debater award, played in the Stanford Woodwind Quintet and Stanford Symphony Orchestra, and won the Hamilton Award for combining excellence in engineering with notable achievements in the humanities and social sciences. Upon his graduation with a BS degree in industrial engineering, he was awarded three national fellowships (National Science Foundation, Tau Beta Pi, and Danforth) for graduate study at Stanford with specialization in operations research. During his three years of graduate study, he took numerous additional courses in mathematics, statistics, and economics beyond what was required for his MS and PhD degrees while also teaching two courses (including "Introduction to Operations Research"). Upon receiving his PhD degree, he joined the faculty of Stanford University and began work on the 1st edition of this textbook two years later. He subsequently earned tenure at the age of 28 and the rank of full professor at 32. He also received visiting appointments at Cornell University, Carnegie-Mellon University, the Technical University of Denmark, the University of Canterbury (New Zealand), and the University of Cambridge (England). After 35 years on the Stanford faculty, he took early retirement from his faculty responsibilities in order to focus full time on textbook writing, and now is Professor Emeritus of Operations Research at Stanford.

Dr. Hillier's research has extended into a variety of areas, including integer programming, queueing theory and its application, statistical quality control, and the application of operations research to the design of production systems and to capital budgeting. He has published widely, and his seminal papers have been selected for republication in books of selected readings at least 10 times. He was the first-prize winner of a research contest on "Capital Budgeting of Interrelated Projects" sponsored by The Institute of Management Sciences (TIMS) and the U.S. Office of Naval Research. He and Dr. Lieberman also received the honorable mention award for the 1995 Lanchester Prize (best English-language publication of any kind in the field of operations research), which was awarded by the Institute of Operations Research and the Management Sciences (INFORMS) for the 6th edition of this book. In addition, he was the recipient of the prestigious 2004 INFORMS Expository Writing Award for the 8th edition of this book.

Dr. Hillier has held many leadership positions with the professional societies in his field. For example, he has served as treasurer of the Operations Research Society of America (ORSA), vice president for meetings of TIMS, co-general chairman of the 1989 TIMS International Meeting in Osaka, Japan, chair of the TIMS Publications Committee, chair of the ORSA Search Committee for Editor of *Operations Research*, chair of the ORSA Resources Planning Committee, chair of the ORSA/TIMS Combined Meetings Committee, and chair of the John von Neumann Theory Prize Selection Committee for INFORMS. He also is a Fellow of INFORMS. In addition, he recently completed a 20-year tenure as the series editor for Springer's International Series in Operations Research and Management Science, a particularly prominent book series with over 200 published books that he founded in 1993.

In addition to *Introduction to Operations Research* and two companion volumes, *Introduction to Mathematical Programming* (2nd ed., 1995) and *Introduction to Stochastic Models in Operations Research* (1990), his books are *The Evaluation of Risky Interrelated Investments* (North-Holland, 1969), *Queueing Tables and Graphs* (Elsevier North-Holland, 1981, co-authored by O. S. Yu, with D. M. Avis, L. D. Fossett, F. D. Lo, and M. I. Reiman), and *Introduction to Management Science: A Modeling and Case Studies Approach with Spreadsheets* (5th ed., McGraw-Hill/Irwin, 2014, co-authored by his son Mark Hillier).

The late **Gerald J. Lieberman** sadly passed away in 1999. He had been Professor Emeritus of Operations Research and Statistics at Stanford University, where he was the founding chair of the Department of Operations Research. He was both an engineer (having received an undergraduate degree in mechanical engineering from Cooper Union) and an operations research statistician (with an AM from Columbia University in mathematical statistics, and a PhD from Stanford University in statistics).

Dr. Lieberman was one of Stanford's most eminent leaders in recent decades. After chairing the Department of Operations Research, he served as associate dean of the School of Humanities and Sciences, vice provost and dean of research, vice provost and dean of graduate studies, chair of the faculty senate, member of the University Advisory Board, and chair of the Centennial Celebration Committee. He also served as provost or acting provost under three different Stanford presidents.

Throughout these years of university leadership, he also remained active professionally. His research was in the stochastic areas of operations research, often at the interface of applied probability and statistics. He published extensively in the areas of reliability and quality control, and in the modeling of complex systems, including their optimal design, when resources are limited.

Highly respected as a senior statesman of the field of operations research, Dr. Lieberman served in numerous leadership roles, including as the elected president of The Institute of Management Sciences. His professional honors included being elected to the National Academy of Engineering, receiving the Shewhart Medal of the American Society for Quality Control, receiving the Cuthbertson Award for exceptional service to Stanford University, and serving as a fellow at the Center for Advanced Study in the Behavioral Sciences. In addition, the Institute of Operations Research and the Management Sciences (INFORMS) awarded him and Dr. Hillier the honorable mention award for the 1995 Lanchester Prize for the 6th edition of this book. In 1996, INFORMS also awarded him the prestigious Kimball Medal for his exceptional contributions to the field of operations research and management science.

In addition to *Introduction to Operations Research* and two companion volumes, *Introduction to Mathematical Programming* (2nd ed., 1995) and *Introduction to Stochastic Models in Operations Research* (1990), his books are *Handbook of Industrial Statistics* (Prentice-Hall, 1955, co-authored by A. H. Bowker), *Tables of the Non-Central t-Distribution* (Stanford University Press, 1957, co-authored by G. J. Resnikoff), *Tables of the Hypergeometric Probability Distribution* (Stanford University Press, 1961, co-authored by D. Owen), *Engineering Statistics*, (2nd ed., Prentice-Hall, 1972, co-authored by A. H. Bowker), and *Introduction to Management Science: A Modeling and Case Studies Approach with Spreadsheets* (McGraw-Hill/Irwin, 2000, co-authored by F. S. Hillier and M. S. Hillier).

PREFACE

When Jerry Lieberman and I started working on the first edition of this book 50 years ago, our goal was to develop a pathbreaking textbook that would help establish the future direction of education in what was then the emerging field of operations research. Following publication, it was unclear how well this particular goal was met, but what did become clear was that the demand for the book was far larger than either of us had anticipated. Neither of us could have imagined that this extensive worldwide demand would continue at such a high level for such an extended period of time.

The enthusiastic response to our first nine editions has been most gratifying. It was a particular pleasure to have the field's leading professional society, the international Institute for Operations Research and the Management Sciences (INFORMS), award the 6th edition honorable mention for the 1995 INFORMS Lanchester Prize (the prize awarded for the year's most outstanding English-language publication of any kind in the field of operations research).

Then, just after the publication of the eighth edition, it was especially gratifying to be the recipient of the prestigious 2004 INFORMS Expository Writing Award for this book, including receiving the following citation:

Over 37 years, successive editions of this book have introduced more than one-half million students to the field and have attracted many people to enter the field for academic activity and professional practice. Many leaders in the field and many current instructors first learned about the field via an edition of this book. The extensive use of international student editions and translations into 15 other languages has contributed to spreading the field around the world. The book remains preeminent even after 37 years. Although the eighth edition just appeared, the seventh edition had 46 percent of the market for books of its kind, and it ranked second in international sales among all McGraw-Hill publications in engineering.

Two features account for this success. First, the editions have been outstanding from students' points of view due to excellent motivation, clear and intuitive explanations, good examples of professional practice, excellent organization of material, very useful supporting software, and appropriate but not excessive mathematics. Second, the editions have been attractive from instructors' points of view because they repeatedly infuse state-of-the-art material with remarkable lucidity and plain language. For example, a wonderful chapter on metaheuristics was created for the eighth edition.

When we began work on the book 50 years ago, Jerry already was a prominent member of the field, a successful textbook writer, and the chairman of a renowned operations research program at Stanford University. I was a very young assistant professor just starting my career. It was a wonderful opportunity for me to work with and to learn from the master. I will be forever indebted to Jerry for giving me this opportunity.

Now, sadly, Jerry is no longer with us. During the progressive illness that led to his death 14 years ago, I resolved that I would pick up the torch and devote myself to subsequent editions of this book, maintaining a standard that would fully honor Jerry. Therefore, I took early retirement from my faculty responsibilities at Stanford in order to work full time on textbook writing for the foreseeable future. This has enabled me to spend far more than the usual amount of time in preparing each new edition. It also has enabled me to closely monitor new trends and developments in the field in order to bring this edition completely up to date. This monitoring has led to the choice of the major additions to the new edition outlined next.

WHAT'S NEW IN THIS EDITION

- **Analytic Solver Platform for Education.** This edition continues to provide the option of using Excel and its Solver (a product of Frontline Systems, Inc.) to formulate and solve some operations research (OR) models. Frontline Systems also has developed some advanced Excel-based software packages. One recently released package, Analytic Solver Platform, is particularly exciting because of its tremendous versatility. It provides strong capability for dealing with the types of OR models considered in most of the chapters considered in this book, including linear programming, integer programming, nonlinear programming, decision analysis, simulation, and forecasting. Rather than requiring the use of a collection of Excel add-ins to deal with all of these areas (as in the preceding edition), Analytic Solver Platform provides an all-in-one package for formulating and solving many OR models in spreadsheets. We are delighted to have integrated the student version of this package, Analytic Solver Platform for Education (ASPE), into this new edition. A special arrangement has been made with Frontline Systems to provide students with a free 140-day license for ASPE.

At the same time, we have integrated ASPE in such a way that it can readily be skipped over without loss of continuity for those who do not wish to use spreadsheets. A number of other attractive software options continue to be provided in this edition (as described later). In addition, a relatively brief introduction to spreadsheet modeling can also be obtained by only using Excel's standard Solver. However, we believe that many instructors and students will welcome the great power and versatility of ASPE.

- **A New Section on Robust Optimization.** OR models typically are formulated to help select some future course of action, so the values of the model parameters need to be based on a prediction of future conditions. This sometimes results in having a significant amount of uncertainty about what the parameter values actually will turn out to be when the optimal solution from the model is implemented. For problems where there is no latitude for violating the constraints even a little bit, a relatively new technique called *robust optimization* provides a way of obtaining a solution that is virtually guaranteed to be feasible and nearly optimal regardless of reasonable deviations of the parameter values from their estimated values. The new Section 7.4 introduces the robust optimization approach when dealing with linear programming problems.
- **A New Section on Chance Constraints.** The new Section 7.5 continues the discussion in Section 7.4 by turning to the case where there is some latitude for violating some constraints a little bit without very serious complications. This leads to the option of using *chance constraints*, where each chance constraint modifies an original constraint by only requiring that there be some very high probability that the original constraint will be satisfied. When the original problem is a linear programming problem, each of these chance constraints can be converted into a deterministic equivalent that still is a linear programming constraint. Section 7.5 describes how this important idea is implemented.
- **A New Section on Stochastic Programming with Recourse.** Stochastic programming provides still another way of reformulating a linear programming model (or another type of model) where there is some uncertainty about what the values of the parameters will turn out to be. This approach is particularly valuable for those problems where the decisions will be made in two (or more) stages, so the decisions in stage 2 can help compensate for any stage 1 decisions that do not turn out as well as hoped because of errors in estimating some parameter values. The new Section 7.6 describes *stochastic programming with recourse* for dealing with such problems.
- **A New Chapter on Linear Programming under Uncertainty That Includes These New Sections.** One of the key assumptions of linear programming (as for many other OR models) is the *certainty assumption*, which says that the value assigned to each parameter

of a linear programming model is assumed to be a *known constant*. This is a convenient assumption, but it seldom is satisfied precisely. One of the most important concepts to get across in an introductory OR course is that (1) although it usually is necessary to make some simplifying assumptions when formulating a model of a problem, (2) it then is very important after solving the model to explore the impact of these simplifying assumptions. This concept can be most readily conveyed in the context of linear programming because of all the methodology that now has been developed for dealing with linear programming under uncertainty. One key technique of this type is sensitivity analysis, but some other relatively elementary techniques now have also been well developed, including particularly the ones presented in the three new sections described above. Therefore, the old Chapter 6 (*Duality Theory and Sensitivity Analysis*) now has been divided into two new chapters—Chapter 6 (*Duality Theory*) and Chapter 7 (*Linear Programming under Uncertainty*). The new Chapter 7 includes the three sections on sensitivity analysis in the old Chapter 6 but also adds the three new sections described above.

- **A New Section on the Rise of Analytics Together with Operations Research.** A particularly dramatic development in the field of operations research over the last several years has been the great buzz throughout the business world about something called *analytics* (or business analytics) and the importance of incorporating analytics into managerial decision making. As it turns out, the discipline of analytics is closely related to the discipline of operations research, although there are some differences in emphases. OR can be thought of as focusing mainly on advanced analytics whereas analytics professionals might get more involved with less advanced aspects of the study. Some fads come and go, but this appears to be a permanent shift in the direction of OR in the coming years. In fact, we could even find *analytics* eventually replacing *operations research* as the common name for this integrated discipline. Because of this close and growing tie between the two disciplines, it has become important to describe this relationship and to put it into perspective in an introductory OR course. This has been done in the new Section 1.3.
- **Many New or Revised Problems.** A significant number of new problems have been added to support the new topics and application vignettes. In addition, many of the problems from the ninth edition have been revised. Therefore, an instructor who does not wish to assign problems that were assigned in previous classes has a substantial number from which to choose.
- **A Reorganization to Reduce the Size of the Book.** An unfortunate trend with early editions of this book was that each new edition was significantly larger than the previous one. This continued until the seventh edition had become considerably larger than is desirable for an introductory survey textbook. Therefore, I worked hard to substantially reduce the size of the eighth edition and then further reduced the size of the ninth edition slightly. I also adopted the goal of avoiding any growth in subsequent editions. Indeed, this edition is 35 pages shorter than the ninth edition. This was accomplished through a variety of means. One was being careful not to add too much new material. Another was deleting certain low-priority material, including the presentation of parametric linear programming in conjunction with sensitivity analysis (it already is covered later in Section 8.2) and a complicated dynamic programming example (the Wyndor problem with three state variables) that can be solved much more easily in other ways. Finally, and most importantly, 50 pages were saved by shifting two little-used items (the chapter on Markov chains and the last two major sections on Markov decision processes) to the supplements on the book's website. Markov chains are a central topic of probability theory and stochastic processes that have been borrowed as a tool of operations research, so this chapter better fits as a reference in the supplements.
- **Updating to Reflect the Current State of the Art.** A special effort has been made to keep the book completely up to date. This included adding relatively new developments (the four new sections mentioned above) that now warrant consideration in an

introductory survey course, as well as making sure that all the material in the ninth edition has been brought up to date. It also included carefully updating both the application vignettes and selected references for each chapter.

OTHER SPECIAL FEATURES OF THIS BOOK

- **An Emphasis on Real Applications.** The field of operations research is continuing to have a dramatic impact on the success of numerous companies and organizations around the world. Therefore, one of the goals of this book is to tell this story clearly and thereby excite students about the great relevance of the material they are studying. This goal is pursued in four ways. One is the inclusion of many application vignettes scattered throughout the book that describe in a few paragraphs how an actual application of operations research had a powerful impact on a company or organization by using techniques like those studied in that portion of the book. For each application vignette, a problem also is included in the problems section of that chapter that requires the student to read the full article describing the application and then answer some questions. Second, real applications also are briefly described (especially in Chapters 2 and 12) as part of the presentation of some OR technique to illustrate its use. Third, many cases patterned after real applications are included at the end of chapters and on the book's website. Fourth, many selected references of award winning OR applications are given at the end of some of the chapters. Once again, problems are included at the end of these chapters that require reading one or more of the articles describing these applications. The next bullet point describes how students have immediate access to these articles.
- **Links to Many Articles Describing Dramatic OR Applications.** We are excited about a partnership with The Institute for Operations Research and the Management Sciences (INFORMS), our field's preeminent professional society, to provide a link on this book's website to approximately 100 articles describing award winning OR applications, including the ones described in all of the application vignettes. (Information about INFORMS journals, meetings, job bank, scholarships, awards, and teaching materials is at www.informs.org.) These articles and the corresponding end-of-chapter problems provide instructors with the option of having their students delve into real applications that dramatically demonstrate the relevance of the material being covered in the lectures. It would even be possible to devote significant course time to discussing real applications.
- **A Wealth of Supplementary Chapters and Sections on the Website.** In addition to the approximately 1,000 pages in this book, another several hundred pages of supplementary material also are provided on this book's website (as outlined in the table of contents). This includes nine complete chapters and a considerable number of supplements to chapters in the book, as well as a substantial number of additional cases. All of the supplementary chapters include problems and selected references. Most of the supplements to chapters also have problems. Today, when students think nothing of accessing material electronically, instructors should feel free to include some of this supplementary material in their courses.
- **Great Flexibility for What to Emphasize.** We have found that there is great variability in what instructors want to emphasize in an introductory OR survey course. They might want to emphasize the mathematics and algorithms of operations research. Others will emphasize model formulation with little concern for the details of the algorithms needed to solve these models. Others want an even more applied course, with emphasis on applications and the role of OR in managerial decision making. Some instructors will focus on the deterministic models of OR, while others will emphasize stochastic models. There also are great differences in the kind of software (if any) that instructors want their students to use. All of this helps to explain why the book is a relatively large

one. We believe that we have provided enough material to meet the needs of all of these kinds of instructors. Furthermore, the book is organized in such a way that it is relatively easy to pick and choose the desired material without loss of continuity. It even is possible to provide great flexibility on the kind of software (if any) that instructors want their students to use, as described below in the section on software options.

