GLOBAL EDITION

13e

OPERATIONS MANAGEMENT

Sustainability and Supply Chain Management

Jay Heizer • Barry Render • Chuck Munson

THIRTEENTH EDITION
GLOBAL EDITION

OPERATIONS MANAGEMENT

Sustainability and Supply Chain Management

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To Kay Heizer, always at my side

J.H.

To Horace Dawson and David Greenberg

B.R.

To Kim, Christopher, and Mark Munson for their unwavering support, and to Bentonville High School teachers Velma Reed and Cheryl Gregory, who instilled in me the importance of detail and a love of learning

C.M.

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ONLINE TUTORIALS (located at MyLab Operations Management)

Preface

New to This Edition

Operations is an exciting area of management that has a profound effect on productivity. The goal of this text and MyLab Operations Management is to present students a broad introduction to the field of operations in a realistic, practical, and applied manner. We want students to understand how operations work within an organization by seeing first-hand what goes on behind the scenes at a concert or major sports event; place an order through Amazon.com; board a flight on Alaska Airlines; or take a cruse with Celebrity Cruises. This text and MyLab Operations Management offer behind the scenes views that no other product on the market provides and one that students tell us they value because they gain a true understanding of operations.

With each edition, we work to gather feedback from instructors and students to enhance our text and MyLab. Based on that feedback, we have added the following new features and improvements.

Video Cases – Celebrity Cruise Line

With each edition, we offer in MyLab Operations Management integrated Video Cases as a valuable teaching tool for students. These short videos help readers see and understand operations in action within a variety of industries. With this edition, we are pleased to take you behind the scenes of Celebrity Cruises, one of the world's premier cruise lines. This fascinating organization opened its doors—and ships—for us to examine and share with you leading-edge OM in the cruise line industry.

The videos provide an inside look at:

- the 10 operations decisions at Celebrity Cruises (Chapter 1);
- how Celebrity Cruises designs a new product (Chapter 5);
- Celebrity's "Save-the-Waves" sustainability program (Supplement 5);
- how Celebrity Cruises treats quality as the heartbeat of the company (Chapter 6); and
- inventory management at Celebrity Cruises (Chapter 12).

Celebrity Cruises: Operations Management at Sea — Video Case

On any given day, Celebrity Cruises, Inc. has tens of thousands of passengers at sea on more than a dozen spectacular ships, spanning 7 continents and 75 countries. With this level of capital investment along with the responsibility for the happiness and safety of so many passengers, excellence in operations is required. To make it all work, the 10 operations management decisions must be executed flawlessly. From product design (which encompasses the ship's layout, the food, and 300 destinations), to scheduling, supply chain, inventory, personnel, maintenance, and the processes that hold them together, OM is critical.

Cruise lines require precise scheduling of ships, with down-to-the-minute docking and departure times. In addition to ship and port scheduling, some 2,000 plus crew members must be scheduled. And there are many schedule variations. Entertainers may arrive and leave at each port, while officers may have a schedule of 10 weeks on and 10 weeks off. Other crew members have onboard commitments varying from 4 to 9 months.

With $400 million invested in a ship and more than 5,000 lives involved in a cruise, detailed processes to ensure maintenance and reliability are vital. The modern ship is a technological marvel with hundreds of electronic monitors operating 24/7 to track everything from ship speed and location, to sea depth, to shipboard power demand and cabin temperature.

Celebrity's ship layout, destinations, and routing are adjusted to meet seasonal demands and the expectations of its premium market segment. With destinations from Alaska to Europe to Asia, crews are recruited worldwide, with as many as 70 nationalities represented. Instilling a quality culture requires an aggressive quality service orientation and, of course, meticulous cleanliness and attention to detail. Processes for food preparation, laundry, quality, and maintenance are complete and detailed.

A cruise ship, as a moving city, requires a comprehensive and precise supply chain that replenishes everything from food to fuel to soap and water. Land-based buyers support Celebrity's annual food and beverage purchases that exceed $110 million. Included in these expenditures are weekly shipments of 6 to 10 containers from the Miami headquarters destined for ships in European ports. An onboard staff organizes inventories to support this massive operation. The logistics effort includes hedging the weekly use of 24,000 gallons of fuel per ship with purchases 6 years into the future. Reliable global supply chains have been developed that deliver the required inventory on a tight time frame.

These crucial shipboard systems typically represent the best of operations management. Such is the case at Celebrity Cruises.

Discussion Questions*

1. Describe how the 10 OM decisions are implemented at Celebrity Cruises, Inc.
2. Identify how the 10 OM decisions at Celebrity Cruises differ from those decisions at a manufacturing firm.
3. Identify how the 10 OM decisions at Celebrity Cruises differ from those decisions at a retail store.
4. How are hotel operations on a ship different from those at a land-based hotel?

*You may wish to view the video that accompanies this case before addressing these questions.

In addition, we continue to offer our previous Video Cases that cover: Alaska Airlines, Orlando Magic basketball team, Frito-Lay, Darden/Red Lobster Restaurants, Hard Rock Cafe, Arnold Palmer Hospital, Wheeled Coach Ambulances, and Regal Marine.

We take the integration of our video case studies seriously, and for this reason, all of our videos are **created by the authors**, with the outstanding coauthorship of Beverly Amer at Northern Arizona University, to explicitly match text content and terminology.

46 Video Cases Listed by Chapter (new videos in bold)

- Frito-Lay: Operations Management in Manufacturing (Chapter 1)
- **Celebrity Cruises: Operations Management at Sea (Chapter 1)**
- Hard Rock Cafe: Operations Management in Services (Chapter 1)
- Strategy at Regal Marine (Chapter 2)
- Hard Rock Cafe's Global Strategy (Chapter 2)
- Outsourcing Offshore at Darden (Chapter 2)
- Project Management at Arnold Palmer Hospital (Chapter 3)
- Managing Hard Rock's Rockfest (Chapter 3)
- Forecasting Ticket Revenue for Orlando Magic Basketball Games (Chapter 4)
- Forecasting at Hard Rock Cafe (Chapter 4)
- **Celebrity Cruises Designs a New Ship (Chapter 5)**
- Product Design at Regal Marine (Chapter 5)
- Building Sustainability at the Orlando Magic's Amway Center (Supplement 5)
- **"Saving the Waves" at Celebrity Cruises (Supplement 5)**
- Green Manufacturing and Sustainability at Frito-Lay (Supplement 5)
- Quality Counts at Alaska Airlines (Chapter 6)
- The Culture of Quality at Arnold Palmer Hospital (Chapter 6)
- **Celebrity Cruises: A Premium Experience (Chapter 6)**
- Quality at the Ritz-Carlton Hotel Company (Chapter 6)
- Frito-Lay's Quality-Controlled Potato Chips (Supplement 6)
- Farm to Fork: Quality at Darden Restaurants (Supplement 6)
- Alaska Airlines: 20-Minute Baggage Process—Guaranteed! (Chapter 7)
- Process Strategy at Wheeled Coach (Chapter 7)
- Process Analysis at Arnold Palmer Hospital (Chapter 7)
- Capacity Planning at Arnold Palmer Hospital (Supplement 7)
- Locating the Next Red Lobster Restaurant (Chapter 8)
- Where to Place the Hard Rock Cafe (Chapter 8)
- Facility Layout at Wheeled Coach (Chapter 9)
- Laying Out Arnold Palmer Hospital's New Facility (Chapter 9)
- The "People" Focus: Human Resources at Alaska Airlines (Chapter 10)
- Hard Rock's Human Resource Strategy (Chapter 10)
- Darden's Global Supply Chains (Chapter 11)
- Supply Chain Management at Regal Marine (Chapter 11)
- Arnold Palmer Hospital's Supply Chain (Chapter 11)
- **Inventory Management at Celebrity Cruises (Chapter 12)**
- Managing Inventory at Frito-Lay (Chapter 12)
- Inventory Control at Wheeled Coach (Chapter 12)
- Using Revenue Management to Set Orlando Magic Ticket Prices (Chapter 13)
- When 18,500 Orlando Magic Fans Come to Dinner (Chapter 14)
- MRP at Wheeled Coach (Chapter 14)
- From the Eagles to the Magic: Converting the Amway Center (Chapter 15)
- Scheduling at Hard Rock Cafe (Chapter 15)
- Lean Operations at Alaska Airlines (Chapter 16)
- JIT at Arnold Palmer Hospital (Chapter 16)
- Maintenance Drives Profits at Frito-Lay (Chapter 17)
- Scheduling Challenges at Alaska Airlines (Module B)

Videos from Recent Graduates for Students

Located in MyLab Operations Management are brief videos of many recent grads who now work in some aspect of operations management. These 2- to 4-minute video clips feature young professionals talking about their jobs in the gamut of OM functions—each tied to a specific chapter and accompanied by multiple-choice quizzes that may be assigned. Each recent grad also talks about tips for success in the job market. This is sure to be a popular feature to engage students!

Kimberly Gersh, Project Manager, Little Green River Software

More Homework Problems—Quantity, Algorithmic, and Conceptual

We know that a vast selection of quality homework problems, ranging from easy to challenging (denoted by one to four dots), is critical for both instructors and students. Instructors need a broad selection of problems to choose from for homework, quizzes, and exams—without reusing the same set from semester to semester. We take pride in having more problems—by far, with 818—than any other OM text.

For this edition, we have added several **HUNDRED new algorithmic problems and concept questions in MyLab Operations Management!**

New Module Called "Applying Analytics to Big Data in Operations Management"

The marriage of business analytics, big data, and operations/supply chain management is a revolutionary change in our field. We are the first text to include a chapter (Module G) on this subject, which includes sections on data management, data visualization, and predictive and prescriptive business analytics tools. The topics include heat maps, conditional formatting for cleaning data, and pivot tables. The module includes numerous exercises that will use students' Excel skills and show them the power of Excel in Big Data.

Detailed Chapter-by-Chapter Changes

Chapter 1: Operations and Productivity

We introduced two new learning objectives for the chapter: "*Identify* the 10 strategic decisions of operations management" and "*Identify* career opportunities in operations management." Our first new video case study is called "Celebrity Cruises: Operations Management at Sea." We updated several entries for the Globalization Era in Figure 1.4. We updated Table 1.4 to reflect employment in various sectors. Finally, we added a new discussion question.

Chapter 2: Operations Strategy in a Global Environment

We updated Figure 2.1 on the growth of world trade and added several key historical events to the graph. We added the new key term *operational hedging*. There are two new OM in Action boxes in this chapter: "Amazon Updates Sears' Strategy" and "China Outsources Too—to Ethiopia." Finally, we updated Figure 2.5 to reflect product life cycle changes.

Chapter 3: Project Management

The Bechtel Global Profile has been rewritten and we have added four new homework problems.

Chapter 4: Forecasting

There are eight new homework problems in this chapter.

Chapter 5: Design of Goods and Services

We modified Figure 5.2 to present the cash flows more clearly. We introduced a discussion of *additive manufacturing* as a new key term to subsume 3-D printing. We added a new discussion of *augmented reality*. There are two new OM in Action boxes: "Product Design at McDonald's" and "Amazon Pushes Product Design." Our second new video case study is called "Celebrity Cruises

Designs a New Ship." We replaced the section on PCN Analysis with a new discussion on service design. We added two discussion questions and have seven new homework problems in this chapter.

Supplement 5: Sustainability in the Supply Chain

There is a new video case study called "Saving the Waves at Celebrity Cruises." We've also added new material on the circular economy and on ISO 50001. There is also a new OM in Action box called "Designing for the End of Life."

Chapter 6: Managing Quality

Our new video case study is called "Celebrity Cruises: A Premium Experience." There is also a new OM in Action box called "Inspecting the Boeing 787," new material on testing Samsung smart phones, and four new homework problems.

Supplement 6: Statistical Process Control

We have added 14 new homework problems and updated the OM in Action box called "Landing a Seat with Frequent Flyer Miles."

Chapter 7: Process Strategies

We updated Figure 7.8 to simplify the presentation of degree of customization and labor for services. We added an OM in Action box called "500,000 Tons of Steel; 14 Jobs." Finally, we updated Table 7.4 to provide more examples of technology's impact on services.

Supplement 7: Capacity and Constraint Management

We modified the numbers used to compute actual output in Table S7.1. We modified Figure S7.6 to improve the exposition for the four approaches to capacity expansion. We added 10 new homework problems for this supplement. Finally, we updated the birth rates in Table S7.4 for the Arnold Palmer Hospital case.

Chapter 8: Location Strategies

We have added seven new homework problems to this chapter.

Chapter 9: Layout Strategies

There is a new OM in Action box called "Amazon Warehouses are Full of Robots," and we have made major revisions to our coverage of Work Cells, Focused Facilities, Focused Work Centers, and Focused Factories. There are also four new homework problems.

Chapter 10: Human Resources, Job Design, and Work Measurement

We have added five new homework problems to this chapter.

Chapter 11: Supply Chain Management

We begin the chapter with a new Global Company Profile featuring Red Lobster. We've added a new section on blockchain, a new OM in Action box called "Samsung and Apple's Complex Supply Chain," and updated our treatment of SCOR. We also added three new homework problems.

Supplement 11: Supply Chain Management Analytics

There is a new discussion question and three new homework problems.

Chapter 12: Inventory Management

There is a new video case study called "Inventory Management at Celebrity Cruises." We have also revised the Amazon Global Company Profile and expanded coverage of the single period model. In addition, there are 13 new homework problems.

Chapter 13: Aggregate Planning and S&OP

We've added three new homework problems to this chapter.

Chapter 14: Material Requirements Planning (MRP) and ERP

We deleted Figure 14.6 and moved the presentation of *allocated items* into Example 3. Under *MRP Management*, we introduced a new section and key term for *demand-driven MRP*, along with a new associated Figure 14.6. A discussion of *blockchains* is introduced in the *Enterprise Resource Planning (ERP)* section. Finally, five new homework problems were added for this chapter.

Chapter 15: Short-Term Scheduling

There are six new homework problems to this chapter.

Chapter 16: Lean Operations

There is a new OM in Action box, "Dr. Pepper's Move to Kaizen," and two new homework problems.

Chapter 17: Maintenance and Reliability

There is new coverage of predictive maintenance, and there are three new homework problems.

Module A: Decision Making Tools

There is a new case study, "Festival App," and seven new homework problems.

Module B: Linear Programming

We have added seven new homework problems to this module.

Module C: Transportation Models

We have added one new homework problem to this module.

Module D: Waiting-Line Models

There are five new homework problems in this module.

Module E: Learning Curves

We have revised Figure E.1, which deals with exponential and log-log learning graphs.

Module F: Simulation

There are three new homework problems in this module.

Module G: Applying Analytics to Big Data in Operations Management

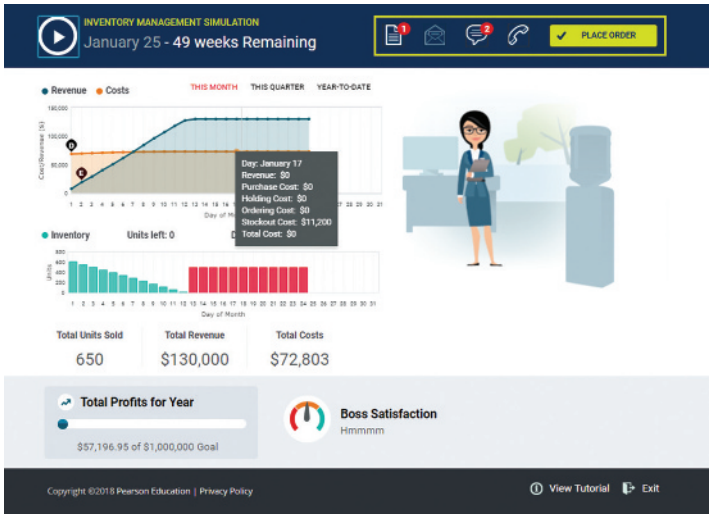
This new module includes sections on big data and business analytics, data management, data visualization, and predictive and prescriptive business analytics tools. There are 10 homework problems, two solved problems, and eight discussion questions.

Solving Teaching and Learning Challenges

Now in its 13th edition, the text and **MyLab Operations Management** provide an extremely comprehensive learning package. This robust program addresses teaching and learning challenges and affords the student with opportunities to learn and practice employable skills. Here are just a few of the key elements offered with this textbook and **MyLab Operations Management**.

MyLab Operations Management

MyLab Operations Management is the teaching and learning platform that empowers *every* student. When combined with educational content written by the authors, **MyLab Operations Management** helps deliver the learning outcomes to which students and instructors aspire.



Operations Management Simulations

Five operations management simulations give students hands-on experience in real-world roles, helping them make decisions, think critically, and link course concepts to on-the-job application.

By receiving real-time, dynamic feedback from stakeholders, students see the impact of their choices and can gauge their performance against individual, peer, and system metrics. Results of these simulations are recorded in the MyLab Gradebook.

The five simulations are:

- Project Management (Chapter 3)
- Forecasting (Chapter 4)
- Quality Management (Chapter 6)
- Supply Chain Management (Chapter 11)
- Inventory Management (Chapter 12)

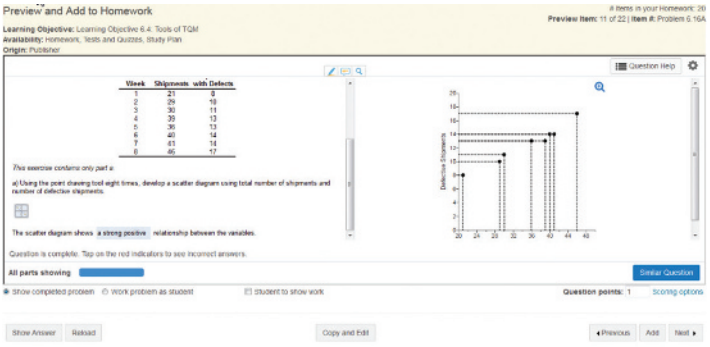
Students tell us that they enjoy learning OM through these simulations!

A Powerful Homework and Test Manager

Problems from the textbook can be assigned to students via a robust platform. This allows instructors to manage, create, and import online homework assignments, quizzes, and tests that are automatically graded. Instructors can choose from a wide range of assignment options, including time limits, proctoring, and maximum number of attempts allowed. The bottom line: **MyLab Operations Management** means more learning and less time grading.

Learning Aids

Right at the time of learning, students can access Learning Aids like Help Me Solve This, Videos from the authors of similar problems being solved, Ask My Instructor, and eText Pages. All of which provides the student feedback and assistance when they need it most.



Working with Excel Software

Excel use in the Operations Management course is becoming more important, and instructors often ask their students to develop their own Excel spreadsheet models. For this reason, we provide "Creating Your Own Excel Spreadsheets," examples toward the end of numerous chapters.

Decision Support Software

We also provide two decision support software programs, Excel OM for Windows and Mac, and POM for Windows, to help solve homework problems and case studies. More information on these packages can be found in **MyLab Operations Management** in the Download Center.

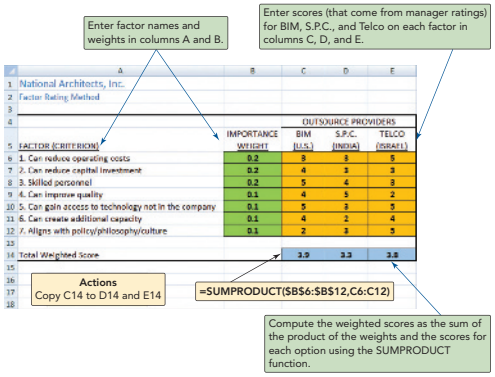
Using Software to Solve Outsourcing Problems

Excel, Excel OM, and POM for Windows may be used to solve many of the problems in this chapter.

CREATING YOUR OWN EXCEL SPREADSHEETS

Program 2.1 illustrates how to build an Excel spreadsheet for the data in Example 1. In this example the factor rating method is used to compare National Architects' three potential outsourcing providers.

This program provides the data inputs for seven important factors, including their weights (0.0–1.0) and ratings (1–5 scale where 5 is the highest rating) for each country. As we see, BIM is most highly rated, with a 3.9 score, versus 3.3 for S.P.C. and 3.8 for Telco.



Program 2.1

Using Excel to Develop a Factor Rating Analysis, With Data from Example 1

USING EXCEL OM

Excel OM (free with your text and also found in MyLab Operations Management) may be used to solve Example 1 (with the Factor Rating module).

USING POM FOR WINDOWS

POM for Windows also includes a factor rating module. For details, refer to Appendix II. POM for Windows is also found in MyLab Operations Management and can solve all problems labeled with a P.

Jay, Barry, & Chuck's OM Blog

As a complement to this text, we have created a companion blog, with coordinated features to help teach the OM course. There are teaching tips, highlights of OM items in the news (along with class discussion questions and links), video tips, guest posts by instructors using our text, and much more—all arranged by chapter. To learn more about any chapter topics, visit *www.heizerrenderOM.wordpress.com*. As instructors prepare their lectures and syllabus, they can scan our blog for discussion ideas, teaching tips, and classroom exercises.

ABOUT THE AUTHORS

JAY HEIZER

The Jesse H. Jones Professor Emeritus of Business Administration, Texas Lutheran University, Seguin, Texas. He received his B.B.A. and M.B.A. from the University of North Texas and his Ph.D. in Management and Statistics from Arizona State University. He was previously a member of the faculty at the University of Memphis, the University of Oklahoma, Virginia Commonwealth University, where he was department chair, and the University of Richmond. He has also held visiting positions at Boston University, George Mason University, the Czech Management Center, and the Otto-Von-Guericke University, Magdeburg.

Dr. Heizer's industrial experience is extensive. He learned the practical side of operations management as a machinist apprentice at Foringer and Company, as a production planner for Westinghouse Airbrake, and at General Dynamics, where he worked in engineering administration. In addition, he has been actively involved in consulting in the OM and MIS areas for a variety of organizations, including Philip Morris, Firestone, Dixie Container Corporation, Columbia Industries, and Tenneco. He holds the CPIM certification from APICS—the Association for Operations Management.

Professor Heizer has co-authored five books and has published more than 30 articles on a variety of management topics. His papers have appeared in the *Academy of Management Journal*, *Journal of Purchasing*, *Personnel Psychology*, *Production & Inventory Control Management*, *APICS—The Performance Advantage*, *Journal of Management History*, *IIE Solutions*, and *Engineering Management*, among others. He has taught operations management courses in undergraduate, graduate, and executive programs.

BARRY RENDER

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

Professor Render has co-authored 10 textbooks for Pearson, including *Managerial Decision Modeling with Spreadsheets*, *Quantitative Analysis for Management*, *Service Management*, *Introduction to Management Science*, and *Cases and Readings in Management Science*. *Quantitative Analysis for Management*, now in its 14th edition, is a leading text in that discipline in the United States and globally. Dr. Render's more than 100 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*, *IIE Solutions*, and *Operations Management Review*, among others. Dr. Render has been honored as an AACSB Fellow and was twice named a Senior Fulbright Scholar. He was Vice President of the Decision Science Institute Southeast Region and served as Software Review Editor for *Decision Line* for six years and as Editor of the *New York Times* Operations Management special issues for five years. For nine years, Dr. Render was President of Management Service Associates of Virginia, Inc., whose technology clients included the FBI, NASA, the U.S. Navy, Fairfax County, Virginia, and C&P Telephone. Dr. Render has received Rollins College's Welsh Award as leading Professor and was selected by Roosevelt University as the recipient of the St. Claire Drake Award for Outstanding Scholarship. Dr. Render also received the Rollins College MBA Student Award for Best Overall Course and was named Professor of the Year by full-time MBA students.

CHUCK MUNSON

Professor of Operations Management and Carson College of Business Ph.D. Program Director, Washington State University, Pullman, Washington. He received his BSBA *summa cum laude* in finance, along with his MSBA and Ph.D. in operations management, from Washington University in St. Louis. For three years, he worked as a financial analyst for Contel Telephone Corporation.

Professor Munson serves as a senior editor for *Production and Operations Management,* and he serves on the editorial review board of four other journals. He has published more than 25 articles in such journals as *Production and Operations Management*, *IIE Transactions*, *Decision Sciences*, *Naval Research Logistics*, *European Journal of Operational Research*, *Journal of the Operational Research Society*, and *Annals of Operations Research.* He is editor of the book *The Supply Chain Management Casebook: Comprehensive Coverage and Best Practices in SCM,* and he has co-authored the research monograph *Quantity Discounts: An Overview and Practical Guide for Buyers and Sellers*. He is also coauthor of *Managerial Decision Modeling: Business Analytics with Spreadsheets* (4th edition), published by deGruyter.

Dr. Munson has taught operations management core and elective courses at the undergraduate, MBA, and Ph.D. levels at Washington State University. He has also conducted several teaching workshops at international conferences and for Ph.D. students at Washington State University. His major awards include winning the Sahlin Faculty Excellence Award for Instruction (Washington State University's top teaching award, 2016); being a Founding Board Member of the Washington State University President's Teaching Academy (2004); winning the WSU College of Business Outstanding Teaching Award (2001 and 2015), Research Award (2004), and Service Award (2009 and 2013); and being named the WSU MBA Professor of the Year (2000 and 2008).

Instructor Teaching Resources

This teaching package comes with the following teaching resources.

Supplements available to instructors at http://www.pearsonglobaleditions.com/	Features of the Supplement
Instructor's Resource Manual authored by Chuck Munson	• Chapter summary • Class Discussion Ideas • Active Classroom Learning Exercises • Company Videos discussion • Cinematic Ticklers • Jay, Barry, and Chuck's OM Blog • Presentation Slides discussion • Additional Assignment Ideas • Internet Resources and Other Supplementary Materials
Instructor's Solutions Manual	The Instructor's Solutions Manual, written by the authors, contains the answers to all of the discussion questions, Ethical Dilemmas, Active Models, and cases in the text, as well as worked-out solutions to all the end-of-chapter problems, additional homework problems, and additional case studies.
Test Bank authored by Jianli Hu, Cerritos College	• More than 1,500 multiple-choice, true-or-false, and essay questions • Keyed by learning objective • Classified according to difficulty level • AACSB learning standard identified (Ethical Understanding and Reasoning; Analytical Thinking Skills; Information Technology; Diverse and Multicultural Work; Reflective Thinking; Application of Knowledge)
Computerized TestGen	TestGen allows instructors to • customize, save, and generate classroom tests. • edit, add, or delete questions from the Test Item Files. • analyze test results. • organize a database of tests and student results.
PowerPoints authored by Jeff Heyl, Lincoln University	An extensive set of PowerPoint presentations is available for each chapter. With well over 2,000 slides, this set has excellent color and clarity. A set of PowerPoints is also available as an ADA-compliant version that meet accessibility standards for students with disabilities. Features include: • Keyboard and screen reader access • Alternative text for images • High contrast between background and foreground colors
Excel Data Files, Excel OM, POM for Windows, and Active Models developed by Howard Weiss, Temple University	• The data files are prepared for specific examples and allow users to solve all the marked text examples without reentering any data. • POM for Windows is a powerful tool for easily solving OM problems. • Excel OM is our exclusive user-friendly Excel add-in. Excel OM automatically creates worksheets to model and solve problems. This software is great for student homework, what-if analysis, and classroom demonstrations. • Active Models are Excel-based OM simulations, designed to help students understand the quantitative methods shown in the textbook examples. Students may change the data to see how the changes affect the answers.

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We thank the many individuals who were kind enough to assist us in this endeavor. The following professors provided insights that guided us in this edition (their names are in bold) and in prior editions:

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In this edition, we were thrilled to be able to include one of the country's premier cruise lines, Celebrity Cruises, in our ongoing Video Case Study series. This was possible because of the wonderful efforts of President and CEO Lisa Lutoff-Perlo, and her superb management team. This included Patrik Dahlgren (Senior V.P. Global Marine Operations), Cornelius Gallagher (Associate V.P., Food and Beverage Operations), Brian Abel (V.P., Hotel Operations), and Paul Litvinov (Associate V.P., Strategic Sourcing and Supply Chain Management). We are grateful to all of these fine people, as well as the many others that participated in the development of the videos and cases during our trips to the Miami headquarters. In addition, we owe a deep gratitude to Rod McLeod, former Executive V.P., Royal Caribbean International, for introducing us to and tutoring us in the intricacies of the cruise industry.

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

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Operations and Productivity

CHAPTER 1

CHAPTER OUTLINE

Beverly Amer/Aspenleaf Productions

A view of the bridge of a Celebrity Cruise ship (Celebrity Cruises is the focus of the new video cases with this edition).

10 OM STRATEGY DECISIONS

- Design of Goods and Services
- Managing Quality
- Process Strategies
- Location Strategies
- Layout Strategies
- Human Resources
- Supply Chain Management
- Inventory Management
- Scheduling
- Maintenance

GLOBAL COMPANY PROFILE
Hard Rock Cafe

Operations Management at Hard Rock Cafe

Operations managers throughout the world are producing products every day to provide for the well-being of society. These products take on a multitude of forms. They may be washing machines at Whirlpool, motion pictures at DreamWorks, rides at Disney World, or food at Hard Rock Cafe. These firms produce thousands of complex products every day—to be delivered as the customer ordered them, when the customer wants them, and where the customer wants them. Hard Rock does this for over 35 million guests worldwide every year. This is a challenging task, and the operations manager's job, whether at Whirlpool, DreamWorks, Disney, or Hard Rock, is demanding.

Andre Jenny/Alamy Stock Photo

Hard Rock Cafe in Orlando, Florida, prepares over 3,500 meals each day. Seating more than 1,500 people, it is one of the largest restaurants in the world. But Hard Rock's operations managers serve the hot food hot and the cold food cold.

Getty Images/Hulton Archive/Getty Images

Operations managers are interested in the attractiveness of the layout, but they must be sure that the facility contributes to the efficient movement of people and material with the necessary controls to ensure that proper portions are served.

Eamonn McCormack/WireImage/Getty Images

Lots of work goes into designing, testing, and costing meals. Then suppliers deliver quality products on time, every time, for well-trained cooks to prepare quality meals. But none of that matters unless an enthusiastic waitstaff, such as the one shown here, holding guitars previously owned by members of U2, is doing its job.

Efficient kitchen layouts, motivated personnel, tight schedules, and the right ingredients at the right place at the right time are required to delight the customer.

Jack Picone/Alamy Stock Photo

Orlando-based Hard Rock Cafe opened its first restaurant in London in 1971, making it over 48 years old and the granddaddy of theme restaurants. Although other theme restaurants have come and gone, Hard Rock is still going strong, with 23 hotels and 168 restaurants in more than 68 countries—and new restaurants opening each year. Hard Rock made its name with rock music memorabilia, having started when Eric Clapton, a regular customer, marked his favorite bar stool by hanging his guitar on the wall in the London cafe. Now Hard Rock has 70,000 items and millions of dollars invested in memorabilia. To keep customers coming back time and again, Hard Rock creates value in the form of good food and entertainment.

The operations managers at Hard Rock Cafe at Universal Studios in Orlando provide more than 3,500 custom products—in this case meals—every day. These products are designed, tested, and then analyzed for cost of ingredients, labor requirements, and customer satisfaction. On approval, menu items are put into production—and then only if the ingredients are available from qualified suppliers. The production process, from receiving, to cold storage, to grilling or baking or frying, and a dozen other steps, is designed and maintained to yield a quality meal. Operations managers, using the best people they can recruit and train, also prepare effective employee schedules and design efficient layouts.

Managers who successfully design and deliver goods and services throughout the world understand operations. In this text, we look not only at how Hard Rock's managers create value but also how operations managers in other services, as well as in manufacturing, do so. Operations management is demanding, challenging, and exciting. It affects our lives every day. Ultimately, operations managers determine how well we live.

LEARNING OBJECTIVES

STUDENT TIP Let's begin by defining what this course is about.

What Is Operations Management?

LO 1.1 *Define* operations management

VIDEO 1.1 Operations Management at Hard Rock

VIDEO 1.2 Operations Management at Frito-Lay

VIDEO 1.3 Celebrity Cruises: Operations Management at Sea

Operations management (OM) is a discipline that applies to restaurants like Hard Rock Cafe as well as to factories like Ford and Whirlpool. The techniques of OM apply throughout the world to virtually all productive enterprises. It doesn't matter if the application is in an office, a hospital, a restaurant, a department store, or a factory—the production of goods and services requires operations management. And the *efficient* production of goods and services requires effective applications of the concepts, tools, and techniques of OM that we introduce in this book.

As we progress through this text, we will discover how to manage operations in an economy in which both customers and suppliers are located throughout the world. An array of informative examples, charts, text discussions, and pictures illustrates concepts and provides information. We will see how operations managers create the goods and services that enrich our lives.

In this chapter, we first define *operations management*, explaining its heritage and exploring the exciting role operations managers play in a huge variety of organizations. Then we discuss production and productivity in both goods- and service-producing firms. This is followed by a discussion of operations in the service sector and the challenge of managing an effective and efficient production system.

Production The creation of goods and services.

Operations management (OM) Activities that relate to the creation of goods and services through the transformation of inputs to outputs.

Production is the creation of goods and services. **Operations management (OM)** is the set of activities that creates value in the form of goods and services by transforming inputs into outputs. Activities creating goods and services take place in all organizations. In manufacturing firms, the production activities that create goods are usually quite obvious. In them, we can see the creation of a tangible product such as a Sony TV or a Harley-Davidson motorcycle.

In an organization that does not create a tangible good or product, the production function may be less obvious. We often call these activities *services*. The services may be "hidden" from the public and even from the customer. The product may take such forms as the transfer of funds from a savings account to a checking account, the transplant of a liver, the filling of an empty seat on an airplane, or the education of a student. Regardless of whether the end product is a good or service, the production activities that go on in the organization are often referred to as operations, or *operations management*.

STUDENT TIP Operations is one of the three functions that every organization performs.

Organizing to Produce Goods and Services

To create goods and services, all organizations perform three functions (see Figure 1.1). These functions are the necessary ingredients not only for production but also for an organization's survival. They are:

1. *Marketing*, which generates the demand, or at least takes the order for a product or service (nothing happens until there is a sale).
2. *Production/operations*, which creates, produces, and delivers the product.
3. *Finance/accounting*, which tracks how well the organization is doing, pays the bills, and collects the money.

Universities, churches or synagogues, and businesses all perform these functions. Even a volunteer group such as the Boy Scouts of America is organized to perform these three basic

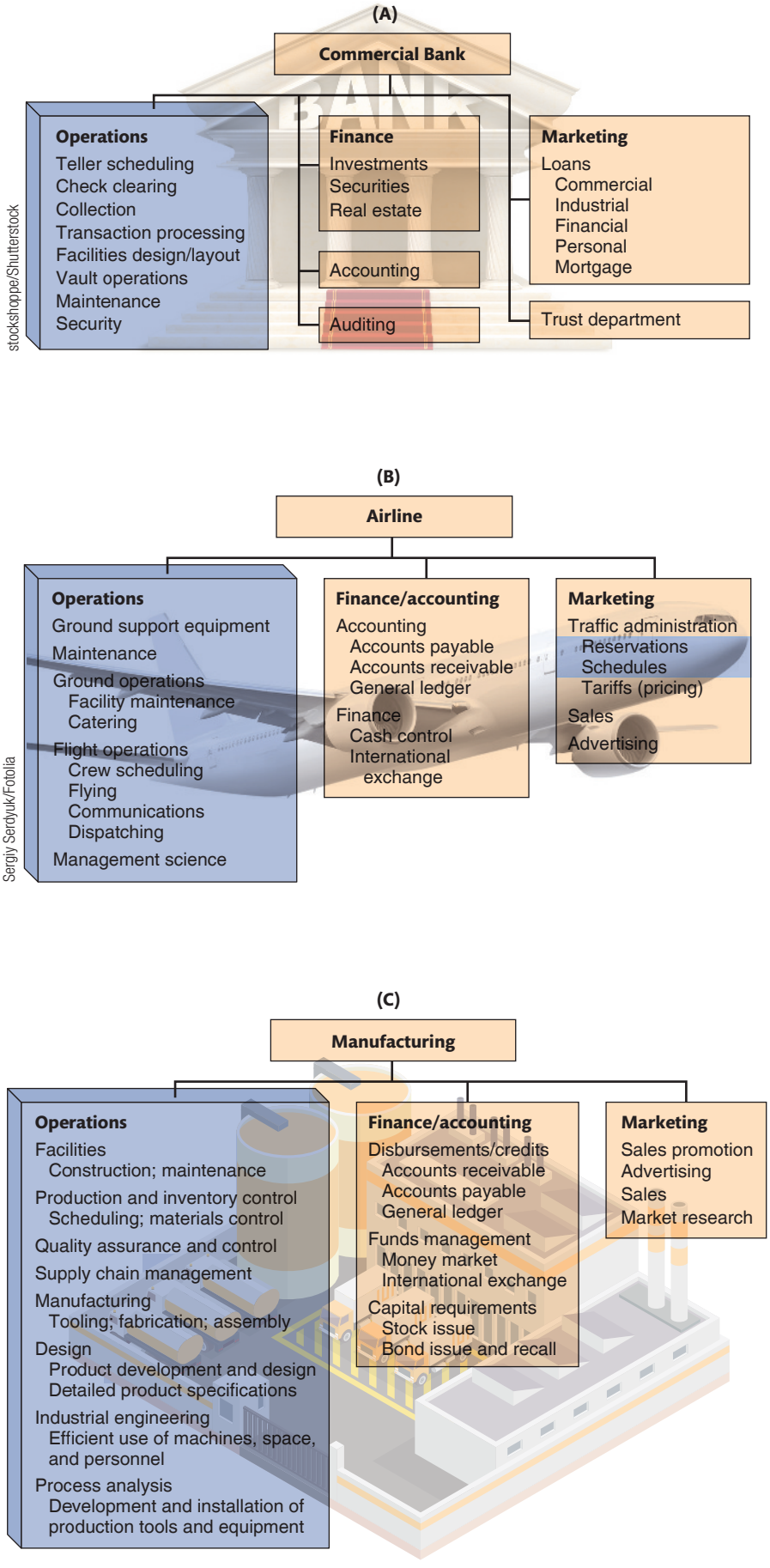


Figure **1.1**

Organization Charts for Two Service Organizations and One Manufacturing Organization

(A) a bank, (B) an airline, and (C) a manufacturing organization. The blue areas are OM activities.

STUDENT TIP

The areas in blue indicate the significant role that OM plays in both manufacturing and service firms.

Figure 1.2

Soft Drink Supply Chain

A supply chain for a bottle of Coke requires a beet or sugar cane farmer, a syrup producer, a bottler, a distributor, and a retailer, each adding value to satisfy a customer. Only with collaborations between all members of the supply chain can efficiency and customer satisfaction be maximized. The supply chain, in general, starts with the provider of basic raw materials and continues all the way to the final customer at the retail store.

functions. Figure 1.1 shows how a bank, an airline, and a manufacturing firm organize themselves to perform these functions. The blue-shaded areas show the operations functions in these firms.

The Supply Chain

Supply chain
A global network of organizations and activities that supplies a firm with goods and services.

Through the three functions—marketing, operations, and finance—value for the customer is created. However, firms seldom create this value by themselves. Instead, they rely on a variety of suppliers who provide everything from raw materials to accounting services. These suppliers, when taken together, can be thought of as a *supply chain.* A **supply chain** (see Figure 1.2) is a global network of organizations and activities that supply a firm with goods and services.

As our society becomes more technologically oriented, we see increasing specialization. Specialized expert knowledge, instant communication, and cheaper transportation also foster specialization and worldwide supply chains. It just does not pay for a firm to try to do everything itself. The expertise that comes with specialization exists up and down the supply chain, adding value at each step. When members of the supply chain collaborate to achieve high levels of customer satisfaction, we have a tremendous force for efficiency and competitive advantage. Competition in the 21st century is not between companies; it is between *supply chains.*

Why Study OM?

STUDENT TIP Good OM managers are scarce, and as a result, career opportunities and pay are excellent.

We study OM for four reasons:

1. OM is one of the three major functions of any organization, and it is integrally related to all the other business functions. All organizations market (sell), finance (account), and produce (operate), and it is important to know how the OM activity functions. Therefore, we study *how people organize themselves for productive enterprise*.
2. We study OM because we want to know *how goods and services are produced*. The production function is the segment of our society that creates the products and services we use.
3. We study OM to *understand what operations managers do*. Regardless of your job in an organization, you can perform better if you understand what operations managers do. In addition, understanding OM will help you explore the numerous and lucrative career opportunities in the field.
4. We study OM *because it is such a costly part of an organization*. A large percentage of the revenue of most firms is spent in the OM function. Indeed, OM provides a major opportunity for an organization to improve its profitability and enhance its service to society. Example 1 considers how a firm might increase its profitability via the production function.

Example 1

EXAMINING THE OPTIONS FOR INCREASING CONTRIBUTION

Fisher Technologies is a small firm that must double its dollar contribution to fixed cost and profit in order to be profitable enough to purchase the next generation of production equipment. Management has determined that if the firm fails to increase contribution, its bank will not make the loan and the equipment cannot be purchased. If the firm cannot purchase the equipment, the limitations of the old equipment will force Fisher to go out of business and, in doing so, put its employees out of work and discontinue producing goods and services for its customers.

APPROACH ► Table 1.1 shows a simple profit-and-loss statement and three strategic options (marketing, finance/accounting, and operations) for the firm. The first option is a *marketing option*, where excellent marketing management may increase sales by 50%. By increasing sales by 50%, contribution will in turn increase 71%. But increasing sales 50% may be difficult; it may even be impossible.

TABLE 1.1 Options for Increasing Contribution

		MARKETING OPTION[a]	FINANCE/ ACCOUNTING OPTION[b]	OM OPTION[c]
	CURRENT	INCREASE SALES REVENUE 50%	REDUCE FINANCE COSTS 50%	REDUCE PRODUCTION COSTS 20%
Sales	$100,000	$150,000	$100,000	$100,000
Costs of goods	–80,000	–120,000	–80,000	–64,000
Gross margin	20,000	30,000	20,000	36,000
Finance costs	–6,000	–6,000	–3,000	–6,000
Subtotal	14,000	24,000	17,000	30,000
Taxes at 25%	–3,500	–6,000	–4,250	–7,500
Contribution[d]	$ 10,500	$ 18,000	$ 12,750	$ 22,500

[a]Increasing sales 50% increases contribution by $7,500, or 71% (7,500/10,500).

[b]Reducing finance costs 50% increases contribution by $2,250, or 21% (2,250/10,500).

[c]Reducing production costs 20% increases contribution by $12,000, or 114% (12,000/10,500).

[d]Contribution to fixed cost (excluding finance costs) and profit.

The second option is a *finance/accounting option*, where finance costs are cut in half through good financial management. But even a reduction of 50% is still inadequate for generating the necessary increase in contribution. Contribution is increased by only 21%.

The third option is an *OM option*, where management reduces production costs by 20% and increases contribution by 114%.

SOLUTION ► Given the conditions of our brief example, Fisher Technologies has increased contribution from $10,500 to $22,500. It may now have a bank willing to lend it additional funds.

INSIGHT ► The OM option not only yields the greatest improvement in contribution but also may be the only feasible option. Increasing sales by 50% and decreasing finance cost by 50% may both be virtually impossible. Reducing operations cost by 20% may be difficult but feasible.

LEARNING EXERCISE ► What is the impact of only a 15% decrease in costs in the OM option? [Answer: A $19,500 contribution; an 86% increase.]

Example 1 underscores the importance of the effective operations activity of a firm. Development of increasingly effective operations is the approach taken by many companies as they face growing global competition.

What Operations Managers Do

All good managers perform the basic functions of the management process. The management process consists of *planning*, *organizing*, *staffing*, *leading*, and *controlling*. Operations managers apply this management process to the decisions they make in the OM function. The **10 strategic OM decisions** are introduced in Table 1.2. Successfully addressing each of these decisions requires planning, organizing, staffing, leading, and controlling.

10 Strategic OM Decisions
- Design of goods and services
- Managing quality
- Process strategies
- Location strategies
- Layout strategies
- Human resources
- Supply-chain management
- Inventory management
- Scheduling
- Maintenance

Where Are the OM Jobs? How does one get started on a career in operations? The 10 strategic OM decisions identified in Table 1.2 are made by individuals who work in the disciplines shown in the blue areas of Figure 1.1. Business students who know their accounting,

STUDENT TIP An operations manager must successfully address the 10 decisions around which this text is organized.

LO 1.2 *Identify* the 10 strategic decisions of operations management

TABLE 1.2 Ten Strategic Operations Management Decisions

DECISION	CHAPTER(S)
1. *Design of goods and services:* Defines much of what is required of operations in each of the other OM decisions. For instance, product design usually determines the lower limits of cost and the upper limits of quality, as well as major implications for sustainability and the human resources required.	5, Supplement 5
2. *Managing quality and statistical process control:* Determines the customer's quality expectations and establishes policies and procedures to identify and achieve that quality.	6, Supplement 6
3. *Process and capacity strategies:* Determines how a good or service is produced (i.e., the process for production) and commits management to specific technology, quality, human resources, and capital investments that determine much of the firm's basic cost structure.	7, Supplement 7
4. *Location strategies:* Requires judgments regarding nearness to customers, suppliers, and talent, while considering costs, infrastructure, logistics, and government.	8
5. *Layout strategies:* Requires integrating capacity needs, personnel levels, technology, and inventory requirements to determine the efficient flow of materials, people, and information.	9
6. *Human resources, job design and work measurement:* Determines how to recruit, motivate, and retain personnel with the required talent and skills. People are an integral and expensive part of the total system design.	10
7. *Supply chain management:* Decides how to integrate the supply chain into the firm's strategy, including decisions that determine what is to be purchased, from whom, and under what conditions.	11, Supplement 11
8. *Inventory management:* Considers inventory ordering and holding decisions and how to optimize them as customer satisfaction, supplier capability, and production schedules are considered.	12, 14, 16
9. *Scheduling:* Determines and implements intermediate- and short-term schedules that effectively and efficiently use both personnel and facilities while meeting customer demands.	13, 15
10. *Maintenance:* Requires decisions that consider facility capacity, production demands, and personnel necessary to maintain a reliable and stable process.	17

statistics, finance, and OM have an opportunity to assume entry-level positions in all of these areas. As you read this text, identify disciplines that can assist you in making these decisions. Then take courses in those areas. The more background an OM student has in accounting, statistics, information systems, and mathematics, the more job opportunities will be available. About 40% of *all* jobs are in OM.

LO 1.3 *Identify* career opportunities in operations management

The following professional organizations provide various certifications that may enhance your education and be of help in your career:

- APICS, the Association for Operations Management (www.apics.org)
- American Society for Quality (ASQ) (www.asq.org)
- Institute for Supply Management (ISM) (www.ism.ws)
- Project Management Institute (PMI) (www.pmi.org)
- Council of Supply Chain Management Professionals (www.cscmp.org)

Figure 1.3 shows some recent job opportunities.

The Heritage of Operations Management

The field of OM is relatively young, but its history is rich and interesting. Our lives and the OM discipline have been enhanced by the innovations and contributions of numerous individuals. We now introduce a few of these people, and we provide a summary of significant events in operations management in Figure 1.4.

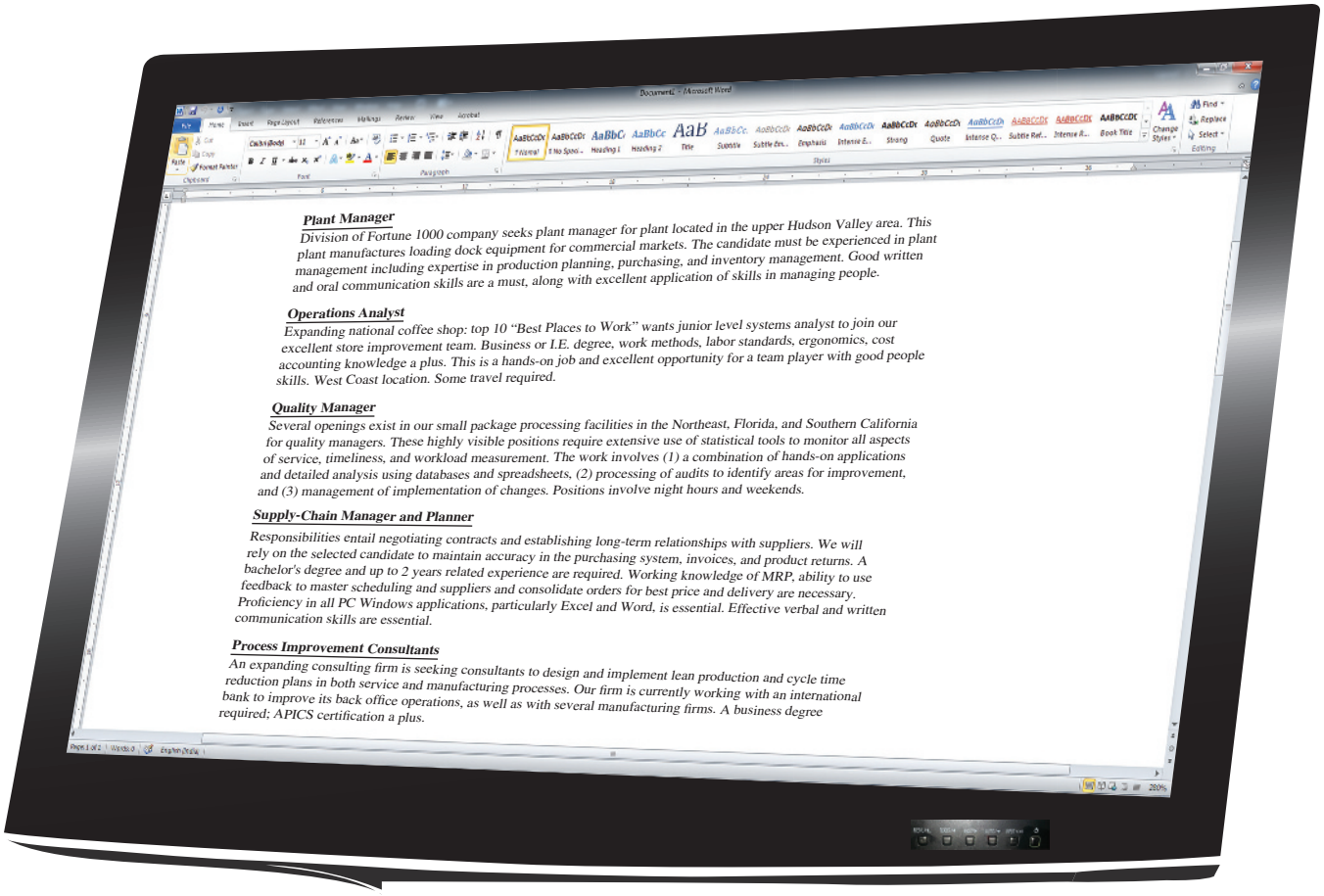


Figure **1.3**

Many Career Opportunities Exist for Operations Managers

Eli Whitney (1800) is credited for the early popularization of interchangeable parts, which was achieved through standardization and quality control. Through a contract he signed with the U.S. government for 10,000 muskets, he was able to command a premium price because of their interchangeable parts.

Frederick W. Taylor (1881), known as the father of scientific management, contributed to personnel selection, planning and scheduling, motion study, and the now popular field of ergonomics. One of his major contributions was his belief that management should be much more resourceful and aggressive in the improvement of work methods. Taylor and his colleagues, Henry L. Gantt and Frank and Lillian Gilbreth, were among the first to systematically seek the best way to produce.

Another of Taylor's contributions was the belief that management should assume more responsibility for:

1. Matching employees to the right job.
2. Providing the proper training.
3. Providing proper work methods and tools.
4. Establishing legitimate incentives for work to be accomplished.

Everett Collection/Newscom

Cost Focus		Quality Focus	Customization Focus	Globalization Focus
Early Concepts 1776–1880 Labor Specialization (Smith, Babbage) Standardized Parts (Whitney) **Scientific Management Era 1880–1910** Gantt Charts (Gantt) Motion & Time Studies (Gilbreth) Process Analysis (Taylor) Queuing Theory (Erlang)	**Mass Production Era 1910–1980** Moving Assembly Line (Ford/Sorensen) Statistical Sampling (Shewhart) Economic Order Quantity (Harris) Linear Programming (Dantzig) Material Requirements Planning (MRP)	**Lean Production Era 1980–1995** Just-in-Time (JIT) Computer-Aided Design (CAD) Electronic Data Interchange (EDI) Total Quality Management (TQM) Baldrige Award Empowerment Kanbans	**Mass Customization Era 1995–2005** Internet/E-Commerce Enterprise Resource Planning International Quality Standards (ISO) Finite Scheduling Supply Chain Management Mass Customization Build-to-Order Radio Frequency Identification (RFID)	**Globalization Era 2005–2025** Global Supply Chains and Logistics Growth of Transnational Organizations Sustainability Ethics in the Global Workplace Internet of Things (IoT) Digital Operations Industry 4.0

Figure **1.4**

Significant Events in Operations Management

By 1913, Henry Ford and Charles Sorensen combined what they knew about standardized parts with the quasi-assembly lines of the meatpacking and mail-order industries and added the revolutionary concept of the assembly line, where men stood still and material moved.

Quality control is another historically significant contribution to the field of OM. Walter Shewhart (1924) combined his knowledge of statistics with the need for quality control and provided the foundations for statistical sampling in quality control. W. Edwards Deming (1950) believed, as did Frederick Taylor, that management must do more to improve the work environment and processes so that quality can be improved.

Operations management will continue to progress as contributions from other disciplines, including *industrial engineering, statistics, management, analytics,* and *economics*, improve decision making.

Innovations from the *physical sciences* (biology, anatomy, chemistry, physics) have also contributed to advances in OM. These innovations include new adhesives, faster integrated circuits, gamma rays to sanitize food products, and specialized glass for iPhones and plasma TVs. Innovation in products and processes often depends on advances in the physical sciences.

Especially important contributions to OM have come from *information technology*, which we define as the systematic processing of data to yield information. Information technology—with wireless links, Internet, and e-commerce—is reducing costs and accelerating communication.

Decisions in operations management require individuals who are well versed in analytical tools, in information technology, and often in one of the biological or physical sciences. In this textbook, we look at the diverse ways a student can prepare for a career in operations management.

Operations for Goods and Services

STUDENT TIP
Services are especially important because almost 80% of all jobs are in service firms.

Manufacturers produce a tangible product, while service products are often intangible. But many products are a combination of a good and a service, which complicates the definition of a service. Even the U.S. government has trouble generating a consistent definition. Because definitions vary, much of the data and statistics generated about the service sector are inconsistent. However, we define **services** as including repair and maintenance, government, food and lodging, transportation, insurance, trade, financial, real estate, education, legal, medical, entertainment, and other professional occupations.

Services
Economic activities that typically produce an intangible product (such as education, entertainment, lodging, government, financial, and health services).

The operation activities for both goods and services are often very similar. For instance, both have quality standards, are designed and produced on a schedule that meets customer demand, and are made in a facility where people are employed. However, some major differences *do* exist between goods and services. These are presented in Table 1.3.

LO 1.4 *Explain* the distinction between goods and services

We should point out that in many cases, the distinction between goods and services is not clear-cut. In reality, almost all services and almost all goods are a mixture of a service and a tangible product. Even services such as consulting may require a tangible report. Similarly, the sale of most goods includes a service. For instance, many products have the service components of financing and delivery (e.g., automobile sales). Many also require after-sale training and maintenance (e.g., office copiers and machinery). "Service" activities may also be an integral part of production. Human resource activities, logistics, accounting, training, field service, and repair are all service activities, but they take place within a manufacturing organization. Very few services are "pure," meaning they have no tangible component. Counseling may be one of the exceptions.

Growth of Services

Services constitute the largest economic sector in postindustrial societies. Until about 1900, most Americans were employed in agriculture. Increased agricultural productivity allowed people to leave the farm and seek employment in the city. Similarly, manufacturing employment has decreased for the past 60 years. The changes in agriculture, manufacturing, and service employment as a percentage of the workforce are shown in Figure 1.5. Although the *number* of people employed in manufacturing has decreased since 1950, each person is now producing almost 20 times more than in 1950. Services became the dominant

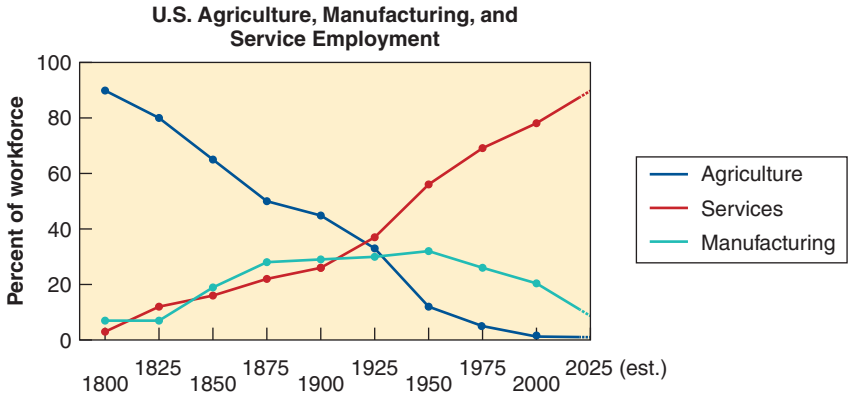
TABLE 1.3 Differences Between Goods and Services

CHARACTERISTICS OF SERVICES	CHARACTERISTICS OF GOODS
Intangible: Ride in an airline seat	Tangible: The seat itself
Produced and consumed simultaneously: Beauty salon produces a haircut that is consumed as it is produced	Product can usually be kept in inventory (beauty care products)
Unique: Your investments and medical care are unique	Similar products produced (iPods)
High customer interaction: Often what the customer is paying for (consulting, education)	Limited customer involvement in production
Inconsistent product definition: Auto insurance changes with age and type of car	Product standardized (iPhone)
Often knowledge based: Legal, education, and medical services are hard to automate	Standard tangible product tends to make automation feasible
Services dispersed: Service may occur at retail store, local office, house call, or via Internet.	Product typically produced at a fixed facility
Quality may be hard to evaluate: Consulting, education, and medical services	Many aspects of quality for tangible products are easy to evaluate (strength of a bolt)
Reselling is unusual: Musical concert or medical care	Product often has some residual value

Figure 1.5

U.S. Agriculture, Manufacturing, and Service Employment

Source: U.S. Bureau of Labor Statistics.



employer in the early 1920s, with manufacturing employment peaking at about 32% in 1950. The huge productivity increases in agriculture and manufacturing have allowed more of our economic resources to be devoted to services. Consequently, much of the world can now enjoy the pleasures of education, health services, entertainment, and myriad other things that we call services. Examples of firms and percentage of employment in the U.S. service sector are shown in Table 1.4. Table 1.4 also provides employment percentages for the nonservice sectors of manufacturing, construction, agriculture, and mining on the bottom four lines.

Service sector
The segment of the economy that includes trade, financial, lodging, education, legal, medical, and other professional occupations.

Service Pay

Although there is a common perception that service industries are low paying, in fact, many service jobs pay very well. Operations managers in the maintenance facility of an airline are very well paid, as are the operations managers who supervise computer services to the financial community. About 42% of all service workers receive wages above the national average. However, the service-sector average is driven down because 14 of the U.S. Department of

TABLE 1.4 Examples of Organizations in Each Sector

SECTOR	EXAMPLE	PERCENTAGE OF ALL JOBS	
Service Sector			
Education, Medical, Other	San Diego State University, Arnold Palmer Hospital	16.2	
Trade (retail, wholesale), Transportation	Walgreen's, Walmart, Nordstrom, Alaska Airlines	17.1	
Information, Publishers, Broadcast	IBM, Bloomberg, Pearson, ESPN	1.8	
Professional, Legal, Business Services, Associations	Snelling and Snelling, Waste Management, American Medical Association, Ernst & Young	17.0	85.9
Finance, Insurance, Real Estate	Citicorp, American Express, Prudential, Aetna	9.6	
Leisure, Lodging, Entertainment	Red Lobster, Motel 6, Celebrity Cruises	10.0	
Government (Fed, State, Local)	U.S., State of Alabama, Cook County	14.2	
Manufacturing Sector	General Electric, Ford, U.S. Steel, Intel		7.9
Construction Sector	Bechtel, McDermott		4.3
Agriculture	King Ranch		1.5
Mining Sector	Homestake Mining		0.4
Grand Total			100.0

Source: Bureau of Labor Statistics, 2017.

Commerce categories of the 33 service industries do indeed pay below the all-private industry average. Of these, retail trade, which pays only 61% of the national private industry average, is large. But even considering the retail sector, the average wage of all service workers is about 96% of the average of all private industries.

The Productivity Challenge

STUDENT TIP

Why is productivity important? Because it determines our standard of living.

Productivity

The ratio of outputs (goods and services) divided by one or more inputs (such as labor, capital, or management).

LO 1.5 *Explain* the difference between production and productivity

The creation of goods and services requires changing resources into goods and services. The more efficiently we make this change, the more productive we are and the more value is added to the good or service provided. **Productivity** is the ratio of outputs (goods and services) divided by the inputs (resources, such as labor and capital) (see Figure 1.6). The operations manager's job is to enhance (improve) this ratio of outputs to inputs. Improving productivity means improving efficiency.[1]

This improvement can be achieved in two ways: reducing inputs while keeping output constant or increasing output while keeping inputs constant. Both represent an improvement in productivity. In an economic sense, inputs are labor, capital, and management, which are integrated into a production system. Management creates this production system, which provides the conversion of inputs to outputs. Outputs are goods and services, including such diverse items as guns, butter, education, improved judicial systems, and ski resorts. *Production* is the making of goods and services. High production may imply only that more people are working and that employment levels are high (low unemployment), but it does not imply high *productivity*.

Measurement of productivity is an excellent way to evaluate a country's ability to provide an improving standard of living for its people. *Only through increases in productivity can the standard of living improve.* Moreover, only through increases in productivity can labor, capital, and management receive additional payments. If returns to labor, capital, or management are increased without increased productivity, prices rise. On the other hand, downward pressure is placed on prices when productivity increases because more is being produced with the same resources.

The benefits of increased productivity are illustrated in the *OM in Action* box "Improving Productivity at Starbucks."

For well over a century (from about 1869), the U.S. has been able to increase productivity at an average rate of almost 2.5% per year. Such growth has doubled U.S. wealth every 30 years. The manufacturing sector, although a decreasing portion of the U.S. economy, has on occasion seen annual productivity increases exceeding 4%, and service sector increases of almost 1%. However, U.S. annual productivity growth in the early part of the 21st century is slightly below the 2.5% range for the economy as a whole and in recent years has been trending down.[2]

In this text, we examine how to improve productivity through operations management. Productivity is a significant issue for the world and one that the operations manager is uniquely qualified to address.

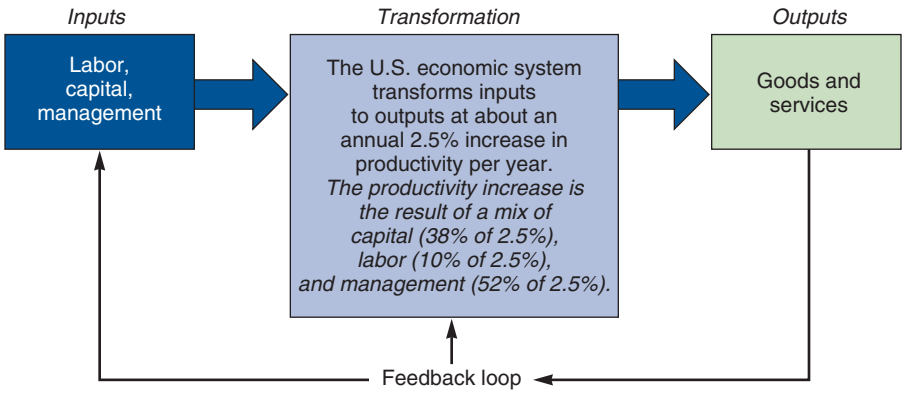


Figure 1.6

The Economic System Adds Value by Transforming Inputs to Outputs

An effective feedback loop evaluates performance against a strategy or standard. It also evaluates customer satisfaction and sends signals to managers controlling the inputs and transformation process.

OM in Action Improving Productivity at Starbucks

"This is a game of seconds …" says Silva Peterson, whom Starbucks has put in charge of saving seconds. Her team of 10 analysts is constantly asking themselves: "How can we shave time off this?"

Peterson's analysis suggested that there were some obvious opportunities. First, stop requiring signatures on credit-card purchases under $25. This sliced 8 seconds off the transaction time at the cash register.

Then analysts noticed that Starbucks' largest cold beverage, the Venti size, required two bending and digging motions to scoop up enough ice. The scoop was too small. Redesign of the scoop provided the proper amount in one motion and cut 14 seconds off the average time of 1 minute.

Third were new espresso machines; with the push of a button, the machines grind coffee beans and brew. This allowed the server, called a "barista" in Starbucks's vocabulary, to do other things. The savings: about 12 seconds per espresso shot.

As a result, operations improvements at Starbucks outlets have increased the average transactions per hour to 11.7—a 46% increase—and yearly volume by $250,000, to about $1 million. The result: a 27% improvement in overall productivity—about 4.5% per year. In the service industry, a 4.5% per year increase is very tasty.

Sources: Businessweek (August 23–30, 2012); *Fortune* (October 30, 2014); and **QZ.com/Starbucks**.

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Productivity Measurement

LO 1.6 *Compute* single-factor productivity

The measurement of productivity can be quite direct. Such is the case when productivity is measured by labor-hours per ton of a specific type of steel. Although labor-hours is a common measure of input, other measures such as capital (dollars invested), materials (tons of ore), or energy (kilowatts of electricity) can be used.[3] An example of this can be summarized in the following equation:

$$\text{Productivity} = \frac{\text{Units produced}}{\text{Input used}} \tag{1-1}$$

For example, if units produced = 1,000 and labor-hours used is 250, then:

$$\text{Single-factor productivity} = \frac{\text{Units produced}}{\text{Labor-hours used}} = \frac{1{,}000}{250} = 4 \text{ units per labor-hour}$$

Single-factor productivity
Indicates the ratio of goods and services produced (outputs) to one resource (input).

Multifactor productivity
Indicates the ratio of goods and services produced (outputs) to many or all resources (inputs).

The use of just one resource input to measure productivity, as shown in Equation (1-1), is known as **single-factor productivity**. However, a broader view of productivity is **multifactor productivity**, which includes all inputs (e.g., capital, labor, material, energy). Multifactor productivity is also known as *total factor productivity*. Multifactor productivity is calculated by combining the input units as shown here:

$$\text{Multifactor productivity} = \frac{\text{Output}}{\text{Labor} + \text{Material} + \text{Energy} + \text{Capital} + \text{Miscellaneous}} \tag{1-2}$$

To aid in the computation of multifactor productivity, the individual inputs (the denominator) can be expressed in dollars and summed as shown in Example 2.

Example 2

COMPUTING SINGLE-FACTOR AND MULTIFACTOR GAINS IN PRODUCTIVITY

Collins Title Insurance Ltd. wants to evaluate its labor and multifactor productivity with a new computerized title-search system. The company has a staff of four, each working 8 hours per day (for a payroll cost of $640/day) and overhead expenses of $400 per day. Collins processes and closes on 8 titles each day. The new computerized title-search system will allow the processing of 14 titles per day. Although the staff, their work hours, and pay are the same, the overhead expenses are now $800 per day.

APPROACH ▶ Collins uses Equation (1-1) to compute labor productivity and Equation (1-2) to compute multifactor productivity.

LO 1.7 *Compute* multifactor productivity

SOLUTION ▶

$$\text{Labor productivity with the old system: } \frac{8 \text{ titles per day}}{32 \text{ labor-hours}} = .25 \text{ title per labor-hour}$$

$$\text{Labor productivity with the new system: } \frac{14 \text{ titles per day}}{32 \text{ labor-hours}} = .4375 \text{ title per labor-hour}$$

$$\text{Multifactor productivity with the old system: } \frac{8 \text{ titles per day}}{\$640 + \$400} = .0077 \text{ title per dollar}$$

$$\text{Multifactor productivity with the new system: } \frac{14 \text{ titles per day}}{\$640 + \$800} = .0097 \text{ title per dollar}$$

Labor productivity has increased from .25 to .4375. The change is $(.4375 - .25)/.25 = 0.75$, or a 75% increase in labor productivity. Multifactor productivity has increased from .0077 to .0097. This change is $(.0097 - .0077)/.0077 = 0.26$, or a 26% increase in multifactor productivity.

INSIGHT ▶ Both the labor (single-factor) and multifactor productivity measures show an increase in productivity. However, the multifactor measure provides a better picture of the increase because it includes all the costs connected with the increase in output.

LEARNING EXERCISE ▶ If the overhead goes to \$960 (rather than \$800), what is the multifactor productivity? [Answer: .00875.]

RELATED PROBLEMS ▶ 1.1, 1.2, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 1.10, 1.11, 1.13, 1.14, 1.17

Use of productivity measures aids managers in determining how well they are doing. But results from the two measures can be expected to vary. If labor productivity growth is entirely the result of capital spending, measuring just labor distorts the results. Multifactor productivity is usually better, but more complicated. Labor productivity is the more popular measure. The multifactor-productivity measures provide better information about the trade-offs among factors, but substantial measurement problems remain. Some of these measurement problems are:

1. *Quality* may change while the quantity of inputs and outputs remains constant. Compare a smart LED TV of this decade with a black-and-white TV of the 1950s. Both are TVs, but few people would deny that the quality has improved. The unit of measure—a TV—is the same, but the quality has changed.
2. *External elements* may cause an increase or a decrease in productivity for which the system under study may not be directly responsible. A more reliable electric power service may greatly improve production, thereby improving the firm's productivity because of this support system rather than because of managerial decisions made within the firm.
3. *Precise units of measure* may be lacking. Not all automobiles require the same inputs: Some cars are subcompacts, others are 911 Turbo Porsches.

Productivity measurement is particularly difficult in the service sector, where the end product can be hard to define. For example, economic statistics ignore the quality of your haircut, the outcome of a court case, or the service at a retail store. In some cases, adjustments are made for the quality of the product sold but *not* the quality of the sales presentation or the advantage of a broader product selection. Productivity measurements require specific inputs and outputs, but a free economy is producing worth—what people want—which includes convenience, speed, and safety. Traditional measures of outputs may be a very poor measure of these other measures of worth. Note the quality-measurement problems in a law office, where each case is different, altering the accuracy of the measure "cases per labor-hour" or "cases per employee."

Productivity Variables

As we saw in Figure 1.6, productivity increases are dependent on three **productivity variables**:

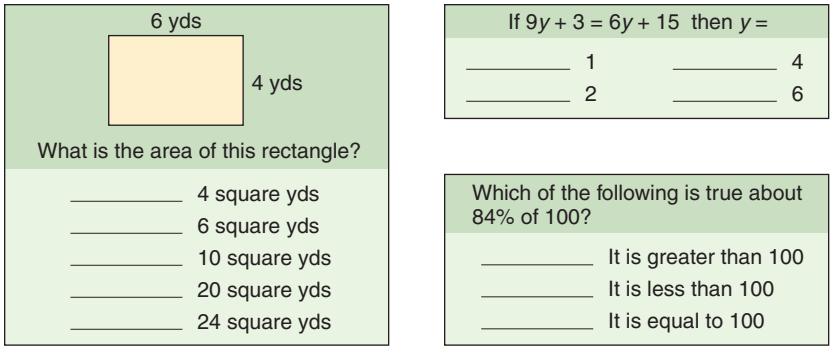
Productivity variables
The three factors critical to productivity improvement—labor, capital, and the art and science of management.

1. *Labor,* which contributes about 10% of the annual increase.
2. *Capital,* which contributes about 38% of the annual increase.
3. *Management,* which contributes about 52% of the annual increase.

These three factors are critical to improved productivity. They represent the broad areas in which managers can take action to improve productivity.

Figure 1.7

About Half of the 17-Year-Olds in the U.S. Cannot Correctly Answer Questions of This Type



LO 1.8 *Identify* the critical variables in enhancing productivity

Labor Improvement in the contribution of labor to productivity is the result of a healthier, better-educated, and better-nourished labor force. Some increase may also be attributed to a shorter workweek. Historically, about 10% of the annual improvement in productivity is attributed to improvement in the quality of labor. Three key variables for improved labor productivity are:

1. Basic education appropriate for an effective labor force.
2. Diet of the labor force.
3. Social overhead that makes labor available, such as transportation and sanitation.

Illiteracy and poor diets are a major impediment to productivity, costing countries up to 20% of their productivity. Infrastructure that yields clean drinking water and sanitation is also an opportunity for improved productivity, as well as an opportunity for better health, in much of the world.

In developed nations, the challenge becomes *maintaining and enhancing the skills of labor* in the midst of rapidly expanding technology and knowledge. Recent data suggest that the average American 17-year-old knows significantly less mathematics than the average Japanese at the same age, and about half cannot answer the questions in Figure 1.7. Moreover, about one-third of American job applicants tested for basic skills were deficient in reading, writing, or math.

Overcoming shortcomings in the quality of labor while other countries have a better labor force is a major challenge. Perhaps improvements can be found not only through increasing competence of labor but also via *better utilized labor with a stronger commitment*. Training, motivation, team building, and the human resource strategies discussed in Chapter 10, as well as improved education, may be among the many techniques that will contribute to increased labor productivity. Improvements in labor productivity are possible; however, they can be expected to be increasingly difficult and expensive.

Capital Human beings are tool-using animals. Capital investment provides those tools. Capital investment has increased in the U.S. every year except during a few very severe recession periods. Annual capital investment in the U.S. has increased at an annual rate of 1.5% after allowances for depreciation.

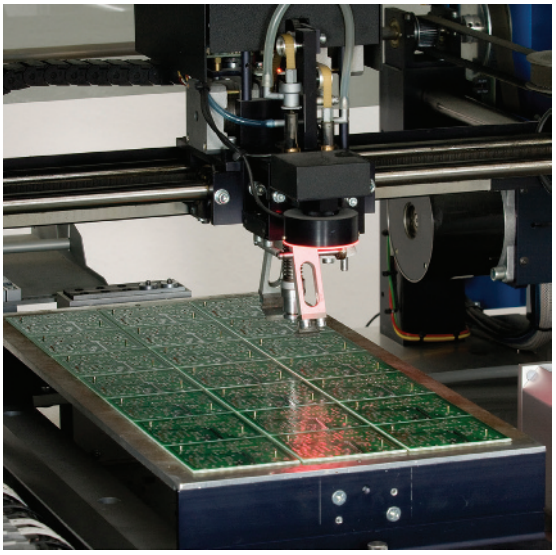
Inflation and taxes increase the cost of capital, making capital investment increasingly expensive. When the capital invested per employee drops, we can expect a drop in productivity. Using labor rather than capital may reduce unemployment in the short run, but it also makes economies less productive and therefore lowers wages in the long run. Capital investment is often a necessary, but seldom a sufficient, ingredient in the battle for increased productivity.

The trade-off between capital and labor is continually in flux. The higher the cost of capital or perceived risk, the more projects requiring capital are "squeezed out": they are not pursued because the potential return on investment for a given risk has been reduced. Managers adjust their investment plans to changes in capital cost and risk.

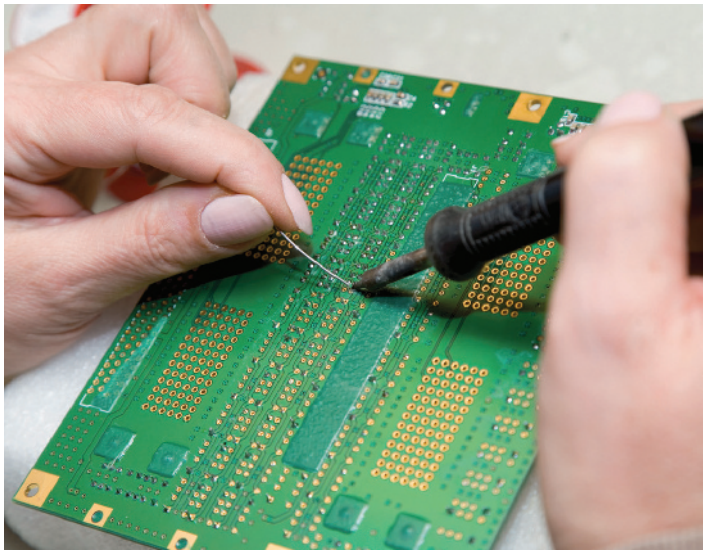
Management Management is a factor of production and an economic resource. Management is responsible for ensuring that labor and capital are effectively used to increase productivity. Management accounts for over half of the annual increase in productivity. This increase includes improvements made through the use of knowledge and the application of technology.

Knowledge society
A society in which much of the labor force has migrated from manual work to work based on knowledge.

Using knowledge and technology is critical in postindustrial societies. Consequently, postindustrial societies are also known as **knowledge societies**. Knowledge societies are those in which much of the labor force has migrated from manual work to technical and information-processing



Andrzej Thiel/Fotolia



Guy Shapira/Shutterstock

The effective use of capital often means finding the proper trade-off between investment in capital assets (automation, left) and human assets (a manual process, right). While there are risks connected with any investment, the cost of capital and physical investments is fairly clear-cut, but the cost of employees has many hidden costs including fringe benefits, social insurance, and legal constraints on hiring, employment, and termination.

tasks requiring ongoing education. The required education and training are important high-cost items that are the responsibility of operations managers as they build organizations and workforces. The expanding knowledge base of contemporary society requires that managers use *technology and knowledge effectively.*

More effective use of capital also contributes to productivity. It falls to the operations manager, as a productivity catalyst, to select the best new capital investments as well as to improve the productivity of existing investments.

The productivity challenge is difficult. A country cannot be a world-class competitor with second-class inputs. Poorly educated labor, inadequate capital, and dated technology are second-class inputs. High productivity and high-quality outputs require high-quality inputs, including good operations managers.

Productivity and the Service Sector

The service sector provides a special challenge to the accurate measurement of productivity and productivity improvement. The traditional analytical framework of economic theory is based primarily on goods-producing activities. Consequently, most published economic data relate to goods production. But the data do indicate that, as our contemporary service economy has increased in size, we have had slower growth in productivity.

Olaf Jandke/Agencja Fotograficzna Caro/Alamy Stock Photo

Siemens, a multi-billion-dollar German conglomerate, has long been known for its apprentice programs in its home country. Because education is often the key to efficient operations in a technological society, Siemens has spread its apprentice-training programs to its U.S. plants. These programs are laying the foundation for the highly skilled workforce that is essential for global competitiveness.