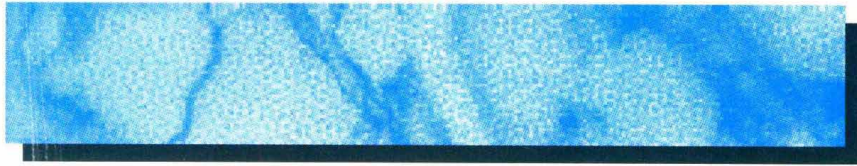


PRODUCTION AND OPERATIONS MANAGEMENT

AN APPLIED MODERN APPROACH



JOSEPH S.
MARTINICH



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University of Missouri-St. Louis



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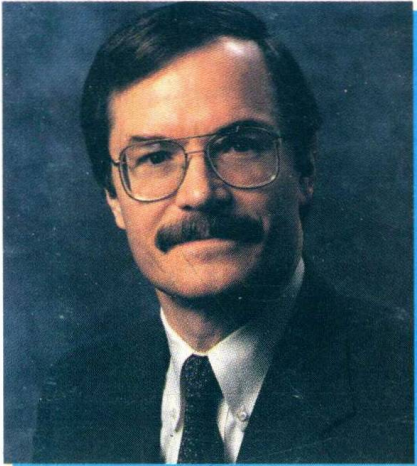
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ABOUT THE AUTHOR

To Vicki: My wife and pipeline to computer technology



Joseph S. Martinich is Professor of Operations Management at the University of Missouri-St. Louis. He holds a B.S. degree in Industrial Engineering from Northwestern University; an M.A. in Economics from Cali-

ifornia State University-Fullerton; and a Ph.D. in Industrial Engineering and Management Sciences from Northwestern University. He has worked and/or consulted for companies in the steel, oil and chemical, paperboard and packaging, retail, business services, and publishing industries, as well as for governmental and not-for-profit organizations. He has held visiting and adjunct faculty positions at the John M. Olin School of Business Administration of Washington University (St.

Louis), the Engineering Management Department of the University of Missouri-Rolla, and the Industrial Engineering Department of California State Polytechnic University-Pomona.

Dr. Martinich is the co-author (with Arthur P. Hurter) of the book *Facility Location and the Theory of Production* (Kluwer Academic), and he is the author of nearly 20 scholarly articles and reviews. His work has appeared in leading journals, such as *Decision Sciences*, *European Journal of Operational Research*, *Naval Research Logistics*, *American Economic Review*, *Journal of Regional Science*, and *Technological Forecasting and Social Change*. His early research focused on the interrelationship between production technology, process selection, and facility location decisions, and the effects of uncertainty and government intervention on these decisions. His current research includes the environmental aspects of operations management, and the application of Lean Production methods to service systems, not-for-profit organizations, and small businesses.

No one undertakes a five-year writing project without compelling personal reasons. In my case I had taught production and operations management for 12 years to over a thousand students, 98% of whom were not operations management majors but rather were majoring in accounting, marketing, finance, MIS, and several other fields. Few students had any idea what operations management was, and their quantitative skills were quite varied, with many of them exhibiting severe math anxiety. These factors presented several special challenges in teaching this course: how to demonstrate the relevance of operations management to this wide variety of non-majors; how to teach the thought processes and analytical reasoning required in operations management in a mathematically accessible and interesting way that reduces math anxiety; how to eliminate artificial separations between quantitative and qualitative/behavioral material; and how to make the discussion and examples realistic, and familiarize students with the richness and importance of operations, without overwhelming them.

Over the years, I prepared in-class notes, transparencies, and exercises that addressed these issues in the course, but I found no textbook that adequately assisted the students (and me) in doing so. Many students encouraged me to turn my notes into a book because they found them more readable and interesting than the text. Little did I know that this “conversion” of notes would take five years of my life, but I believe the result has been a book that will help instructors teach, and students learn, about the extent, substance, and excitement of operations management.

GOALS AND CORRESPONDING FEATURES

In writing this book I had the following goals:

1. **To demonstrate the importance of operations management to non-majors.** Anyone seeking a supervisory or managerial career in marketing,

accounting, finance, engineering, MIS, medicine, law, and most other professions, will find that a large part of their jobs will be devoted to operational issues.

- Opening each chapter is an **On the Job** box, which briefly describes the featured person's operations management activities. Many of the people profiled work outside the operations function of their companies; they include accounting managers, financial officers, customer service and sales personnel, purchasing managers, engineers, and entrepreneurs. Few had extensive formal training in operations management, but most have found that their formal exposure to operations management, though limited, has been invaluable.
 - **Over 200 companies** are used to illustrate the applicability and importance of operations management to a wide variety of organizations, as well as a variety of jobs.
 - Each chapter contains an **In Good Company** box, which describes how the profiled organization has addressed the operations management issues in that chapter to improve its performance.
2. **To familiarize students with real production systems.** Although many of my students hold part- or full-time jobs, most of them are familiar with very few production systems and frequently with only a small part of their own companies, such as the accounts receivable department. Accountants, sales representatives, and computer systems analysts who understand the general nature and activities of production systems are better able to work with and communicate with customers, suppliers, and co-workers and be more effective in their jobs.
 - **Chapter 3**, therefore, provides **tours of four production systems**. These tours, which include both manufacturing and service operations, describe the main activities involved in producing the compa-

nies' products, whether it be a roll of liner-board or a title insurance policy. More importantly, the chapter identifies operational problems and issues important to the success of the company. These discussions preview and motivate the topics to be covered in the remainder of the book.

- The end-of-chapter **Cases** and some in-text **examples** have also been designed to provide descriptions of real production systems or parts of systems.
3. **To make the topics realistic and applicable.** Because of their work experiences, students want to see how the topic applies to their jobs. They have also encountered the ambiguities, "messiness," and unanticipated consequences of real situations, so they will not accept tools that work only in idealized worlds.
- I have used real examples extensively to show how companies and workers are confronting P/OM issues and problems. Over 100 photos make the people, companies, and situations more tangible.
 - Many of the illustrative examples are a bit longer and "messier" than the "toy" problems commonly used in texts. Typically, a single example will grow in complexity and realism as the discussion progresses and additional factors are introduced. For example, Chapter 7 first presents the rationale, thought-process, and mechanics of a standard heuristic for designing a single repetitive flow process (assembly line). Unlike many P/OM texts, however, this chapter then discusses methods for improving the design, including switching heuristics and nonquantitative considerations involving staffing, technology, and task synergies. More advanced topics, such as the use of parallel work-stations, parallel production lines, and the effects of randomness and variation on the production system, are presented for instructors who wish to cover the topic in greater depth. Without being smothered in mathematical calculations, students can see the complexity of operational problems and possible approaches to resolving them and become familiar with available tools.
 - The end-of-chapter **Cases** provide detailed and realistic examples of how quan-

titative and qualitative aspects of P/OM must be integrated to solve real problems and bring together the topics of the chapter and related chapters. With two exceptions (Walt Disney World and Southwest Airlines), the companies used are fictitious, but the problems underlying most of the cases are a synthesis of actual situations from my experiences and those of colleagues or from written reports. The cases are quite different from those in other books in that they tell a story of the problem and how it was solved. They demonstrate the problems that occur in implementation; the unexpected events that can occur; and how behavioral and quantitative tools can be combined to obtain better solutions than either one alone can achieve. Although the cases are not designed for "solution," discussion questions are provided with each one.

4. **To provide a state-of-the art treatment of topics.** In the past 20 years, businesses have radically changed the way they design and produce goods and services; they have redesigned jobs and work systems, quality management systems, and material management and inventory systems, and they have changed the technologies they use at a dizzying pace. Terms such as *lean production*, *just-in-time production*, *electronic data interchange*, *total quality management*, *concurrent engineering*, and *cellular production* have entered the vernacular of the business press.
- These approaches and methodologies are not simply tacked onto this book as a separate "new methods" section resembling a glossary. They are discussed extensively throughout the book in an integrated fashion. For example, not only is Chapter 11 devoted entirely to *quality management*, total quality management principles and techniques are woven into the chapters on operations strategy, product design, process design, job design, and lean production.
 - Entire chapters or substantial sections, not just brief abstracts, are devoted to topics such as *lean and just-in-time production*, *cellular production*, and *vendor relations*.
 - Attention to the *ecological implications* of operations decisions has been increasing, and not

simply because of environmental regulations. Several chapters contain sections that point out, and illustrate with real examples, the opportunities that exist for companies to increase profits by designing products and production processes and managing operations in an environmentally sound manner.

5. To emphasize the strategic role of operations in organizations.

The major changes occurring in business have involved fundamental changes in strategy. Companies such as Hewlett-Packard, Southwest Airlines, Walt Disney, Wal-Mart, Toyota, and Chrysler have become successful not simply because they have marketed their products well, but because they have developed production systems that allow them to excel in various ways: introducing new products more quickly, producing products of higher quality or at lower cost than competitors, or being more responsive and flexible in the timeliness of delivery and variety of products produced.

- Chapter 2, therefore, provides an extensive discussion of the *role of operations in the development and execution of an organization's strategy*. The need for compatibility between the marketing strategy, such as one based on providing customized products, and the operations strategy and production system is emphasized. Numerous real-world examples and numerical illustrations are used to show how companies can, and have, exploited operational strengths.
- Subsequent chapters dealing with *system design issues* reinforce and expand the discussion of operations strategy, such as how capacity and facility location decisions can be used to enhance competitive position.

6. To make the quantitative models and tools accessible.

The proliferation of computers and model-based software has made the use of quantitative models and methods in operations management *more* wide-spread and important rather than less so. However, the form and level of knowledge students need regarding quantitative methods has changed. Every student needs to develop the ability to analyze a situation or problem, identify what information is known, structure the problem, identify what is to be determined, and select a method for finding the solution.

- When presenting quantitative material I have tried to focus on the thought-process of how to approach various types of problems, and *when* and *why* the approach presented is appropriate in practice.
- To a large extent, I have avoided presenting quantitative material in a fashion where assumptions and formulas are stated, followed by a “toy” numerical example where the student simply substitutes numbers for variables. Because my illustrative examples explain *the rationale of the approach and the reasons* for each step, the mathematical steps are more intuitive, less magical, and more likely to be comprehended and retained by students.
- **Solved Problems** are provided at the end of all chapters that contain quantitative material. The solutions for these problems are explained in detail, providing further reinforcement and practice for students.

ORGANIZATION OF THE BOOK

The general organization of the book is consistent with most P/OM courses. It begins with *general background information* on operations management, strategy, and production processes. It then discusses issues related to the *design* of production systems. The final part focuses on shorter-term operations *planning* and *control* decisions. Three features of the organization of the book should also assist instruction.

Topics are integrated and reinforced. Topics such as quality management and lean production permeate so many aspects of operations that it is artificial to segment totally their coverage from other operations management topics. For example, mistake-proofing of jobs (*poka yoke*) is a common tool used in quality management, but not to include it in the job design chapter would be to omit an important job design principle. For this reason, many popular topics are covered in more than one place in the book. Typically, one chapter will provide detailed discussion of the topic, but it will be discussed within other relevant chapters as well. This approach allows instructors to omit chapters from the course and still be able to cover desired topics.

Quantitative and qualitative topics are integrated.

To perform good operational planning and to solve operational problems, a manager must utilize a wide set of skills and knowledge. A theme of this book is that quantitative methods are *tools* to be used as part of the decision-making process, not an end in themselves. Too often operations management topics and problems are divided into mutually exclusive categories—quantitative or qualitative—where one and only one approach is presented. I have organized the book by general topics or problems and have included whatever knowledge or skills are helpful or appropriate. For example, Chapter 9 not only presents mathematical models of queueing systems, it also considers “qualitative” issues, such as the relative advantages of single waiting lines and express servers, the psychology of waiting, and selection of appropriate performance measures.

The book is flexible and usable by a wide audience.

Material in this book has been used at four universities in both undergraduate and graduate business courses and in a senior level engineering management course with success. The topics covered in introductory P/OM courses vary considerably from school to school and instructor to instructor. Therefore, this book contains all the standard P/OM topics, from which an instructor can customize his or her course. Further, almost all chapters are sufficiently self-contained so any set of chapters can be combined for a course.

Instructors should find this text very flexible with respect to the degree of mathematical content desired in the course. By choosing to include or omit individual chapter sections, **Chapter Supplements**, or **Tutorials**, instructors can use this book for courses ranging from those with quite modest to very substantial mathematical emphasis. The core of the book only assumes students have prerequisite knowledge of college algebra and basic probability and statistics. For those schools that wish to introduce management science tools, such as linear programming or simulation, as part of the P/OM course, three **Tutorials** provide in-depth introductions with special focus on how these tools can be used for operations management. At those schools where students have more advanced mathematical preparation, such as a prerequisite management science course, the tutorials can either be omitted or sections of them can be used to illustrate the application of these tools to P/OM topics.



OTHER FEATURES

In addition to the features mentioned earlier—**On the Job** and **In Good Company** profiles, **End-of-Chapter Cases**, **Plant Tours**, and **Solved Problems**—the book contains several other features that support the learning process:

- **Chapter Summaries.** The most important issues discussed in the chapter are presented in one- or two-sentence statements at the end of each chapter. These reinforce key ideas and provide a quick reference for the main ideas.
- **Highlighted Formulas and Key Formulas Section.** The most important and frequently needed formulas and equations are highlighted with color in the body of the chapter. They are then printed together at the end of the chapter for easy reference when students are solving numerical problems.
- **Highlighted Key Terms and Key Terms Section.** Key terms are highlighted in bold where they are first defined and then are listed at the end of each chapter with the page number cited where their definition was given.
- **End-of-Chapter Problems.** The book contains approximately 250 end-of-chapter problems. I have intentionally tried to provide a set of problems with a wide range of difficulty from the very direct and simple to relatively complex mini-cases requiring considerable analysis and possibly the use of computer software. (The most difficult ones are designated by an asterisk *.) To a large extent, the problems have been constructed in pairs; problems 1 and 2 address the same topic, and so on. In general, even-numbered problems will only use data from other even-numbered problems and similarly for odd-numbered problems. The answers to almost all odd-numbered problems are given at the end of the book.
- **Discussion and Review Questions.** Over 270 questions are provided at the end of the chapters. These not only help students review the important topics, but many require students to relate the topics to their own experiences and to draw upon several topics together to answer the questions.

SUPPLEMENTARY MATERIALS

Instructor's Guide. The Instructor's Guide was written by the author to make sure it was compatible with the themes and style of the text. For each chapter, the Guide contains: (1) a list of learning objectives, (2) possible in-class exercises to motivate or illustrate the chapter topic, (3) suggested examples or additional comments instructors can use to illustrate topics, (4) solutions to all end-of-chapter problems, (5) answers to review and discussion questions where there is a dominant answer (for many questions, especially those requiring students to use their own experiences no single answer exists), and (6) possible answers to the case questions.

PowerPoint Presentation. These PowerPoint lecture slides contain a combination of key concepts, images, and examples from the text. Developed by Lance Matheson of Virginia Tech, the slides are divided into a thorough presentation file for each chapter, and consist of over 600 instructional images. Designed according to the organization of the material in the text, this series of electronic transparencies can be used for classroom presentation to reinforce P/OM concepts visually and graphically.

Computer Software. Software developed by Y. Chang (developer of QSOM™ Prentice Hall) is available with the book. However, the book is designed so it can be used with any of the standard operations management or management science packages.

Test Bank. Including objective questions and problems, as well as short-answer and essay questions, the Test Bank has been designed to meet the varying testing needs of instructors.

Computerized Test Bank. The entire Test Bank is also available in a computerized form, allowing instructors to create and modify exams. It is available in a Windows format for IBM and IBM compatibles.

Video Tapes. The Wiley/Nightly Business Report Video contains segments from the highly respected Nightly Business Report that have been selected for their applicability to P/OM concepts, their discus-

sion of various companies and industries, and for their reinforcement of key concepts in the text. Each segment is approximately 3-5 minutes long and can be used to introduce topics to students and provide a real-world context for related concepts. Additionally, a selection of plant tour videos are available, related to companies and industries in the text.

Software Animated Simulations. This selection of software simulations of key concepts from the text are designed for use in classroom presentation. The simulations, including queuing and JIT scheduling, allow instructors to demonstrate the effects of key parameters.

Supplement CD-ROM. This CD-ROM contains all of the supplements for this text (excluding video) in computerized form, allowing instructors to print, edit, and project the material as needed. Instructors may print out any of the material for their own use or for distribution to students. Also included on the CD-ROM are the Software Animated Simulations, the PowerPoint Presentations, and the text illustrations. Available for IBM or IBM compatibles.

ACKNOWLEDGMENTS

This book is the result of hard work by many people. First, I would like to thank the hundreds of students who used parts of this book in class and provided helpful feedback. I would especially like to thank Carolyn Weigel Schriefer, my research assistant for this book. I am also grateful to Professor L. S. Hiraoka's P/OM students at Kean College of New Jersey, who told us what pedagogical elements were most useful to them as they studied and who evaluated the proposed design of the text. Second, I would like to thank the following faculty reviewers who reviewed various drafts very conscientiously and provided superb comments to improve the style and content of the text.

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STUDENT TO STUDENT



Hello!

I am a business student with an emphasis in accounting, and I hope to get a job as a staff accountant in a large firm. I took a required production/operations management course. I was pleasantly surprised at how interesting and exciting this course was. I had expected a rather dry description of production systems but soon realized that operations management is about how all types of companies can effectively manage and improve the way they conduct their business. This course has introduced me to the management tools that can help me become more organized and efficient in my duties as a staff accountant.

If you are like me, you've probably never seen the inside of a manufacturing plant. You will find the plant tours in Chapter 3 very helpful in describing the components of a production system as well as introducing the issues and problems that are relevant to operations management. In each chapter, Dr. Martinich gives you many examples of how actual service and manufacturing companies deal with the basic operations topics of process design, queueing, and scheduling. For instance, the "In Good Company" box describes how a company has applied the concepts discussed in the chapter to solve its specific problems and improve its performance.

This course can be difficult because much of the material is quantitative in nature. Dr. Martinich explains the reasons behind the quantitative models and makes the necessary math more intuitive and easier to understand. Further, to illustrate how real problems are solved, Dr. Martinich combines the quantitative solutions with the qualitative factors that are important to operations. The interplay between quantitative and qualitative factors is presented in the fun and interesting cases at the end of each chapter.

Recently, you have probably read many newspaper and business magazine articles on lean and just-in-time production, electronic data interchange, total quality management, and environmentally responsible companies. This text will give you more background in these and many other current topics as it describes how businesses are using this information to remain competitive. The "On the Job" boxes demonstrate how today's POM professionals and those in various other professions are using the principles of operations management on a daily basis to solve problems and improve the quality of their work.

Good luck, and I hope you enjoy this course as much as I did!

Carolyn Weigel Schriefer

University of Missouri–St. Louis

PART 1

AN INTRODUCTION TO OPERATIONS AND STRATEGY

<p>CHAPTER 1 PRODUCTION SYSTEMS AND OPERATIONS MANAGEMENT 5</p> <hr style="border: 0.5px solid #C00000; margin-top: 5px;"/> <p><i>1.1</i> P/OM'S VALUE TO YOU 6 <i>On the Job:</i> Carol R. Caruthers, Price Waterhouse LLP 6</p> <p><i>1.2</i> PRODUCTION SYSTEMS AND THE FUNCTIONAL UNITS OF ORGANIZATIONS 7 Production of Goods and Services 7 Functional Units of the Organization 9</p> <p><i>1.3</i> WHAT IS OPERATIONS MANAGEMENT? 10 Operations as a Strategic Weapon: Reaching the Goals 11 <i>In Good Company:</i> Quality Drives the Gap 12 Responsibilities and Challenges Facing Operations Managers 13 Skills and Knowledge Needed to Be a Successful Operations Manager 16</p> <p><i>1.4</i> THE HISTORY OF OPERATIONS MANAGEMENT 18 The Industrial Revolution 18 Scientific Management 20 The Human Relations Movement 23 Operations Research/Management Science (OR/MS) 24 Computers in Operations Management 24 The Japanese Production System 25 Operations Management Today 27</p> <p><i>1.5</i> OPERATIONS MANAGEMENT, PRODUCTIVITY, AND COMPETITIVENESS 28</p>	<p><i>1.6</i> OPERATIONS MANAGEMENT IS FOR EVERYONE 29</p> <hr style="border: 0.5px solid #C00000; margin-top: 10px;"/> <p>CHAPTER 2 OPERATIONS STRATEGY 34</p> <hr style="border: 0.5px solid #C00000; margin-top: 5px;"/> <p><i>2.1</i> STEERING THE SHIP 35 <i>On the Job:</i> Bob Anastasi, CTI-Cryogenics 35</p> <p><i>2.2</i> THE ORGANIZATION'S STRATEGY 36 Goals 36 Market and Competitive Analysis 37 Selecting Products, Markets, and Order-Winning Dimensions 37 Philosophy and Policies 38 The Business Unit Strategy 38</p> <p><i>2.3</i> OPERATIONS AS A COMPETITIVE WEAPON 38</p> <p><i>2.4</i> DEVELOPING AN OPERATIONS STRATEGY 40</p> <p><i>2.5</i> OPERATIONALIZING GOALS AND MEASURING PERFORMANCE 41 Measuring Productivity 42 Cost Measures and Accounting Practices 44 Goal-Based Measures of Performance 45</p> <p><i>2.6</i> GUIDING OPERATIONS DECISIONS: OPERATIONS SUBSTRATEGIES 47 Technology Strategy: Capabilities and Expertise 47 Capacity Strategy 49 Facility Location Strategy 51 Process Strategy 53 Quality Strategy 56 Human Resources Strategy 56 Information in Operations Strategy 57</p>
---	--

2.7	PRODUCTION COST STRUCTURE AND THE OPERATIONS AND MARKETING STRATEGIES	58	3.3	STANDARD REGISTER COMPANY: PRODUCTION OF BUSINESS FORMS	79
	Leverage and Capacity Utilization	58		Order Receipt and Production Scheduling	81
	Using Experience Effects and Economies of Scale Strategically	60		Printing	82
	<i>In Good Company: Hewlett-Packard's Strategy Takes Aim at Its Competitors</i>	63		Collating and Finishing	83
2.8	REVISING AND UPDATING THE OPERATIONS STRATEGY	63		Packing and Shipping	84
	<i>Walt Disney World, Orlando, Florida: An Operations Strategy Case</i>	68		Major Operational Issues	84
CHAPTER 3	TOURS OF OPERATIONS	71	3.4	UNITED PARCEL SERVICE (UPS): LOCAL, NATIONAL, AND WORLDWIDE DELIVERY	87
3.1	ONE SIZE DOES NOT FIT ALL	72		The Delivery Network and a Typical Delivery Cycle	87
3.2	JEFFERSON SMURFIT CORPORATION: PAPERBOARD MANUFACTURING	72		The Facility	89
	Products	73		Sorting	89
	Pulp Preparation	74		Loading	90
	The Fourdrinier Machine	75		Major Operational Issues	90
	Winding, Cutting, and Shipping	76	3.5	APPROVED STATEWIDE TITLE AGENCY: PROCESSING TITLE INSURANCE	91
	Major Operational Issues	76		Customers and Products	92
				The Production Process	93
				Major Operational Issues	94

PART 2

DESIGNING PRODUCTION SYSTEMS 98

CHAPTER 4	FORECASTING	101		When to Use Qualitative Methods	107
4.1	GOOD DECISIONS BEGIN WITH GOOD FORECASTS	102		How to Improve Qualitative Forecasting	107
	<i>On the Job: Jayne Rosselli, Garden Valley Ranch</i>	102	4.4	QUANTITATIVE FORECASTING METHODS	110
	What Is Forecasting?	102		Background and Strategy of Quantitative Forecasting	110
	Importance of Demand Forecasting	103		Steps in Modeling	111
	<i>In Good Company: CompaQ Bets on Forecasts—and Wins Big</i>	104		Time Series and Causal Models	113
4.2	FORECASTING METHODS	105	4.5	CONSTANT PROCESSES AND THE CUMULATIVE AVERAGE	115
	The Role of Time	105			
	Quantitative versus Qualitative Methods	106	4.6	QUASI-CONSTANT PROCESSES	117
4.3	QUALITATIVE FORECASTING METHODS	106		Simple Moving Average	118
				Weighted Moving Average	119
				Simple Exponential Smoothing	120

4.7	COMPARING ALTERNATIVE MODELS	122			Steps in Problem Formulation	173
	Verifying Model Assumptions	122			Feed Mix or Diet Problem	173
	Evaluating Forecast Accuracy	123			Blending Problem	175
					Multiperiod Planning	177
4.8	LINEAR TREND PROCESSES	126				
	Linear Regression for Trend Processes	127				
	Moving Linear Regression	129				
	Double Exponential Smoothing	130				
4.9	SEASONAL PROCESSES	132				
	Constant or Quasi-Constant Processes with Seasonality	133				
	Linear Trend Processes with Seasonality	137				
4.10	CAUSAL MODELS	141				
	Selecting an Independent Variable	141				
	Estimating the Relationship and Forecasting	142				
	Practical Hints for Using Causal Models	144				
4.11	ADVANCED MODELS	144				
4.12	IMPLEMENTATION AND USE OF FORECASTING SYSTEMS	145				
	Model Evaluation and Testing	145				
	Combining Forecasting Methods	145				
	Monitoring Forecasts: Tracking Signals and Adaptive Models	146				
	Buildup and Breakdown Models	148				
	<i>Reynolds and Hill College: A Forecasting Case</i>	162				
TUTORIAL 1	OPTIMIZATION MODELS, LINEAR PROGRAMMING, AND HEURISTICS	166				
T1.1	MATHEMATICAL MODELS AND OPERATIONS DECISION MAKING	167				
T1.2	CONSTRAINED OPTIMIZATION MODELS	167				
T1.3	ADVANTAGES AND PITFALLS OF USING OPTIMIZATION MODELS	170				
T1.4	CHARACTERISTICS AND ASSUMPTIONS OF LINEAR PROGRAMMING MODELS	172				
T1.5	FORMULATING LINEAR PROGRAMS	173				
T1.6	THE GEOMETRY OF LINEAR PROGRAMS					179
	Graphical Solution	180				
	Multiple Optima, Infeasible Problems, and Unbounded Problems	182				
T1.7	THE SIMPLEX ALGORITHM					182
	Preparing the Problem for Solution	183				
	The Algebraic Foundations of the Algorithm	184				
	The Initial Simplex Tableau	185				
	The Simplex Pivot and the Second Tableau	186				
	The Third Tableau	187				
	The Fourth Tableau	187				
	General Comments About the Algorithm	188				
T1.8	USING ARTIFICIAL VARIABLES					188
	The Big-M Method	189				
	The Two-Phase Method	190				
T1.9	INFEASIBLE PROBLEMS, MULTIPLE OPTIMA, UNBOUNDEDNESS, AND DEGENERACY					191
T1.10	COMPUTER SOLUTION OF LINEAR PROGRAMS					191
	Problem Input	191				
	Computer Output	191				
	Sensitivity Analysis	191				
T1.11	USING LINEAR PROGRAMMING MODELS FOR DECISION MAKING					193
	Healthy Pet Food Revisited	193				
	Solar Oil Company Revisited: Updating Production Decisions	195				
T1.12	INTEGER AND MIXED-INTEGER PROGRAMS					195
T1.13	HEURISTIC METHODS IN OPERATIONS					197
	Characteristics	197				
	Advantages of Heuristics	197				

CHAPTER 5 PRODUCT DESIGN AND OPERATIONS 211

5.1	THE PRODUCT DESIGN REVOLUTION	212
	<i>On the Job:</i> Dee Ambrosia, Standard Register Company 212	
5.2	PRODUCT DEVELOPMENT	213
5.3	THE PRODUCT DESIGN PROCESS	214
	Designing for Production 215	
	Concurrent Design and Engineering 215	
	Team Design 217	
	Working with Customers and Suppliers 217	
5.4	BASIC PRINCIPLES OF DESIGNING PRODUCTS FOR PRODUCTION	219
	Minimize the Number of Parts Used 220	
	Use Common Components 221	
	Use Standard Components 221	
	Simplify the Assembly Process 222	
	Use Modularity to Obtain Product Variety 225	
	Make Product Specifications and Tolerances Reasonable 226	
	Design for Robustness 227	
5.5	PRODUCT DESIGN TOOLS	228
	Quality Function Deployment 228	
	Value Analysis 231	
	The Taguchi Method 232	
	Computer-Aided Design 234	
	Design for Manufacturability and Design for Assembly 235	
	<i>In Good Company:</i> Boeing's Design Takes Off 236	
	Prototyping 237	
5.6	PRODUCT DESIGN FOR SERVICES	237
5.7	PRODUCTION DOCUMENTS	238
5.8	ENVIRONMENTALLY SENSITIVE DESIGN	240
	<i>Fibre-Pack:</i> A Product Design Case 244	

CHAPTER 5 SUPPLEMENT PRODUCT RELIABILITY 247

5s.1	COMPUTING PRODUCT RELIABILITY	247
------	-------------------------------	-----

5s.2	INCREASING RELIABILITY USING REDUNDANT (BACKUP) COMPONENTS	247
------	--	-----

CHAPTER 6 CAPACITY PLANNING AND FACILITY LOCATION 250

6.1	THE IMPORTANCE OF CAPACITY AND LOCATION DECISIONS	251
	<i>On the Job:</i> Sandy Boyd, Espresso Roma 251	
6.2	MEASURING CAPACITY	252
	Factors That Determine Capacity 253	
6.3	CAPACITY STRATEGY	255
	The Organization of Production and Facility Focus 255	
	Capacity Expansion Strategies 257	
	Demand Strategies 260	
6.4	CAPACITY PLANNING AND EVALUATION METHODS	262
	Forecasting Demand and Capacity Requirements 262	
	Break-Even Analysis 263	
	Decision Analysis 265	
6.5	FACILITY LOCATION	266
6.6	LOCATION DECISION STAGES AND FACTORS AFFECTING FACILITY LOCATION	266
	The Regional Decision 267	
	The Local Decision 268	
	The Site Decision 270	
	Public Service Facilities 270	
	Retail/Competitive Service Facilities 271	
6.7	A SCORING RULE FOR LOCATION DECISION MAKING	272
	<i>In Good Company:</i> Mercedes Benz Finds a Home in Alabama 274	
6.8	MATHEMATICAL MODELS FOR FACILITY LOCATION PLANNING	275
	Adding Capacity at an Existing or New Facility 278	
	Locating Several Facilities Simultaneously: Fixed-Charge Problem 278	
	Public Service Facility Location Models 280	
	Planar Location: Median and Center of Gravity Models 282	

6.9	LOCATING FACILITIES GLOBALLY	285
	Why Have Foreign Operations?	285
	A Checklist for Evaluating Foreign Sites	286
	<i>Shenandoah Valley Trauma Centers: A</i>	
	Facility Location Case	295

CHAPTER 6 SUPPLEMENT

SOLVING TRANSPORTATION PROBLEMS **298**

6s.1	INTRODUCTION	298
6s.2	PREPARING THE PROBLEM AND THE TRANSPORTATION TABLEAU	298
6s.3	OBTAINING AN INITIAL FEASIBLE SOLUTION	299
	Northwest Corner Method	300
	Vogel's Approximation Method	300
6s.4	THE STEPPING STONE METHOD	301
	Checking for Optimality	301
	Obtaining an Improved Solution	302
6s.5	THE MODIFIED DISTRIBUTION METHOD	303
6s.6	SPECIAL SITUATIONS	304
	Maximization Problems	304
	Total Supply Not Equal to Total Demand	304
	Degeneracy	305

TUTORIAL 2 DECISION ANALYSIS **312**

T2.1	UNCERTAINTY AND RISK IN DECISION MAKING	313
T2.2	STATIC DECISIONS	313
	Decision Criteria	313
T2.3	SEQUENTIAL DECISIONS AND DECISION TREES	315
	Constructing a Decision Tree	315
	Folding Back the Tree and Computing the Expected Payoff	315
	Expected Value of Perfect Information	318

CHAPTER 7 SELECTING THE PROCESS STRUCTURE AND TECHNOLOGY **325**

7.1	THERE'S MORE THAN ONE WAY TO MAKE THAT PRODUCT	326
------------	---	------------

On the Job: Marvin D. Dixon, Nabisco Foods, Inc. 326

7.2 A COMMON CLASSIFICATION OF PRODUCTION PROCESS STRUCTURES **327**

7.3	FLOW PROCESSES	328
	Continuous Flow Processes	329
	Repetitive or Discrete Flow Processes	330
	Disconnected or Batch Flow Processes	331
	Advantages and Disadvantages of Flow Processes	331

7.4 JOB-SHOP PROCESSES **332**

7.5 CELLULAR PROCESSES **335**

7.6 PROJECT PROCESSES **340**

7.7 MODERN PRODUCTION TECHNOLOGIES **340**

	Group Technology	341
	Process Automation	342
	Computer-Aided Design/Computer-Assisted Manufacturing	344
	Flexible Manufacturing Systems	344
	Computer-Integrated Manufacturing	346
	Bar Coding and Optical Scanning	346
	Electronic Data Interchange	347
	Process Technology and the Environment	348

In Good Company: Waste Turns to Energy for Anheuser-Busch 349

7.8 METHODS FOR EVALUATING PROCESS AND TECHNOLOGY ALTERNATIVES **349**

	Product Variety and Volume	350
	The Product-Process Matrix	350
	Analyzing Costs and Risk: Crossover Analysis	352
	Capital Investment Analysis: Net Present Value	355

7.9 SERVICE SYSTEMS STRUCTURE **356**

	The Service Package and Intended Customers	357
	Customer Contact Intensity	358
	Service System Design and Strategy	360

7.10	CUSTOMIZING THE PRODUCTION PROCESS	360
	<i>Southwest Airlines: A Process Structure and Technology Case</i>	366

CHAPTER 8 PROCESS DESIGN AND FACILITY LAYOUT **369**

8.1	GOING WITH THE FLOW IN PROCESS DESIGN AND LAYOUT	370
	<i>On the Job: Chuck Wise, U.S. Precision Lens</i>	370
8.2	DESIGN OF REPETITIVE PROCESSES: LINE BALANCING AND PRODUCT LAYOUT	371
	Decomposing the Process Into Tasks	372
	Criteria for Evaluating Work Station Design	372
	Cycle Time, Production Rate, and Efficiency	373
	A Work Station—Minimizing Heuristic	374
	Improving Line Design to Increase Balance and Output	377
	Parallel Work Stations	380
	Parallel Production Lines	381
	Mixed Model Production	382
	Continuous and Batch Flow Processes	383
	Spatial Configuration	384
	The Effects of Randomness on Line Design	385
8.3	DESIGN OF FUNCTIONAL LAYOUTS	387
	Procedure for Designing Functional Layouts	388
	Structured Analytical Layout Tools	391
	CRAFT	394
8.4	DESIGN OF CELLULAR PROCESSES	397
	Cell Composition and Type	397
	Production Flow Analysis	398
	Trade-offs and Considerations in the Detailed Design	400
	Spatial Configuration	402
	<i>In Good Company: Hybrids Bloom at Sony Corporation</i>	403
8.5	DESIGN OF SERVICE SYSTEMS	404
	The Process Flow Diagram and the Process Chart	404
	The Service Blueprint	406

8.6	LAYOUT OF SOME SERVICE FACILITIES	408
	Warehouse and Storage Layout	408
	Retail Facilities Layout	410
	<i>Pesti-Chemical: A Process Design and Capacity Expansion Case</i>	422

CHAPTER 9 WAITING LINES **426**

9.1	QUEUEING THEORY	427
	<i>On the Job: Deb Holler, Great Western Bank</i>	427
9.2	CHARACTERISTICS OF QUEUEING SYSTEMS	429
	Customer Characteristics	430
	Service Characteristics	432
	System Configuration	433
9.3	NOTATION, TERMINOLOGY, AND THE EXPLODING QUEUE PROPERTY	434
	Measures of System Performance	435
	Capacity Utilization and the Exploding Queue Property	436
	The Kendall-Lee Notation for Queueing Systems	437
9.4	SINGLE-SERVER SYSTEMS WITH EXPONENTIAL SERVICE TIMES (M/M/I SYSTEMS)	437
9.5	MULTISERVER SYSTEMS WITH EXPONENTIAL SERVICE TIMES (M/M/S SYSTEMS)	441
	Benefits of Pooling Servers Into One System	445
	The Number of Queues for Multiserver Systems	446
9.6	SINGLE-SERVER SYSTEMS WITH GENERAL OR CONSTANT SERVICE TIMES (M/G/I AND M/D/I SYSTEMS)	448
9.7	THE ROLE OF VARIANCE IN QUEUEING SYSTEMS	450
	Slower Servers Are Sometimes More Efficient	451
	Pacing of Customer Arrivals Reduces Waiting	451
	Exploiting Customer Heterogeneity to Improve Service	452
	Other Issues Regarding Designated Servers	454