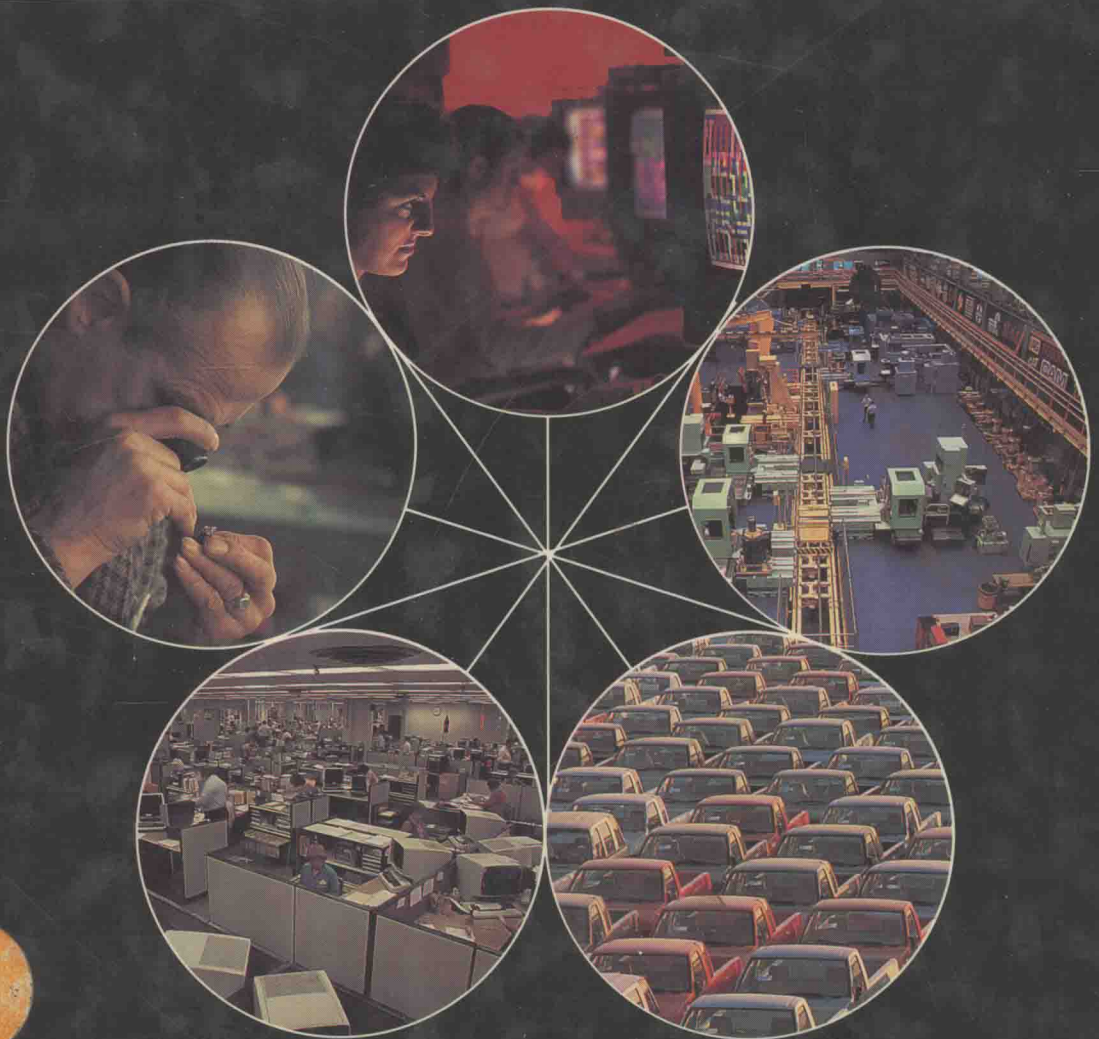


OPERATIONS MANAGEMENT

Decision Making in the Operations Function



ROGER G. SCHROEDER

Third Edition

MANAGEMENT

Decision Making in the Operations Function

THIRD EDITION

Roger G. Schroeder

Curtis L. Carlson School of Management
University of Minnesota

McGraw-Hill Book Company

New York St. Louis San Francisco Auckland Bogotá Caracas
Colorado Springs Hamburg Lisbon London Madrid Mexico Milan
Montreal New Delhi Oklahoma City Panama Paris San Juan
São Paulo Singapore Sydney Tokyo Toronto

OPERATIONS MANAGEMENT

Decision Making in the Operations Function

Copyright © 1989, 1985, 1981 by McGraw-Hill, Inc. All rights reserved.
Printed in the United States of America. Except as permitted under the
United States Copyright Act of 1976, no part of this publication may be
reproduced or distributed in any form or by any means, or stored in a
data base or retrieval system, without the prior written permission of
the publisher.

1 2 3 4 5 6 7 8 9 0 HAL HAL 8 9 4 3 2 1 0 9

ISBN 0-07-055618-0

This book was set in Palatino by Black Dot, Inc.
The editors were Kathleen L. Loy and Ira C. Roberts;
the production supervisor was Janelle S. Travers.
New drawings were done by Fine Line Illustrations, Inc.
Arcata Graphics/Halliday was printer and binder.

Library of Congress Cataloging-in-Publication Data

Schroeder, Roger G.

Operations management.

(McGraw-Hill series in management)

Includes index.

1. Production management. 2. Decision making.

I. Title. II. Series.

TS155.M335 1989

658.5'036

88-13477

ISBN 0-07-055618-0

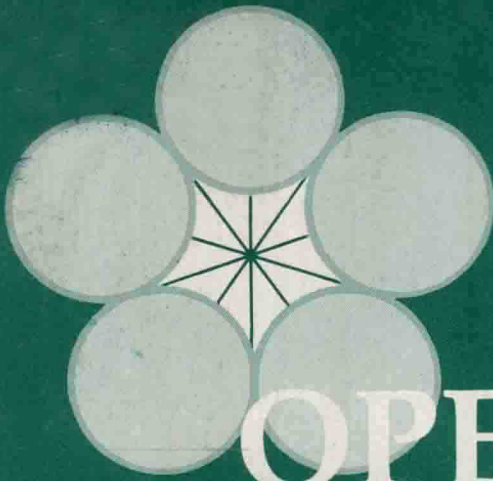
SCHAUM'S OUTLINE SERIES IN ACCOUNTING, BUSINESS & ECONOMICS

Each outline includes basic theory, definitions, and hundreds of solved problems and supplementary problems with answers.

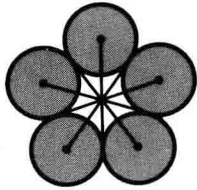
Current List Includes:

Accounting I, 3d edition
Accounting II, 2d edition
Advanced Accounting
Advanced Business Law
Advertising
Bookkeeping & Accounting
Introduction to Business
Business Law
Business Mathematics
Introduction to Business Organization & Management
Business Statistics, 2d edition
College Business Law
Contemporary Mathematics of Finance
Cost Accounting I, 2d edition
Cost Accounting II
Development Economics
Financial Accounting
Intermediate Accounting I
International Economics, 2d edition
Macroeconomic Theory
Managerial Accounting
Managerial Finance
Marketing
Mathematics for Economists
Mathematics of Finance
Microeconomic Theory, 2d edition
Money and Banking
Operations Management
Personal Finance & Consumer Economics
Principles of Economics
Quantitative Methods in Management
Statistics and Econometrics
Tax Accounting

Available at Your College Bookstore



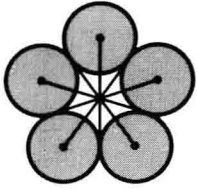
OPERATIONS



About the Author

ROGER G. SCHROEDER is Chairman and Professor of Operations and Management Science at the Curtis L. Carlson School of Management, University of Minnesota. He received his B.S. degree in industrial engineering with high distinction from the University of Minnesota, MSIE University of Minnesota, and his Ph.D. from Northwestern University. Prior to joining the faculty at the University of Minnesota, he was a member of the faculty of the U.S. Naval Postgraduate School, Monterey, California, and an analyst for the office of the Assistant Secretary of Defense. Professor Schroeder has conducted research for the Ford Foundation, the Exxon Education Foundation, and the American Production and Inventory Control Society, and he has published numerous research articles. His current research interests include operations strategy, management of technology, quality improvement, and materials requirements planning systems. Professor Schroeder is a recipient of the Morse-Amoco Award for outstanding teaching at the University of Minnesota. He is on the faculty of the Minnesota Executive Program and has been a consultant for many public and private organizations. Professor Schroeder is currently a member of the Editorial Board of the *Journal of Operations Management*, and he is a past President of the Operations Management Association.

To:
Marlene, Kristen, and Bethany



Preface

This book is intended for the introductory course in production and operations management offered by most schools of business administration and some schools of engineering. It may be used at either the undergraduate or introductory graduate level, and it addresses the “production” accreditation requirement of the AACSB for both manufacturing and service industries.

This book has several features which set it apart from others in the field.

1. **Functional emphasis.** In this text, operations is treated as a major functional area of business along with the marketing and finance functions. While other books recognize operations as a functional area of business, they do not always stress the management of the operations function—rather, they tend to emphasize quantitative analysis or a planning and control approach to operations. As a result, students can become confused about the organizational importance of operations and the role of the operations function in a business enterprise.
2. **Decisions in operations.** In this text, the important decision responsibilities in operations are organized into five major decision categories—process, capacity, inventory, work force, and quality—each of which is the theme of a major part of the text. Each chapter within a part is devoted to one or more critical decisions topics, while management concepts and quantitative analysis are treated as underlying disciplines supporting decision making. This is the first text to use this decision-making framework.
3. **The general business student.** This text is written primarily for the general business student. For this audience, it is important to stress management decision making, responsibilities, and the relationship of operations to other business functions. The main chapters do not require prior preparation in quantitative analysis, the behavior sciences, economics, or other underlying disciplines. For courses in which quantitative disciplines are taught, chapter supplements are provided. The chapter supplements generally treat more advanced quantitative methods, while the basic methods are included in the chapters themselves.
4. **Manufacturing and service industries.** The manufacturing and service industries are presented together in a common conceptual framework. For each decision topic, the book provides a framework which is independent of any particular industry. The examples are then balanced between manufacturing and service industries. In other texts, material on service industries has often been “tacked on” and not properly integrated with manufacturing topics.
5. **Case studies.** Cases are included in the text to improve the student’s skills in the

identification and formulation of problems. These are substantive cases derived from real companies and not just "enlarged problems." Twenty-one case studies are included in the last part of the book under major section headings. This permits the use of cases which are somewhat more integrative than the short case sketches typically included at the end of each chapter.

6. **New material.** Since it is based on a great deal of research, this book provides an up-to-date treatment of the field. About one-third of the material is new or revised over that found in other operations management textbooks. Important chapters with new material are those on operations strategy, choice of technology, service operations design, just-in-time manufacturing, managing quality, international operations, and productivity.

The book's educational objectives can be summarized as follows:


- To provide an understanding of operations as a major functional area of business, including its five management decision areas in operations.
- To show how operations decision making can be improved by utilizing all the underlying disciplines: behavioral, quantitative, economic, and systems.
- To present manufacturing and service industries within a common conceptual framework.

Since a wide variety of courses are taught in operations management, a modular approach is used in organizing this text. Various chapters and supplements can be selected or omitted without interrupting the flow of material. Past adopters have also found that they can choose to either emphasize or deemphasize the quantitative material, depending on their own particular orientation to operations management.

The third edition has incorporated decision examples near the beginning of each chapter. Some of these examples include: forecasting at Rubbermaid, operations strategy at IDS Life Insurance, service improvement at SAS Airlines, CIM at Allen-Bradley, inventory control at Blue Bell, JIT at IBM, Total Quality Control at Ford Motor, and Statistical Quality Control at Hewlett-Packard. Numerous other examples are included throughout the text to help students grasp operations management concepts.

The third edition has been thoroughly updated. New chapters were added on Service Operations Design and International Operations. Major revisions were made to chapters on Operations Strategy, Choice of Technology, Managing Quality, and Productivity to bring them up-to-date. Several new case studies were added and others were improved. The problems at the end of each chapter were revised and expanded by 50 percent to provide greater variety. The objective of the third edition is to maintain the most current and best organized textbook in the operations management field.

The third edition comes with or without software. The text can be ordered with a computer disc which will run on an IBM PC or compatible computer. The disc contains thirty Lotus 1-2-3® templates and three basic programs which can be used to aid in the solution of the problems at the end of the chapters. Lotus

templates are available for many types of problems including: forecasting, queuing, financial analysis, aggregate planning, inventory models, MRP, quality control, and some of the case studies. Basic programs are provided for linear programming, transportation, and project scheduling. These programs are specifically written for this edition of the text which eliminates the usual confusion of a separate software manual or package. Those problems which are supported by a program on the disc are noted by the special computer symbol  in the text.

Many people have helped to prepare this book. I want to express my appreciation to the following reviewers who read the third edition manuscript and helped to refine and improve the material presented: R. Balachandra, Northeastern University; Thomas Billesbach, University of Nebraska; Peter Billington, Northeastern University; Sudhakar Deshmukh, Northwestern University; Sidney Siegel, Drexel University; R. Daniel Reid, University of New Hampshire; and Om C. Sharma, St. John's University.

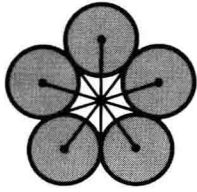
I also want to acknowledge the contributions of my colleagues on the faculty at the University of Minnesota. In addition there are many graduate students who have helped with the text over the years and I am grateful for their support along with the efforts of the office staff in my department. In particular, I appreciate the invaluable contributions of Karen Goodner and Susan Misterek who helped with this third edition. I also want to thank my editors at McGraw-Hill, Kathy Loy and Ira Roberts, for their helpful advice and assistance. The IBM Grant for the Management of Information Systems to the University of Minnesota provided assistance in developing the computer disc for the text. I am very grateful to Doug Chard for preparing the index to the book.

Finally, I wish to thank my family for their patience and perseverance during the many years of text development and editing. Without their continued support and encouragement this textbook would not be possible.

Roger G. Schroeder

OPERATIONS MANAGEMENT

Decision Making in the Operations Function



Contents

| | |
|--------------------------|------|
| <i>Preface</i> | xvii |
|--------------------------|------|

PART ONE INTRODUCTION

| | |
|---|----|
| 1. The Operations Function | 3 |
| 2. Operations Strategy | 24 |
| 3. Forecasting | 48 |
| <i>Supplement: Advanced Methods</i> | 81 |
| 4. Product Design | 85 |

PART TWO PROCESS DESIGN

| | |
|---|-----|
| 5. Process Selection | 109 |
| 6. Service Operations Design | 131 |
| <i>Supplement: Waiting Lines</i> | 151 |
| 7. Choice of Technology | 161 |
| <i>Supplement: Financial Analysis</i> | 185 |
| 8. Process-Flow Analysis | 194 |
| <i>Supplement: Simulation</i> | 218 |
| 9. Layout of Facilities | 234 |

PART THREE CAPACITY PLANNING AND SCHEDULING

| | |
|--|-----|
| 10. Facilities Decisions | 267 |
| <i>Supplement: Transportation Method</i> | 298 |
| 11. Aggregate Planning | 306 |
| <i>Supplement: Linear Programming</i> | 335 |
| 12. Scheduling Operations | 350 |
| 13. Planning and Scheduling Projects | 383 |

| | | |
|------------|---|-----|
| PART FOUR | INVENTORY MANAGEMENT | |
| | 14. Independent-Demand Inventory | 415 |
| | <i>Supplement: Advanced Models</i> | 450 |
| | 15. Materials Requirements Planning | 453 |
| | 16. Just-in-Time Manufacturing | 487 |
| | | |
| PART FIVE | WORK FORCE MANAGEMENT | |
| | 17. Managing the Work Force in Operations | 513 |
| | 18. Job Design | 529 |
| | 19. Work Measurement | 545 |
| | | |
| PART SIX | QUALITY MANAGEMENT AND CONTROL | |
| | 20. Managing Quality | 573 |
| | 21. Quality Control | 601 |
| | | |
| PART SEVEN | INTEGRATION OF OPERATIONS | |
| | 22. International Operations | 635 |
| | 23. Productivity | 662 |
| | | |
| PART EIGHT | CASE STUDIES | |
| | Introduction | |
| | Sheldahl | 689 |
| | FHE, Inc. | 693 |
| | Merriwell Bag Company | 699 |
| | | |
| | Process Design | |
| | Benihana of Tokyo | 701 |
| | Eastern Gear, Inc. | 714 |
| | First City National Bank | 718 |
| | | |
| | Capacity Planning and Scheduling | |
| | Commonwealth Ice Cream Company | 721 |
| | Lawn King, Inc. | 723 |
| | World Industrial Abrasives | 727 |

Inventory Management

| | |
|---|-----|
| Slayton's Furniture Store | 730 |
| Consolidated Electric | 731 |
| Southern Toro Distributor, Inc. | 734 |
| ToysPlus, Inc. | 742 |
| U.S. Stroller. | 747 |

Work Force Management

| | |
|---|-----|
| Southwestern University | 754 |
| Houston State Bank | 757 |
| Minnesota Diversified Industries. | 760 |

Quality Management

| | |
|--|-----|
| General Appliance Company | 763 |
| Bayfield Mud Company | 767 |
| Hank Kolb, Director, Quality Assurance | 769 |

Integration of Operations

| | |
|-----------------------------|-----|
| Donaldson Company | 772 |
|-----------------------------|-----|

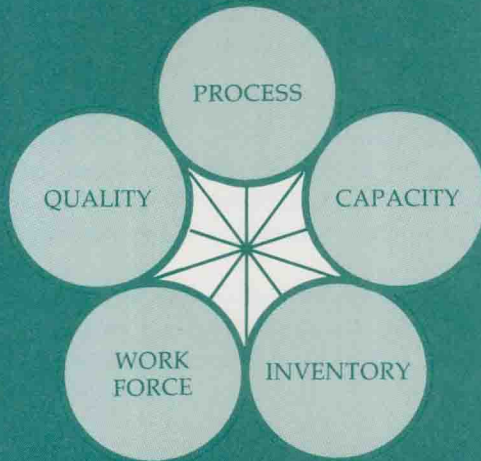
Appendixes

| | |
|--|-----|
| A Areas under the Standard Normal Probability Distribution | 781 |
| B Random Number Table | 782 |
| C Present-Value Factors for Future Single Payments | 783 |
| D Present-Value Factors for Annuities | 784 |

| | |
|------------------------|-----|
| <i>Index</i> | 785 |
|------------------------|-----|

PART ONE

INTRODUCTION



- THE OPERATIONS FUNCTION
- OPERATIONS STRATEGY
- FORECASTING
- PRODUCT DESIGN

The introductory part of this book will provide an overview of the operations management field and a survey of some of the underlying disciplines required for further study. In Chapter 1, a decision-making framework is developed which is the basis for organizing the remainder of the text. This framework identifies five major decision responsibilities of the operations function in all organizations: process, capacity, inventory, work force, and quality. Each subsequent section of the book is devoted to one of these decision types.

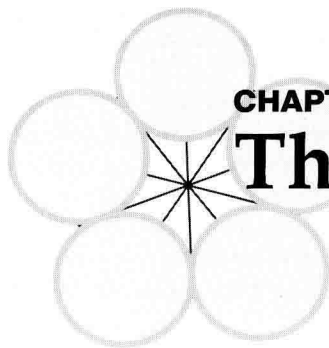
Chapter 2 deals with operations policy and strategy. It is intended to show how the five decision-making areas in operations can be integrated within an overall policy framework and how operations can be guided by a strategic orientation. Operations objectives are defined, tradeoffs among objectives are discussed, and the focused factory concept is presented. It is also

shown how operations strategy can be used to integrate operations with the external environment.

Forecasting, discussed in Chapter 3, is a major input to operations decision making. Chapter 3 describes the types of forecasting methods available and the interaction between forecasting and operations decisions. Some of the important organizational considerations for the use of forecasting in operations are also discussed, along with the requirements for a successful forecasting system.

Another important input for all operations decisions is the design of the product or service, as discussed in Chapter 4. Product design, however, should not precede the design of the productive process; rather, product and process should be designed together. Product design is viewed as interfunctional in nature, requiring close cooperation between the product designers and the operations function.

After studying this section, the reader should be able to define the operations management field, describe operations strategy, and discuss the relationship of forecasting and product design to operations. The reader should also have gained some basic skills related to these subjects. This section will provide background for studying the five major decision responsibilities of operations in the remainder of the text.



CHAPTER 1

The Operations Function

- 1.1 Definition of Operations Management
- 1.2 History of Operations Management
- 1.3 Resurgence of Interest in Operations Management
- 1.4 The Operations Function
- 1.5 Operations as a Productive System
- 1.6 Operations Decisions—A Framework
- 1.7 Decision Framework—Example
- 1.8 Decisions in Operations—Another View
- 1.9 Producers of Services and Goods
- 1.10 Key Points
- Questions
- Selected Bibliography

In the broadest sense, operations management is concerned with the production of goods and services. Everyday we come in contact with an abundant array of goods or services, all of which are produced under the supervision of operations managers.

One example of an operations manager is the plant manager who is in charge of a factory. All other managers who work in the factory—including production and inventory control managers, quality managers, and line supervisors—are also operations managers. Collectively, this group of factory managers is responsible for producing the supply of products in a manufacturing business. Carrying this example one step further, we should also include in the group of operations managers all manufacturing managers at the corporate or divisional level. These managers might include a corporate vice president of operations (or manufacturing) and a group of corporate staff operations managers concerned with quality, production and inventory control, facilities, and equipment.