SIXTH EDITION

Operations Management

JAY HEIZER

BARRY RENDER

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new chapter on E-commerce

OPERATIONS MANAGEMENT

Sixth Edition

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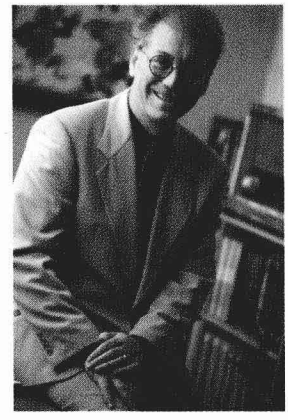

Barry Render is the Charles Harwood Distinguished Professor of Operations Management at the Crummer Graduate School of Business at Rollins College, in Winter Park, Florida. He received his M.S. in Operations Research and his Ph.D. in Quantitative Analysis at the University of Cincinnati (1975). He previously taught at George Washington University, University of New Orleans, Boston University, and George Mason University, where he held the GM Foundation Professorship in Decision Sciences and was Chair of the Decision Science Department. Dr. Render has also worked in the aerospace industry for General Electric, McDonnell Douglas, and NASA.

Professor Render has co-authored nine textbooks with Prentice-Hall, including *Quantitative Analysis for Management, Service Operations Management, Introduction to Management Science,* and *Cases and Readings in Management Science.* His more than one hundred articles on a variety of management topics have appeared in *Decision Sciences, Production and Operations Management, Interfaces, Information and Management, Journal of Management Information Systems, Socio-Economic Planning Sciences,* and *Operations Management Review,* among others.

Dr. Render has also been honored as an AACSB Fellow and named as a Senior Fullbright Scholar in 1982 and again in 1993. He was twice vice-president of the Decision Science Institute Southeast Region and served as Software Review Editor for *Decision Line* from 1989 to 1995. He has also served as Editor of the *New York Times* Operations Management special issues since 1996. Finally, Professor Render has been actively involved in consulting for government agencies and for many corporations, including NASA, FBI, U.S. Navy, Fairfax County, Virginia, and C&P Telephone.

He teaches operations management courses in Rollins College's MBA and Executive MBA programs. In 1995 he was named as that school's Professor of the Year, and in 1996 was selected by Roosevelt University to receive the St. Claire Drake Award for Outstanding Scholarship.

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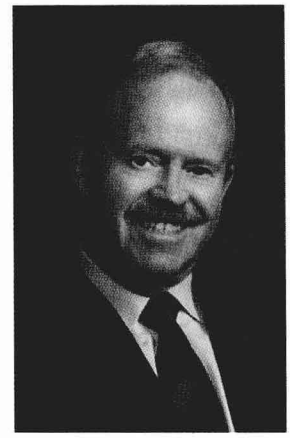
Foreword

FOREWORD TO THE SIXTH EDITION OF OPERATIONS MANAGEMENT



When I first entered a production operation in 1952 the world of business was divided into two parts, like the Red Sea had been. One part made big things out of little things; the other part purchased the little things, found the customers, took care of the money, sold stuff, and complained about the activities of the first part. The two portions of the company had nothing in common and little interest in each other.

Over the years it was discovered that there are no separate parts of an organization. It is a body that requires all components to function together as a unit if a successful life is to be obtained.

However everyone knew that the world was made up of separate parts. Markets were described as domestic and international. The latter was not part of the organization and often had a great deal of difficulty obtaining information about plans, products, and people. Now we have learned that we have suppliers and customers who do not speak our language or observe our holidays.

Functional operations used to be responsible for whatever noun was in their title. Manufacturing manufactured, purchasing purchased, personnel personneled, and quality was done by the quality department. When I was a quality manager top management held me personally responsible if a customer received something that was not proper. Everyone else were "bad guys" trying to get stuff by quality, and we were the "good guys." When enough things went wrong the practice was to find a tougher, smarter cop. There was no thought of getting things done right.

When I began preaching the prevention of problems, called quality management, it took a while for people to catch on. The breakthrough came with the determination of the "price of nonconformace." How much did it cost to do things wrong, and then fix them. Most companies came to the realization that it took 25% and more of their revenues to live that way. That was the beginning of the quality revolution.

When I talk to Professor Render's classes each year I am always impressed that the students are learning to look at the world from a platform that did not exist in my early career. The broad scope of this book assures that this will happen. It provides a place to begin the future by reviewing the past. The students always want to know about the "reality" of quality management, which is the general subject of my chat. I tell them that basic concepts are the important part of business management, that there are no "systems" to do the executive's work. Concepts come from understanding, understanding begins with learning, and learning comes from examining credible resources with an open mind.

I know you will enjoy yourself in this course.

PHILIP CROSBY
Winter Park, Fl.

Preface

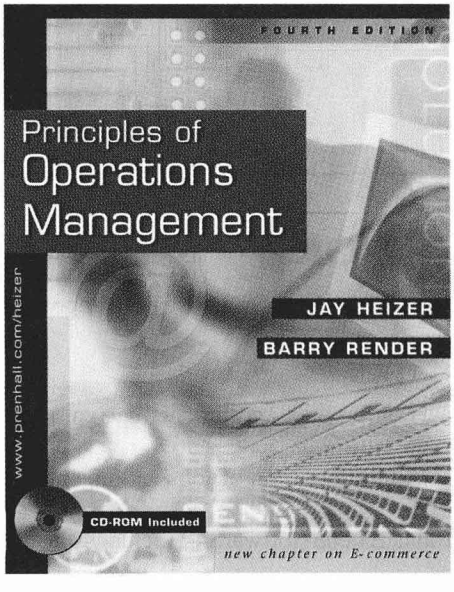
Welcome to *Operations Management*, Sixth Edition, written as a broad introduction to the field of operations management. In this book, we present a state-of-the-art view of the activities of the operations function. Operations is an exciting area of management that has a profound effect on manufacturing, services, and productivity. Indeed, few activities have as much impact on the quality of our lives. The goal of this text is to present the field of operations as realistic, practical activities that improve the quality of life.

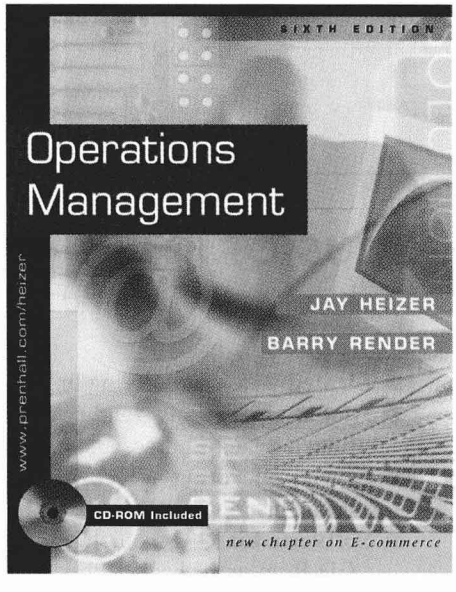
Operations management includes a blend of topics from accounting, industrial engineering, management, management science, and statistics. Operations management jobs can be challenging, important, and rewarding, and can lead to successful careers. Even if you are not employed in the operations area, you will be working directly with people who are. This book can help you understand how OM functions and impacts society and your life. Certainly, you will better understand what goes on behind the scenes when you place an order through Amazon.com or buy a customized Dell computer over the Internet.

Although many of our readers are not OM majors, we think that the marketing, finance, accounting, and MIS students will find the material both interesting and useful. Over 250,000 readers of our earlier editions seem to have endorsed this premise.

TWO VERSIONS OF THE TEXT

This text is available to professors and students in two versions: *Operations Management*, Sixth Edition, which is hardbound, and *Principles of Operations Management*, Fourth Edition, a paperback. Both books include the identical core chapters 1–17. However, *Operations Management*, Sixth Edition, also includes six quantitative modules in Part IV.





OPERATIONS MANAGEMENT, SIXTH EDITION
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2. Operations Strategy for Competitve Advantage
3. Operations in a Global Environment
4. Forecasting

PART II DESIGNING OPERATIONS
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6. Managing Quality
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7. Process Strategy and Capacity Planning
7S. Operations Technology, the Internet, and ERP
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16. Project Management
17. Maintenance and Reliability

PART IV QUANTITATIVE MODULES
A. The Decision Process
B. Linear Programming
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E. Learning Curves
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PRINCIPLES OF OPERATIONS MANAGEMENT, FOURTH EDITION
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16. Project Management
17. Maintenance and Reliability

FOCUS OF THE NEW EDITION

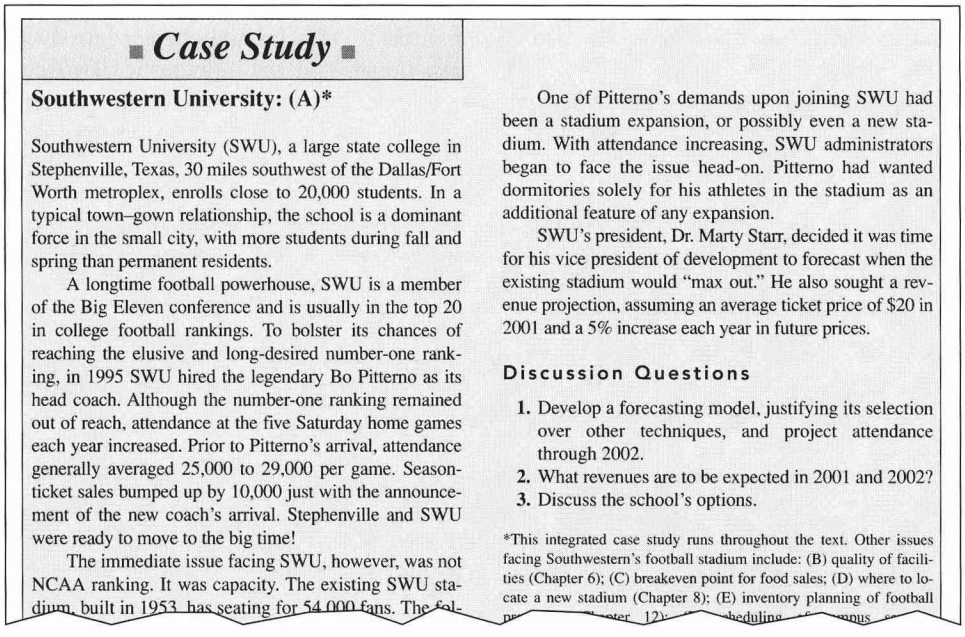
This sixth edition of *Operations Management* continues to place a focus on important aspects of OM:

- **Strategy**—as our unifying link in every chapter
- **Global Operations**—and how this impacts on product and process design, location, human resources and other issues
- **Service operations**—recognizing the dominant proportion of jobs and operations decisions in the services
- **Software for OM**—our free Excel OM and Extend software is included on the CD-Rom in the back of this book

- **Thoroughly modern**—with coverage of the Internet, E-commerce, ERP, and mass customization. A whole new supplement to Chapter 11 called E-commerce and Operations
- **Real world operations**—to maximize interest and excitement in OM.

NEW TO THIS EDITION

Running Case Study In this edition, we add our first integrated, running case study, Southwestern University. Southwestern University faces a series of eight operations decisions as it expands its successful football program. The case continues in chapters 4, 6, 7, 8, 12, 13, and 16 and provides the first truly integrative OM textbook case.



■ *Case Study* ■

Southwestern University: (A)*

Southwestern University (SWU), a large state college in Stephenville, Texas, 30 miles southwest of the Dallas/Fort Worth metroplex, enrolls close to 20,000 students. In a typical town–gown relationship, the school is a dominant force in the small city, with more students during fall and spring than permanent residents.

A longtime football powerhouse, SWU is a member of the Big Eleven conference and is usually in the top 20 in college football rankings. To bolster its chances of reaching the elusive and long-desired number-one ranking, in 1995 SWU hired the legendary Bo Pitterno as its head coach. Although the number-one ranking remained out of reach, attendance at the five Saturday home games each year increased. Prior to Pitterno's arrival, attendance generally averaged 25,000 to 29,000 per game. Season-ticket sales bumped up by 10,000 just with the announcement of the new coach's arrival. Stephenville and SWU were ready to move to the big time!

The immediate issue facing SWU, however, was not NCAA ranking. It was capacity. The existing SWU stadium, built in 1953, has seating for 54,000 fans. The fol-

One of Pitterno's demands upon joining SWU had been a stadium expansion, or possibly even a new stadium. With attendance increasing, SWU administrators began to face the issue head-on. Pitterno had wanted dormitories solely for his athletes in the stadium as an additional feature of any expansion.

SWU's president, Dr. Marty Starr, decided it was time for his vice president of development to forecast when the existing stadium would "max out." He also sought a revenue projection, assuming an average ticket price of $20 in 2001 and a 5% increase each year in future prices.

Discussion Questions

1. Develop a forecasting model, justifying its selection over other techniques, and project attendance through 2002.
2. What revenues are to be expected in 2001 and 2002?
3. Discuss the school's options.

*This integrated case study runs throughout the text. Other issues facing Southwestern's football stadium include: (B) quality of facilities (Chapter 6); (C) breakeven point for food sales; (D) where to locate a new stadium (Chapter 8); (E) inventory planning of football

A Revamped Homework Problem Set One of the trademarks of our text has always been a large selection of homework problems, example problems, and solved problems. Now each and every problem has been re-examined, "stress-tested" for clarity, and each chapter's homework set expanded for more choices. The result is scores of new problems and rewritten problems, giving us the largest, clearest, most diverse problem set of any text. Problems are also now sequenced within each chapter by topic.

The number of homework problems has been expanded by almost a third to a total of 555 problems. These problems focus on problem formulation and interpretation as well as calculation. Each problems is identified as one of three levels; introductory (one dot), moderate (two dots), and challenging (three dots).

More Case Studies There are 55 case studies in this edition, with 29 being new to this edition. The cases are generally 1–2 pages in length, making them short enough to cover in weekly assignments, but detailed enough to add depth to each topic they represent. Thirty of the cases focus on the service sector, such as Shouldice Hospital, IKON, Chicago Southern Hospital, Mayo Clinic, Mutual Insurance of Iowa, and Accountfree. In addition, our home page, at *www.prenhall.com/heizer*, includes over 30 additional case studies. All are solved in the Instructor's Solutions Manual.

CHAPTER BY CHAPTER CHANGES

To highlight the extent of the revision of our previous edition, here are a few of the changes on a chapter-by-chapter basis.

Chapter 1: Operations and Productivity With new material on OM jobs, productivity, and the service sector, this revision sets the tone for goods and services throughout the book. Three new homework problems have been added.

Chapter 2: Operations Strategy for Competitive Advantage This chapter features an expanded coverage of strategy, with a focus on activity mapping at Southwest Airlines. One new problem has been added.

Chapter 3: Operations in a Global Environment This revised chapter introduces four new strategies: global, international, transnational, and multi-domestic. Two new homework problems and a case study on how GM is emulating Toyota's global strategy have been added. Two new *OM in Action* boxes on jobs in Mexico and on crime in foreign capitals have also been added.

Chapter 4: Forecasting This chapter contains new coverage of cyclical variation and trend projection. Nine new problems, a new case study (Southwestern University: A), and a new *OM in Action* box on Taco Bell have been added.

Chapter 5: Design of Goods and Services This chapter now includes Quality Function Deployment and new material on time-based competition, including joint ventures and alliances. Five new problems have been added.

Chapter 6: Managing Quality This chapter has a new focus on the seven tools of TQM, with new material on the Cost of Quality and Service Quality. Five new problems, a new case (Southwestern University: B), and a new *OM in Action* box on quality spies has been added. This chapter was Chapter 4 in the previous edition.

Supplement to Chapter 6: Statistical Process Control We have added the new topic of "Managerial Issues and Control Charts," and expanded coverage on building control charts. Ten new problems and a new *OM in Action* box on Unisys' Health Care Services have been added.

Chapter 7: Process Strategy and Capacity Planning This chapter is a major revision, with focus on mass customization and service blueprinting. New case studies on Southwestern University: C and Shouldice Hospital have been added as well as twelve new problems and a new *Global Company Profile* featuring Dell Computer's mass customization strategy. A new *OM in Action* box features Borders Books.

Supplement to Chapter 7: Operations Technology, The Internet, and ERP This supplement's major revision focuses on the Internet as an OM tool and on Enterprise Resource Planning, including "efficient consumer response" (ECR). New *OM in Action* boxes include Cisco's productivity gain via the Internet and ERP at Benetton. A new case study describing IKON's unsuccessful attempt at ERP is also included.

Chapter 8: Location Strategies This chapter now includes the topic of "clustering," an *OM in Action* box on Columbia Hospital's location decisions, and a new case study (Southwestern University: D). There are also seven new problems.

Chapter 9: Layout Strategies This chapter now begins with a *Global Company Profile* featuring McDonald's High Tech Kitchens. Also included is new material on retail layout called "servicescapes," an Excel OM module for layout, an *OM in Action* box on Amazon.com's warehouse, and two new problems.

Chapter 10: Human Resources and Job Design The new *Global Company Profile* features Southwest Airlines. New *OM in Action* boxes feature the Chicago Bulls basketball team and Northrop-Grumman's B-2 bomber.

Supplement to Chapter 10: Work Measurement Our revision includes a new treatment of work sampling, ten new homework problems, and a new case study, Chicago Southern Hospital.

Chapter 11: Supply Chain Management This chapter now features Internet purchasing (e-procurement) and includes an *OM in Action* box, "E-ssembly Lines at GM and Ford."

Supplement to Chapter 11: E-commerce and Operations This brand new supplement continues our emphasis on e-commerce and the Internet. A wide variety of examples of business-to-business electronic commerce illustrate the importance of this exciting topic. A new case study is provided.

Chapter 12: Inventory Management Our *Global Company Profile* is now Green Gear Cycling and two new cases, Southwestern University: (E) and Mayo Clinic, have been added. Nine new homework problems have also been included.

Supplement to Chapter 12: Just-in-time Systems The topic of Lean Production is now included and a new case, Mutual Insurance Company of Iowa, is added.

Chapter 13: Aggregate Planning New material on aggregate planning in the hotel industry and the Andrew-Carter case have been added.

Chapter 14: Material Requirements Planning (MRP) An Excel OM module is now available for MRP. The problem set has been extensively modified with ten rewritten problems.

Chapter 15: Short-Term Scheduling This chapter has a new *OM in Action* box, New Brunswick Telephone Co., and a new case study of a Chicago software firm, Accountfree, Inc.

Chapter 16: Project Management We have revised Figure 16.1 on Project Planning Scheduling, and Controlling, included an example of an ERP Consulting Project, added a new Excel OM module, added two new problems, and added Southwestern University: G case study.

Chapter 17: Maintenance and Reliability We have added material on the full cost of maintenance and compared it to traditional costing approaches.

Quantitative Module A: Decision Making Tools This module now includes Decision Making under Uncertainty, including maximax, maximin, and equally likely criteria. There are two new problems and a new case study, Starting Right Corp.

Quantitative Module B: Linear Programming There is a new focus on Excel. The CD tutorial on the Simplex Method can be used to supplement this module.

Quantitative Module C: Transportation Models We now include the "intuitive lowest-cost method." The Vogel and MODI methods are on a CD tutorial and can be used to supplement this module. A new case is Custom Vans.

Quantitative Module D: Waiting Line Models Characteristics of queues is now the first topic treated and one new homework problem has been added.

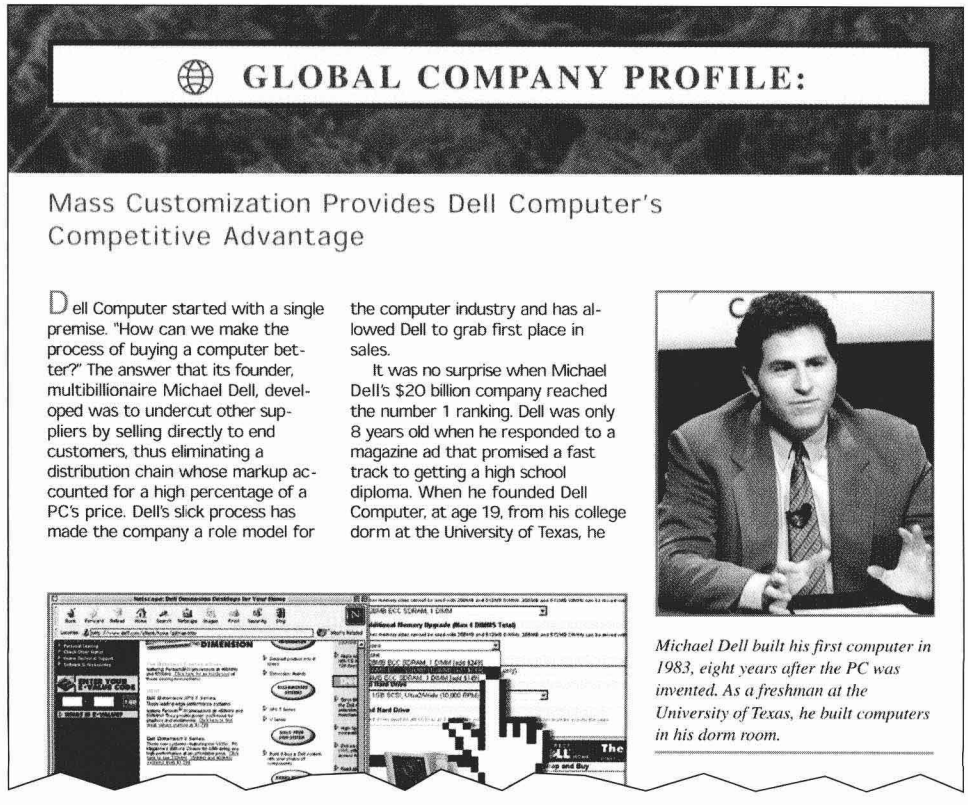
Quantitative Module E: Learning Curves Additional learning material on limitations of learning curves has been included and there are two new homework problems.

Quantitative Module F: Simulation This topic is basically unchanged, but a new *OM in Action* box on Taco Bell appears.

PEDAGOGICAL FOCUS AND FEATURES

Our goal in this revision is to provide the finest pedagogical package available to students and instructors in the operations discipline. We think we have succeeded. Here are some of the features to help enhance learning and teaching.

Global Company Profiles Each of our 17 chapters opens with a two-page full color analysis of a leading global organization. These include Dell, NASA, Delta Air Lines, Komatsu, McDonald's, Boeing, Motorola, Whirlpool, and many more.



GLOBAL COMPANY PROFILE:

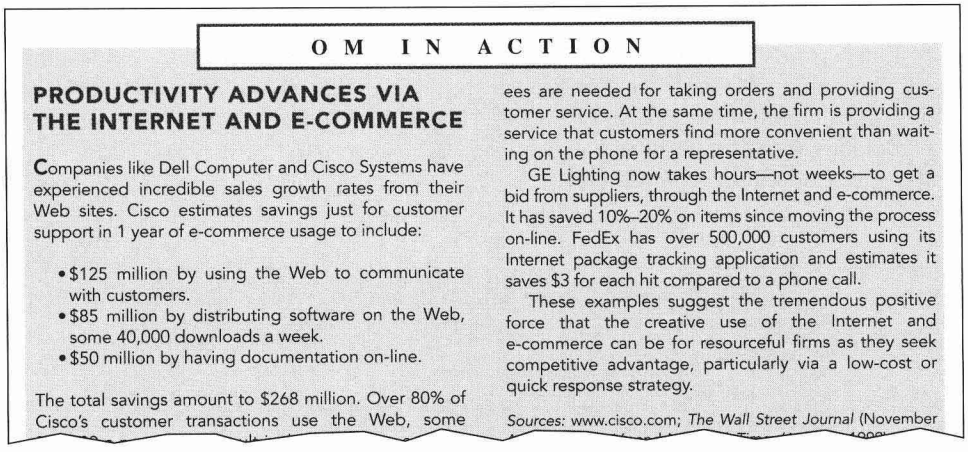
Mass Customization Provides Dell Computer's Competitive Advantage

Dell Computer started with a single premise. "How can we make the process of buying a computer better?" The answer that its founder, multibillionaire Michael Dell, developed was to undercut other suppliers by selling directly to end customers, thus eliminating a distribution chain whose markup accounted for a high percentage of a PC's price. Dell's slick process has made the company a role model for the computer industry and has allowed Dell to grab first place in sales.

It was no surprise when Michael Dell's $20 billion company reached the number 1 ranking. Dell was only 8 years old when he responded to a magazine ad that promised a fast track to getting a high school diploma. When he founded Dell Computer, at age 19, from his college dorm at the University of Texas, he

Michael Dell built his first computer in 1983, eight years after the PC was invented. As a freshman at the University of Texas, he built computers in his dorm room.

OM In Action Boxes These 49 half-page examples of recent OM practice are drawn from a wide variety of sources, including *The Wall Street Journal, New York Times, Fortune, Forbes,* and *Harvard Business Review*. These boxes bring OM to life.



OM IN ACTION

PRODUCTIVITY ADVANCES VIA THE INTERNET AND E-COMMERCE

Companies like Dell Computer and Cisco Systems have experienced incredible sales growth rates from their Web sites. Cisco estimates savings just for customer support in 1 year of e-commerce usage to include:

- $125 million by using the Web to communicate with customers.
- $85 million by distributing software on the Web, some 40,000 downloads a week.
- $50 million by having documentation on-line.

The total savings amount to $268 million. Over 80% of Cisco's customer transactions use the Web, some

ees are needed for taking orders and providing customer service. At the same time, the firm is providing a service that customers find more convenient than waiting on the phone for a representative.

GE Lighting now takes hours—not weeks—to get a bid from suppliers, through the Internet and e-commerce. It has saved 10%–20% on items since moving the process on-line. FedEx has over 500,000 customers using its Internet package tracking application and estimates it saves $3 for each hit compared to a phone call.

These examples suggest the tremendous positive force that the creative use of the Internet and e-commerce can be for resourceful firms as they seek competitive advantage, particularly via a low-cost or quick response strategy.

Sources: www.cisco.com; *The Wall Street Journal* (November

Video Cases There are eight video cases, short (5–8 minute) videos, plus half-page case studies at the end of appropriate chapters. Three firms are highlighted—Ritz Carlton (hotel), Regal Marine (boat manufacturer), and Wheeled Coach (ambulance maker).

Data Base Applications Some chapters include large data base problems, which are intended for analysis by computer. They permit students to spend more time interpreting outputs of realistic problems to supplement problem-solving skills developed with a regular program.

Other standard features include **Critical Thinking Exercises, Solved Problems, Marginal Notes and Definitions**, and **Solutions to Even-Numbered Problems** in Appendix VI.

FREE STUDENT CD-ROM WITH EVERY TEXT

Packaged free with each copy of the text is a new CD-ROM containing many new items to enliven the course and help students learn the material.

Eight Exciting Video Cases These video cases feature real companies and allow students to watch a short video clip, read about the key topics, see the authors discuss the case and pose several questions to the student, who can then email their answers to their instructors. These case studies can also be assigned without using class time to show the videos.

CD Video Clips Another new feature on the student CD-ROM is several 1-to 2-minute videos, which appear throughout the book and are noted in the margins. These video clips illustrate chapter-related topics with films at Harley-Davidson, Ritz Carlton, Kurt Manufacturing, and other firms.

Video 2.1

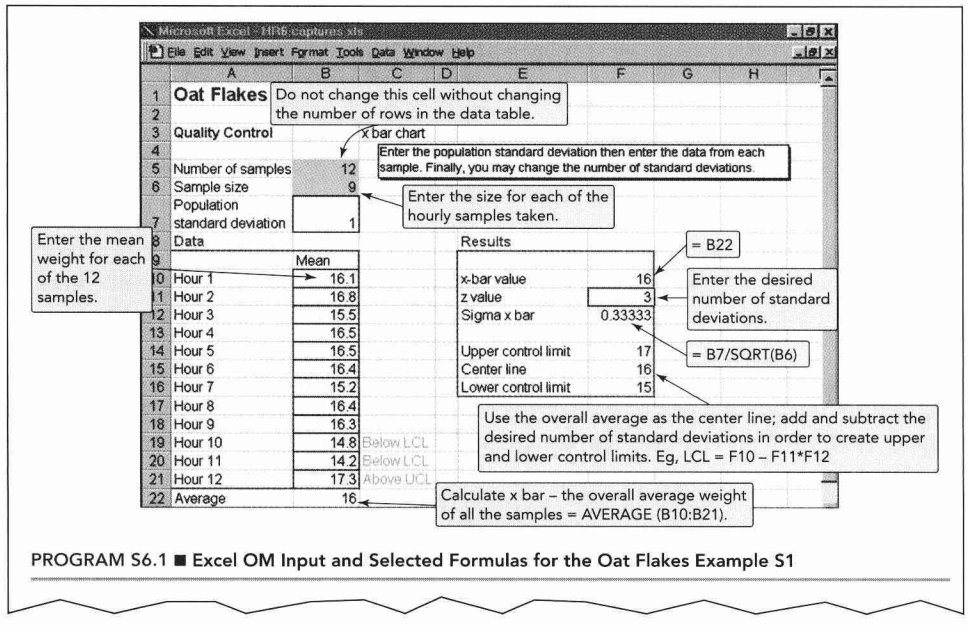
Operations Strategy at Regal Marine

Lecture Notes Based on an extensive set of PowerPoint slides, these lecture notes provide reinforcement to the main points of each chapter and allow students to review the chapter material.

Additional Practice Problems Provide additional problem-solving experience. They supplement the examples and solved problems found in each chapter.

Self-Review Quizzes Included for each chapter, these quizzes allow you to test your understanding of each topic.

Problem-Solving Software Excel OM is our exclusive user-friendly Excel add-in. Excel OM automatically creates worksheets to model and solve problems. Users select a topic from the pull-down menu, fill in the data, and then Excel will display and graph (where appropriate) the results. This software is great for student homework, "what if" analysis, or classroom demonstrations.



PROGRAM S6.1 ■ Excel OM Input and Selected Formulas for the Oat Flakes Example S1

Simulation Software The student version of **Extend** is provided free on the Student CD-ROM. This powerful graphic-simulation package, developed by Imagine That, Inc., allows users to build models of up to 75 blocks, and then save and print the results. It includes a tutorial, a users manual, and a dozen pre-built models.

Four Bonus Chapters Statistical Tools for Managers, Acceptance Sampling, The Simplex Method of Linear Programming, and The MODI and VAM Methods of Solving Transportation Problems are provided as additional reference material.

INTERNET SUPPORT AND RESOURCES

By logging on to *www.prenhall.com/heizer*, you will find the most advanced, text-specific and *personalized* site available on the Web. Students can log on and have a dialogue with their peers, talk to a tutor, take a quiz and get immediate feedback, and read articles about current events—all with the click of a mouse. Our goal is to build an on-line community dedicated to excellence in teaching and optimal learning. Teaching and learning extends far beyond the classroom, and this partnership is dedicated to providing readers with the

very best possible support and service. We encourage professors to integrate the Internet into the operations management course. Some of the resources you will find include:

FOR STUDENTS . . .

On-line Quizzes These extensive quizzes contain a broad assortment of questions, 20–25 per chapter, which include multiple choice, true/false, and Internet essay questions. The quiz questions are graded and can be transmitted to the instructor for extra credit, or can serve as practice exams.

Virtual Tours These company tours provide direct links to companies ranging from a hospital to an auto manufacturer, that practice key concepts. After touring each Web site, students are asked questions directly related to the concepts discussed in the chapter.

In the News New current events articles are added throughout the year. Each article is summarized by our teams of expert professors, and fully supported by exercises, activities, and instructor materials.

Internet Resources Provide discipline-specific sites, including preview information that allows you to review site information before you view the site, ensuring you visit the best available business resources found by our learning community.

Notes Allows you to add personal notes to our resources for personal reminders and references.

FOR FACULTY . . .

This password-protected area provides faculty with the most current and advanced support materials available: The Instructor's Resource Manual, Solutions Manual, PowerPoint slides, and Test Questions. For more information on the full list of support material, please look inside the front cover of the text.

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We wish you a pleasant and productive introduction to operations management.

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