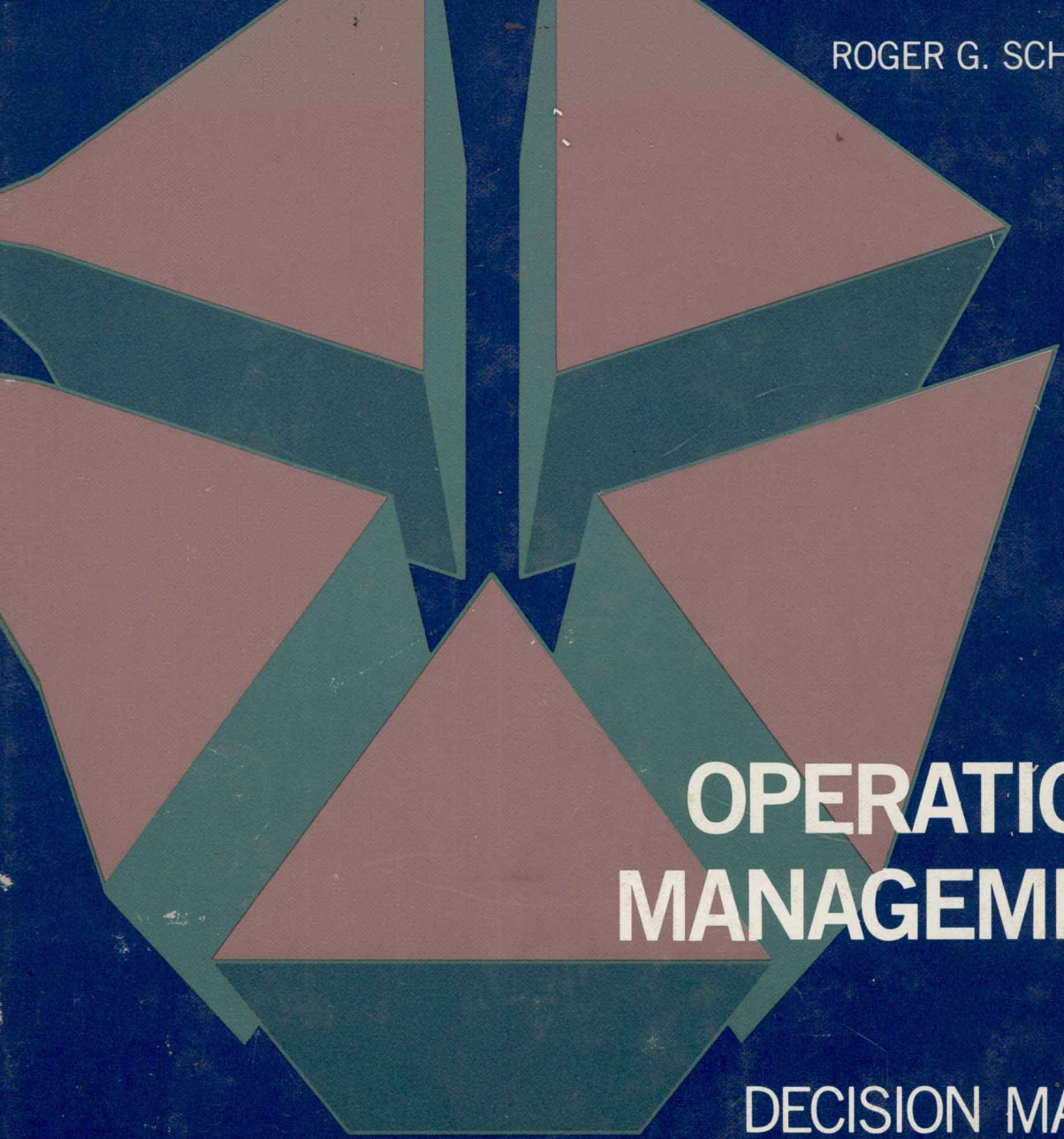
ROGER G. SCHROEDER



# OPERATIONS MANAGEMENT

## DECISION MAKING IN THE OPERATIONS FUNCTION

SECOND EDITION

McGRAW-HILL SERIES IN MANAGEMENT

# OPERATIONS MANAGEMENT

## DECISION MAKING IN THE OPERATIONS FUNCTION

**OPERATIONS MANAGEMENT:**
DECISION MAKING IN THE OPERATIONS FUNCTION



1234567890 VNHVNH 898765

ISBN 0-07-055615-6

This book was set in Century Schoolbook by Black Dot, Inc.
The editors were John R. Meyer and Frances Koblin;
the designer was Charles A. Carson;
the production supervisor was Phil Galea.
New drawings were done by Fine Line Illustrations, Inc.
Von Hoffmann Press, Inc., was printer and binder.

**Library of Congress Cataloging in Publication Data**

Schroeder, Roger G.
Operations management.

(McGraw-Hill series in management)
Includes bibliographies and index.
1. Production management. 2. Decision-making.
I. Title. II. Series.
TS155.S335 1985 658.5'036 84-17115
ISBN 0-07-055615-6

# ABOUT THE AUTHOR

**Roger G. Schroeder** is Director of the Operations Management Center and Professor of Operations Management at the 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. in operations research 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, materials requirements planning systems, and management of service operations. 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 President of the Operations Management Association and Associate Editor of the *Journal of Operations Management.*

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 systems approach to the design of operations systems. 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 the systems approach 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 for the general business student as well as those students who may go on in operations. 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 substan-

tive 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 process selection, choice of technology, productivity, just-in-time, distribution requirements planning, planning quality, and operations strategy.

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.

Before this book was written, a survey was conducted of professors of operations management throughout the United States. The book's design—both in its approach and in its specific content areas—represents much of their input. During the survey, it became apparent that a wide diversity of courses are taught in the operations management field. A modular approach was therefore chosen, so that different courses can stress different parts of the subject matter.

To emphasize the decision-making approach, a typical decision problem is included near the beginning of each chapter. These problems, written in a case format, help to show how decisions are made in an organizational context. They also help to integrate the text and make it more relevant to students.

The second edition has been thoroughly updated. New chapters were added on just-in-time manufacturing and distribution requirements planning. The chapter on strategy was revised and moved to the front of the text to emphasize strategy at the outset. A new section was added on computer integrated manufacturing and the factory of the future. All of the problems and cases were revised so that new answers are required, and many changes were made throughout to clarify points or update references. The objective of the second edition is to maintain the most current and best organized textbook in the operations management field.

Many people have helped to prepare this book. I want to express my appreciation to the following reviewers who read the manuscript thoroughly and helped to refine and improve the material presented: Kevin N. Bott; Rod Carlson, Tennessee Technological University; Joseph R. Carter, Boston University; John Hannon, Towson State University; Michael Hottenstein, Pennsylvania State University; Ronald B. Johnson, Tennessee Technological

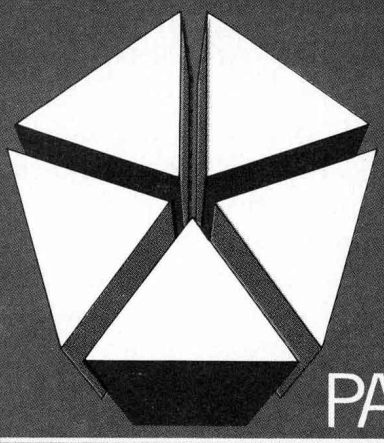
University; Matthew J. Liberatore, Villanova University; James Rice, University of Wisconsin, Oshkosh; Brooke Saladin, Wake Forest University; and Herbert L. Schuette, Duke University.

I want to acknowledge the contributions of my colleagues on the faculty at the University of Minnesota. There were also many students at the University of Minnesota who commented on the text, particularly students from my introductory operations management classes. Students who assisted in preparation of the manuscript and the Instructor's Manual were Jeff Alch and Adam Parten.

Finally, I wish to thank my family for their patience and perseverance during the many years of text development and editing. I would also like to thank the secretaries who typed various portions of the manuscript: Deb Brashear and Pat Brager. To all these individuals I express my appreciation for their contributions and assistance.

Roger G. Schroeder

# CONTENTS



# PART ONE
# INTRODUCTION

THE OPERATIONS FUNCTION•
OPERATIONS STRATEGY•
PRODUCT DESIGN FOR GOODS AND SERVICES•
FORECASTING•

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.

An important input for all operations decisions is the design of the product or service, as discussed in Chapter 3. 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.

Forecasting, discussed in Chapter 4, is another major input to operations decision making. Chapter 4 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.

After studying this section, the reader should be able to define the operations management field, describe operations strategy, and discuss the relationship of product design and forecasting to operations. The reader should also have gained some basic skills related to forecasting and product decisions. 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



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.

But operations managers are not employed only in manufacturing companies; they work in service industries as well. In the government, for example, there are operations managers in the post office, welfare department, and housing department, to name only a few. In private service industries, operations

managers are employed in hotels, restaurants, airlines, and retail stores. In each of these organizations, operations managers—much like their counterparts in manufacturing who produce the supply of goods—are responsible for providing the supply of services.

On the surface, it may appear that service operations have very little in common with manufacturing operations. However, a unifying feature of these operations is that both can be viewed as transformation processes. In manufacturing, inputs of raw materials, energy, labor, and capital are transformed into finished goods. In service operations, these same types of inputs are transformed into service outputs. Managing the transformation process in an efficient and effective manner is the task of the operations manager in any type of organization.

There has been a tremendous shift in our economy from the production of goods to the production of services. It comes as a surprise to many people that today more than 70 percent of the American work force is employed in service industries.[1] We have already shifted from a manufacturing-based economy to a service-based economy. Because of the importance of both service and manufacturing operations, they will be treated on an equal basis in this text.

For many years, when the field was related primarily to manufacturing operations, operations management was called "production management." Later, the name was expanded to "production and operations management" or, more simply, "operations management" to include the service industries as well. The term "operations management" as used in this text refers to both manufacturing and service industries.

## 1.1 DEFINITION OF OPERATIONS MANAGEMENT

The above ideas can be summarized by the following definition:

**Operations managers are responsible for producing the supply of goods or services in organizations. Operations managers make decisions regarding operations functions and the transformation systems used. Operations management is the study of decision making in the operations function.**

There are three points in this definition which deserve emphasis:

**1. Function.** As we have indicated, operations managers are responsible for managing those departments or functions in organizations that produce goods and services. These departments, however, often have different names in different industries. In manufacturing companies, the operations function may be called the manufacturing, production, or operations department. In service organizations, the operations function might be called the operations department, or it may be given some other name peculiar to the particular industry. In general, the generic term "operations" is used to refer to the function which

[1]U.S. Bureau of the Census, *Statistical Abstract of the United States,* Washington, D.C., 1984, p. 421.

**BOX 1.1**
**TYPICAL DECISION PROBLEM**

In reviewing earnings reports for the fourth quarter of 1984, Linda Farwell, president of American Car Rental Company, noticed that profits were down once again. This was the third successive quarter in which profits had dropped, and Linda decided that she must act. She picked up her phone and called the vice president of operations, Tom Storch. After briefly explaining the situation, she asked Storch to meet with her later in the day to go over the recent figures. During the meeting, Linda observed that the primary cause of poor profits could be found in the operations department. Car inventories were up, and the unit cost of rental operations had increased over the past year. About the only bright spot in operations was that the quality of service had not deteriorated over time. She also noted that union relations had been getting progressively worse over the past few months.

Storch replied that costs could be cut and car inventories reduced, but not without adverse effects on customer service, quality, and union relations. Storch argued that reduced inventories would offer less model variety for the customer, and some customers would not get the car they wanted at the time and place of their choice. Rental costs could be reduced by layoffs of personnel, but this might aggravate the already deteriorating union situation. Storch suggested, with tongue in cheek, that the problem could be solved by more aggressive marketing, since sales had dropped along with profits. Storch added, "I am sorry, but there is no such thing as a free lunch. If costs are to be reduced, something else must give. We simply have too much capacity for the present level of sales."

At this point, Storch suddenly realized that the problem went deeper than simply cutting back present operations to improve profits. To prevent this situation from occurring again in the future, he must do a better job of planning, decision making, and managing within the operations function. This could be done by identifying the critical decisions in operations and assuring that these decisions were made in a timely manner with the best information available by professional operations managers. Storch, therefore, set out to develop a system of decision making in operations to ensure that the operations department would consistently meet its cost, quality, and customer-service objectives. He also agreed with the president that drastic actions would have to be taken now to cut costs, despite possible adverse effects. Storch vowed that this situation would not arise again in the future.

produces goods or services in any organization. Treating operations management in this manner, as an organizational function, puts it on a similar footing with other business functions such as marketing and finance.

**2. System.** The above definition refers to transformation systems which produce goods and services. The systems view provides not only a common ground for defining service and manufacturing operations as transformation systems but also a powerful basis for design and analysis of operations. Using the systems view, we consider operations managers as managers of the conversion process in the firm.

The systems view of operations also provides insights for the design and management of productive systems in functional areas outside the operations function. For example, a sales office within a marketing function may be viewed as a productive system with inputs, transformation, and outputs. The same is true for an accounts payable office and for keypunch operations within a data processing center. In terms of the systems view, operations management concepts have applicability beyond the functional area of operations.

**3. Decisions.** Finally, the above definition refers to decision making as an important element of operations management. Since all managers make decisions, it is natural to focus on decision making as a central theme in operations. This decision focus provides a basis for dividing operations into parts based on major decision types. In this text, we identify the five major decision responsibilities of operations management as process, capacity, inventory, work force, and quality. These decisions provide the framework for organizing the text and describing what operations managers do. See Box 1.1 for a typical decision problem faced by an operations manager.

Since the operations management field can be defined by function, systems, and decisions, we will expand on these three elements in detail in this chapter. Before doing so, however, a brief historical survey of operations management is given.

## 1.2 HISTORY OF OPERATIONS MANAGEMENT

Operations management has existed for as long as people have produced goods and services. Although the origins of operations can be traced to early civilizations, most of our attention in this section will be focused on the last two hundred years.

In the following discussion, the recent history of operations management is organized according to major contributions or thrusts rather than in strict chronological terms. On this basis, there are seven major areas of contribution to the operations management field.

**Division of Labor.** The division of labor is based on a very simple concept. Specialization of labor to a single task can result in greater productivity and efficiency than the assignment of many tasks to a single worker. This concept was recognized in 400 B.C. by Plato in *The Republic* when he said, "A man whose work is confined to such a limited task [e.g., shoe stitching] must necessarily excel at it." [See George (1968).] The ancient Greeks also recognized the concept of the division of labor when they assigned some workers to do nothing but sharpen stone chisels.

The first economist to discuss the division of labor was Adam Smith, author of the classic *Wealth of Nations* (1776). Smith noted that specialization of labor increases output because of three factors: (1) increased dexterity on the part of workers, (2) avoidance of lost time due to changing jobs, and (3) the addition of tools and machines. Later, in 1832, Charles Babbage expanded on these ideas with his study of pin manufacturing. [See Babbage (1832).] He noted that specialization of labor not only increases productivity but also makes it possible to pay wages for only the specific skills required. Although division of labor has been widely applied, it is now being reevaluated because of its effect on worker morale, turnover, job boredom, and job performance. We shall discuss this issue at length later.

**Standardization of Parts.** Parts are standardized so that they can be interchanged. According to Chase and Aquilano, standardization was prac-

ticed in early Venice, where rudders on warships were made to be interchangeable. [See Chase and Aquilano (1977), p. 5.] This provided a great advantage when rudders were damaged in battle. Eli Whitney used interchangeable parts in musket production. Prior to his time, musket parts and even ammunition were tailored to each individual musket. When Henry Ford introduced the moving automobile assembly line in 1913, his concept required standardized parts as well as specialization of labor. The idea of standardized parts is by now so ingrained in our society that we rarely stop to think of it. For example, it is difficult to imagine light bulbs which are not interchangeable.

INDUSTRIAL REVOLUTION. The industrial revolution was in essence the substitution of machine power for human power. Great impetus was given to this revolution in 1764 by James Watt's steam engine, which was a major source of mobile machine power for agriculture and factories. The industrial revolution was further accelerated in the late 1800s with the development of the gasoline engine and electricity. Early in this century, mass-production concepts were developed but they did not gain widespread use until World War I, when heavy demands for production were placed on American industry. The age of mass marketing has continued this pressure for automation and high-volume production. However, our society has now entered a postindustrial period, characterized by a shift to a service economy and greater concern for the natural and social environment.

SCIENTIFIC STUDY OF WORK. The scientific study of work is based on the notion that the scientific method can be used to study work as well as physical and natural systems. This school of thought aims to discover the best method of work by using the following scientific approach: (1) observation of the present work methods, (2) development of an improved method through scientific measurement and analysis, (3) training the workers in the new method, and (4) continuing feedback and management of the work process. These ideas were first advanced by Frederick Taylor in 1911 and later refined by Frank and Lillian Gilbreth throughout the early 1900s. [See Taylor (1911).] The scientific study of work has come under attack by labor unions, workers, and academics. In some cases, these attacks have been justified because the approach was misapplied or used as a "speedup" campaign by management. Nevertheless, the principles of scientific management can still be applied in today's world by recognizing the interaction between the social and technical work environments.

HUMAN RELATIONS. The human relations movement highlighted the central importance of motivation and the human element in work design. Elton Mayo and others developed this line of thought in the 1930s at Western Electric, where the now famous Hawthorne studies were conducted. [See Wren (1972).] These studies indicated that worker motivation—along with the physical and technical work environment—is a crucial element in improving productivity. This led to a moderation of the scientific management school, which had emphasized the more technical aspects of work design. The human relations school of thinking has also led to job enrichment, now recognized as a method