

OPERATIONS
RESEARCH
AND
MANAGEMENT
SCIENCE
HANDBOOK

EDITED BY
A. RAVI RAVINDRAN

OPERATIONS RESEARCH AND MANAGEMENT SCIENCE HANDBOOK

Operations Research (OR) began as an interdisciplinary activity to solve complex military problems during World War II. Utilizing principles from mathematics, engineering, business, computer science, economics, and statistics, OR has developed into a full-fledged academic discipline with practical applications in business, industry, government, and the military. Currently regarded as a body of established mathematical models and methods essential to solving complicated management issues, OR provides quantitative analysis of problems from which managers can make objective decisions. Operations Research and Management Science (OR/MS) methodologies continue to flourish in numerous decision making fields.

Featuring a mix of international authors, *Operations Research and Management Science Handbook* combines OR/MS models, methods, and applications into one comprehensive, yet concise volume. The first resource to reach for when confronting OR/MS difficulties, this text —

- Provides a single source guide in OR/MS
- Bridges theory and practice
- Covers all topics relevant to OR/MS
- Offers a quick reference guide for students, researchers, and practitioners
- Contains unified and up-to-date coverage designed and edited with non-experts in mind
- Discusses software availability for all OR/MS techniques
- Includes contributions from a mix of domestic and international experts

The 26 chapters in the handbook are divided into two parts. Part I contains 14 chapters that cover the fundamental OR/MS models and methods. Each chapter gives an overview of a particular OR/MS model, its solution methods and illustrates successful applications. Part II of the handbook contains 11 chapters discussing the OR/MS applications in specific areas. They include airlines, e-commerce, energy systems, finance, military, production systems, project management, quality control, reliability, supply chain management, and water resources. Part II ends with a chapter on the future of OR/MS applications.



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Abingdon, Oxon OX14 4RN, UK

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The Operations Research Series

Series Editor: A. Ravi Ravindran
Dept. of Industrial & Manufacturing Engineering
The Pennsylvania State University, USA

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Dedication

This book is dedicated to the memory of Professor G. V. Loganathan,
author of Chapter 24, who was killed in the Virginia Tech
campus tragedy on April 16, 2007.

Preface

Operations Research (OR), which began as an interdisciplinary activity to solve complex problems in the military during World War II, has grown in the last 50 years to a full-fledged academic discipline. Now OR is viewed as a body of established mathematical models and methods to solve complex management problems. OR provides a quantitative analysis of the problem from which management can make an objective decision. OR has drawn upon skills from mathematics, engineering, business, computer science, economics, and statistics to contribute to a wide variety of applications in business, industry, government, and military. Operations Research and Management Science (OR/MS) methodologies and their applications continue to grow and flourish in a number of decision-making fields.

The objective of this handbook is to provide a comprehensive overview of OR/MS models, methods, and applications in a single volume. The handbook is not an OR textbook or a research monograph. The intent is that the handbook becomes the first resource a practitioner would reach for when faced with an OR/MS problem or question. The key features of the handbook are the following:

- Single source guide in OR/MS
- Comprehensive resource, but concise
- Covers all topics in OR/MS
- Quick reference guide to students, researchers, and practitioners
- Bridges theory and practice
- References to computer software availability
- Designed and edited with non-experts in mind
- Unified and up-to-date coverage ideal for ready reference

The handbook is divided into two parts. Part I contains 14 chapters that cover the fundamental OR/MS models and methods. Each chapter gives an overview of a particular OR/MS model and its solution methods, illustrates successful applications, and provides references to computer software availability. Each chapter in Part I is devoted to a topic listed below:

- Linear programming
- Nonlinear programming
- Integer programming
- Network optimization
- Multiple criteria decision making
- Decision analysis
- Dynamic programming
- Stochastic processes
- Queueing theory
- Inventory control
- Complexity and large-scale networks
- Simulation
- Metaheuristics
- Robust optimization

Part II of the handbook contains 11 chapters discussing the OR/MS applications in specific areas. They include:

- Airlines
- E-commerce
- Energy systems
- Finance
- Military
- Production systems
- Project management
- Quality control
- Reliability
- Supply chain management
- Water resources

Part II ends with a chapter on the future of OR/MS applications.

The handbook is an ideal reference book for OR/MS practitioners in business, industry, government, and academia. It can also serve as a supplemental text in undergraduate and graduate OR/MS courses at the university level.

A. Ravi Ravindran
University Park, Pennsylvania

Acknowledgments

First and foremost I would like to thank the authors, who have worked diligently in writing the various handbook chapters that are comprehensive, concise, and easy to read, bridging the gap between theory and practice. The development and evolution of this handbook have also benefited substantially from the advice and counsel of my colleagues and friends in academia and industry, who are too numerous to acknowledge individually. They helped me identify the key topics to be included in the handbook, suggested chapter authors, and served as reviewers of the manuscripts.

I express my sincere appreciation to Atul Rangarajan, an industrial engineering doctoral student at Penn State University, for serving as my editorial assistant and for his careful review of the page proofs returned by the authors. Several other graduate students also helped me with the handbook work, in particular, Ufuk Bilsel, Ajay Natarajan, Richard Titus, Vijay Wadhwa, and Tao Yang. Special thanks go to Professor Prabha Sharma at the Indian Institute of Technology, Kanpur, for her careful review of several chapter manuscripts. I also acknowledge the pleasant personality and excellent typing skills of Sharon Frazier during the entire book project.

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A. Ravi Ravindran

Editor

A. Ravi Ravindran, Ph.D., is a professor and the past department head of Industrial and Manufacturing Engineering at the Pennsylvania State University. Formerly, he was a faculty member at the School of Industrial Engineering at Purdue University for 13 years and at the University of Oklahoma for 15 years. At Oklahoma, he served as the director of the School of Industrial Engineering for 8 years and as the associate provost of the university for 7 years, with responsibility for budget, personnel, and space for the academic area. He holds a B.S. in electrical engineering with honors from the Birla Institute of Technology and Science, Pilani, India. His graduate degrees are from the University of California, Berkeley, where he received an M.S. and a Ph.D. in industrial engineering and operations research.

Dr. Ravindran's area of specialization is operations research with research interests in multiple criteria decision-making, financial engineering, health planning, and supply chain optimization. He has published two major textbooks (*Operations Research: Principles and Practice* and *Engineering Optimization: Methods and Applications*) and more than 100 journal articles on operations research. He is a fellow of the Institute of Industrial Engineers. In 2001, he was recognized by the Institute of Industrial Engineers with the Albert G. Holzman Distinguished Educator Award for significant contributions to the industrial engineering profession by an educator. He has won several Best Teacher awards from IE students. He has been a consultant to AT&T, General Motors, General Electric, IBM, Kimberly Clark, Cellular Telecommunication Industry Association, and the U.S. Air Force. He currently serves as the Operations Research Series editor for Taylor & Francis/CRC Press.

Contributors

Réka Albert

Pennsylvania State University
University Park, Pennsylvania

Farhad Azadivar

University of Massachusetts–Dartmouth
North Dartmouth, Massachusetts

Adedeji B. Badiru

Air Force Institute of Technology
Dayton, Ohio

P. Balasubramanian

Theme Work Analytics
Bangalore, India

Qianmei Feng

University of Houston
Houston, Texas

Bobbie L. Foote

U.S. Military Academy (Retd.)
West Point, New York

Natarajan Gautam

Texas A&M University
College Station, Texas

Robin C. Gilbert

University of Oklahoma
Norman, Oklahoma

H. J. Greenberg

University of Colorado at Denver
and
Health Sciences Center
Denver, Colorado

Catherine M. Harmonosky

Pennsylvania State University
University Park, Pennsylvania

Aliza R. Heching

IBM T. J. Watson Research Center
Yorktown Heights, New York

C. Randy Hudson

Oak Ridge National Laboratory
Oak Ridge, Tennessee

Kailash C. Kapur

University of Washington
Seattle, Washington

Rex K. Kincaid

College of William and Mary
Williamsburg, Virginia

Alan J. King

IBM T. J. Watson Research Center
Yorktown Heights, New York

Cerry M. Klein

University of Missouri–Columbia
Columbia, Missouri

Soundar R. T. Kumara

Pennsylvania State University
University Park, Pennsylvania

Lawrence M. Leemis

College of William and Mary
Williamsburg, Virginia

G. V. Loganathan

Virginia Tech
Blacksburg, Virginia

Abu S. M. Masud

Wichita State University
Wichita, Kansas

Tod Morrison

University of Colorado at Denver
and
Health Sciences Center
Denver, Colorado

Katta G. Murty

University of Michigan
Ann Arbor, Michigan

Giuseppe Paleologo

IBM T. J. Watson Research Center
Yorktown Heights, New York

Atul Rangarajan

Pennsylvania State University
University Park, Pennsylvania

A. Ravi Ravindran

Pennsylvania State University
University Park, Pennsylvania

Sowmyanarayanan Sadagopan

Indian Institute of Information Technology
Bangalore, India

Jane L. Snowdon

IBM T. J. Watson Research Center
Yorktown Heights, New York

Hari P. Thadakamalla
Pennsylvania State University
University Park, Pennsylvania

Marlin U. Thomas
Air Force Institute of Technology
Wright-Patterson AFB, Ohio

Theodore B. Trafalis
University of Oklahoma
Norman, Oklahoma

José A. Ventura
Pennsylvania State University
University Park, Pennsylvania

Donald P. Warsing
North Carolina State University
Raleigh, North Carolina

Jeffery D. Weir
Air Force Institute of Technology
Wright-Patterson AFB, Ohio

Michael Weng
University of South Florida
Tampa, Florida

Susan H. Xu
Pennsylvania State University
University Park, Pennsylvania

Mehmet Bayram Yildirim
Wichita State University
Wichita, Kansas