

Principles of Operations Management

Sustainability and Supply Chain Management

TWELFTH EDITION

Jay Heizer • Barry Render • Chuck Munson



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TWELFTH EDITION

GLOBAL EDITION

PRINCIPLES OF OPERATIONS MANAGEMENT

Sustainability and Supply Chain Management

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To Kay Heizer, always at my side

J.H.

To Donna, Charlie, and Jesse

B.R.

To Kim, Christopher, and Mark Munson for their unwavering support

C.M.

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Preface

Operations is an exciting area of management that has a profound effect on productivity. The goal of this text and its accompanying online resources 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, placing an order through Amazon.com, boarding a flight on Alaska Airlines, or taking a cruise with Celebrity Cruises. This text along with its online learning tools and resources offers 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.

New to This Edition

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

New Coverage and Examples

We provide a detailed list of chapter-by-chapter changes below, but here are a few important topics we are discussing in the 12th edition.

- Industry 4.0, sometimes called the Fourth Industrial Revolution, with extensive digitalization and pervasive impact on OM, is now introduced throughout the text via discussion, photos, and cases. For instance, an introduction is provided in Chapter 1 and illustrated in Chapter 7's discussion of sensors and vision technology. It is further discussed in Chapter 9's digitalization of layout and Chapter 10's digital monitoring of workers. In Chapter 11, we also added a new section called "Digitalization and the Internet of Things," noting how sensors are impacting the logistics process.
- COVID-19 had, of course, a major impact of lives, education, work habits, and global supply chains. Not every aspect of business will return to normal immediately, and we address the fallouts throughout the text. For example, Figure 2.1 shows the impact of COVID on world trade. We note COVID's impact on forecasting in Chapter 4. We added an online case study, "Global Chemical's COVID-19 Capacity Decision," in Supplement 7. We revamped coverage of office layout changes due to COVID in Chapter 9. Finally, we added a new case study, "Premiere Bicycles' COVID Problem," and a discussion of supermarket supply chain shortages in Chapter 11.
- Every chapter supplement now opens with a photo vignette that provides a motivational image of OM as applied to that topic.
- There are 42 "OM in Action" boxes, which are real-world examples and tell interesting tales
 of OM in business throughout the text. Thirteen are new to this edition and deal with such
 topics as 3-D printed steaks (Chapter 5), an automated sushi restaurant (Chapter 7), bitcoin
 (Chapter 8), and scheduling in the NBA (Chapter 15).

Product Design at Nautique Boat Company

For nearly 100 years, Florida-based Nautique Boat Company has built innovative boats in a very competitive market. Nautique, as the premier boat for waterskiing, wakeboarding, and wake surfing, is on the cutting edge of style, customer satisfaction, and performance. There is continuing and rapid change in this industry, which sees substantial input from imaginative, experimenting customers. Success means integrating customer feedback, technological change, and creative engineering talent into a dynamic, but ongoing, product line. As number one in its market, Nautique is a vivid example of what it takes to be a creative leader.

From the introduction of waterskiing in the 1920s to barefoot skiing to wake boarding in the 1990s and wake surfing in the 2000s, Nautique has led. While these new sport expectations were placed on boat performance, changes in marine engineering and technology were also taking place. Ski boats were initially made of wood, changing to fiberglass in the late 1950s, with tracking fins added in the 1960s. The 1990s brought longer and wider boats with hull changes, slopping transoms, spray relief, and flight control towers. This was followed by *Total Wake Control*, which allows users to instantly switch from wakeboarding to wake surfing. Indeed, the wake can now be customized, providing ramp-style and vertical-style wakes behind the same boat. Simultaneously, carpet, trim, and color options and a variety of powerful engines, as well as major electronic innovations such as sonar. Video Case D

GPS, and sophisticated sound systems with strategically placed speakers, have been introduced. Nautique's design team is now developing the boat of the future—the electric boat—with the prototype in testing.

To maintain Nautique's innovative prowess, Chief Designer Steve Carlton (shown in photo) has organized his 40-person department into three teams: model integration, design, and engineering. In addition to creating, developing, and designing new innovations, Nautique also plans on two to four new models each year, with remodeling or updating every 2 years.

To facilitate efficient development and design integrity, Carlton's design and development team uses sophisticated CAD software from Rhino and SolidWorks. NX software is also available for tooling, and StrataSys 3D printers facilitate prototyping small parts. Design typically begins with sketches and clay models, progressing to CAD drawings and then to a fullscale wooden model, followed by a full-size boat for testing in Nautique's private lake.

Each design innovation requires ongoing discussion with the in-house engineering staff to provide design integrity. Similarly, the team sends staff to the factory floor to work with production personnel to ensure production capability and with external suppliers to ensure raw material and component quality and delivery. This coordination with external suppliers and internal production by the design group has the goal of facilitating a smooth transition to production.

Video Cases—Nautique Boat Company

With each edition, we offer 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 Nautique Boat Company, maker of the iconic Ski Nautique and other premium pleasure boats. This fascinating organization opened its doors for us to examine and share with you leadingedge OM in the boating industry.

These new videos provide an inside look at:

- Operations strategy at Nautique (Chapter 2);
- How Nautique designs a new product (Chapter 5);
- Supply chain issues facing Nautique (Supplement 11); and
- Inventory management at Nautique (Chapter 12).

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

We take the integration of our video case studies seriously, and for this reason, all 45 videos are created by the authors to explicitly match text content and terminology.

VIDEO CASES	Ch 1: Operations & Productivity	Ch 2: Operations Strategy	Ch 3: Project Management	Ch 4: Forecasting	Ch 5: Design of Goods & Services	Sup 5: Sustainability	Ch 6: Managing Quality	Sup 6: Statistical Process Control	Ch 7: Process Strategies	Sup 7: Capacity & Constraint Mgt	Ch 8: Location Strategies	Ch 9: Layout Strategies	Ch 10: HR & Work Measurement	Ch 11: Supply Chain Management	Sup 11: Supply Chain Mgt Analysis	Ch 12: Inventory Management	Ch 13: Aggregate Planning & S&OP	Ch 14: MRP and ERP	Ch 15: Short-Term Scheduling	Ch 16: Lean Operations	Ch 17: Maintenance & Reliability
Alaska Airlines							1		1				1							1	
Arnold Palmer Hospital			1				1		1	1		1		1						1	
Celebrity Cruises	1				1	1	1									1					
Darden Restaurants		1						1			1			1							
Frito-Lay	1					1		1								1					1
Hard Rock Cafe	1	1	1	1							1		1						1		
Nautique Boat Company		1			1										1	1					
Orlando Magic (Amway Center)				1		1											1	1	1		
Wheeled Coach Ambulance									1			1				1		1			

New Videos to Help Students Build Their Own Excel Spreadsheets

Excel use in the Operations Management course is more and more important. Instructors often ask their students to develop their own Excel spreadsheet models. We include "Creating Your Own Excel Spreadsheets" examples toward the end of numerous chapters to illustrate how students can build their own spreadsheets to solve OM problems, and in this edition, we've created 12 new videos to accompany these examples.

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 than any other OM text.

For this edition, we have added scores of new algorithmic problems and concept questions in MyLab Operations Management!

Algorithmic Test Bank Questions

About 200 numerical multiple choice test bank questions have been converted to algorithmic so that every student sees different numbers and a different set of answers for these questions.

Detailed Chapter-by-Chapter Changes

Chapter 1: Operations and Productivity

- New chapter opener features OM career opportunities with real job listings for five jobs.
- New section covering Industry 4.0 (the 4th industrial revolution).
- New author-created video to accompany "Creating Your Own Excel Spreadsheets."
- Uber Technologies case study rewritten to bring it up-to-date with recent company changes.

Chapter 2: Operations Strategy in a Global Environment

- New chapter opener/photo features Super Air Nautique product differentiation.
- Global Company Profile on Boeing completely rewritten to focus on the whole product line, not just the 787. This includes new photos.
- Figure 2.1 updated to show USMCA and the impact of containerization and COVID on world trade.
- NAFTA material updated to include USMCA.
- Figure 2.5, Product Life Cycle, has mostly new product examples.
- New author-created video to accompany "Creating Your Own Excel Spreadsheets."
- Competitive ranking homework problem uses a new index.
- New video case: "Strategy at Nautique Boat Company."

Chapter 3: Project Management

- New chapter opener photo features Celebrity Cruises ship construction.
- Overlays for Figure 3.10 have been removed and replaced by a revamped figure.
- Section on Microsoft Project is more generic and now called "Using Software to Manage Projects." Program 3.3 is deleted.
- Four homework problems (3.16, 3.26, 3.27) have been changed to make them more assignable in quizzes and tests.

Chapter 4: Forecasting

- New chapter opener/photo features Yamaha products, illustrating seasonal forecasts.
- Material on COVID's impact on forecasting is added.
- Forecasting technique called "stagger charts" is added.
- New author-created video to accompany "Creating Your Own Excel Spreadsheets."
- Three very large homework problems have been shortened to make them more assignable in quizzes and tests.

Chapter 5: Design of Goods and Services

- New chapter opening photo/caption shows McDonald's revamped Happy Meal.
- New Global Company Profile features Nautique Boats' product design (with new photos).
- Overlays for Example 1 have been removed and the figure redrawn.
- New OM in Action box features 3D printed steaks.
- New homework problems 5.26–5.27 have been added.
- New video case study: "Product Design at Nautique Boat Company."

Chapter 6: Managing Quality

- New chapter opening/photo caption features Alaska Airlines.
- Update from ISO 9001:2015 to ISO 9004:2018.
- Six Sigma material shortened and simplified.
- Figure 6.4 (Taguchi) redrawn for clarity.
- New discussion question 18 relates to the OM in Action Box on Boeing 787.

Supplement 6: Statistical Process Control

- New explanation of *p*-chart sample size restrictions.
- Example S4 is revised.
- New homework problems: \$6.14, \$6.15, \$6.20, \$6.25, \$6.26, \$6.27, \$6.31, \$6.35, \$6.38, and \$6.47
- Extensive revision to the treatment of process ratio and capability index, including Example S7.
- New author-created video to accompany "Creating Your Own Excel Spreadsheets."
- New case study: "PEI Potato Purveyors."
- New case study: "Alabama Airlines' On-Time Schedule."

Chapter 7: Process Strategies

- New chapter opening photo of process control at an Australian steel mill.
- Major revision of the treatment of mass customization.
- Chapter revisions focus on technology, including: the section on Production Technology now includes a discussion of sensors, a new OM in Action box on Tyson Chicken's use of vision technology, and a new OM in Action box on an automated sushi restaurant.
- Revised homework problems 7.13–7.17 are now specific enough to be assigned in MyLab.
- New case study: "Rochester Manufacturing's Process Decision."

Supplement 7: Capacity and Constraint Management

- Rewritten OM in Action box on airline capacity to note impacts of the pandemic.
- Updated Arnold Palmer Hospital capacity case with 3 years of recent data, which creates a new solution.
- Added the online case "Global Chemical's COVID-19 Capacity Decision."
- New author-created video to accompany "Creating Your Own Excel Spreadsheets."

Chapter 8: Location Strategies

- New chapter opener on Geographic Information Systems used in site location.
- Updated the Global Company Profile on FedEx.
- Replaced Table 8.1's "Competitive Index" with a new index called "Ease of Doing Business."
- Added OM in Action box: "Bitcoin Goes to Where the Power Is Cheap."
- Revised Table 8.2-corruption rankings-with 2020 data.
- New author-created video to accompany "Creating Your Own Excel Spreadsheets."
- Added 3 new homework problems: 8.25, 8.33, 8.34.
- New case study: "National Assembly Services."

Chapter 9: Layout Strategies

- New chapter opener/photo features Hard Rock's retail layout.
- New material on digitalization of layout.
- Material on Muther's Grid moved from office layout section to process layout, with two new assignable questions/problems.
- Office layout revised to reflect the realities of COVID-19.
- New homework problem 9.24.
- New case study: "Layout Strategies: IKEA."

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

- New chapter-opening photo features Alaska Airlines' CPR training for crew.
- The Global Company Profile on NASCAR has been updated.
- New OM in Action box called "The Rise of the Exoskeleton."
- New material on use of sensors in helping workers ergonomically.

- New section introducing Digital Monitoring Techniques.
- Four new homework problems: 10.38, 10.43, 10.45, 10.46.

Chapter 11: Supply Chain Management

- New opening photo relating supermarket supply chain shortages during COVID.
- New material on Korean coalitions called "chaebols."
- New section on the Omnichannel strategy.
- New material on blockchain, with an example from Carrefour's chicken supply chain, including graphic flowchart in Figure 11.3.
- New section on Digitalization and the Internet of Things (IoT).
- New photo/material on sensors in the logistics process.
- New OM in Action box: "New York City Chokes on Deliveries from Online Orders."
- New case study: "Premiere Bicycles' COVID Problem."

Supplement 11: Supply Chain Management Analytics

- New OM in Action Box: "The Recurring Bullwhip Effect."
- New Figure S11.3 on RFID at Walmart.
- New homework problem S11.15.
- New video case study: "Supply Chain Issues at Nautique Boat Company."
- New additional case study: "JIT after a Catastrophe" appears in MyLab.

Chapter 12: Inventory Management

- New chapter opening featuring inventory control at LEGO.
- Updated Global Company Profile on Amazon.com.
- New OM in Action box on Mattel.
- New OM in Action box on apparel companies' unsold clothes.
- New author-created video to accompany "Creating Your Own Excel Spreadsheets."
- ABC homework problems 12.5–12.6 rewritten with new data.
- Inventory Control at Wheeled Coach case study moved to MyLab.
- New case study: "Amazon: Using Chaos as an Inventory Management System."
- New video case study: "Inventory Control at Nautique Boat Co."

Chapter 13: Aggregate Planning and S&OP

- New chapter-opening photo features John Deere.
- New case study: "Revenue Management: Theater Tickets."

Chapter 14: Material Requirements Planning (MRP) and ERP

- New opening photo featuring Nautique Boat Company's MRP system.
- Figure 14.1 on the planning process revised.
- Major rewrite and reorganization of material on Lot sizing, MRP management and MRPII, with a new section on finite scheduling in MRP.
- Problems 14.11 and 14.12 modified.
- New additional case study: "OSI's Attempt at ERP."

Chapter 15: Short-Term Scheduling

- New chapter-opening photo featuring scheduling on Celebrity Cruises.
- New OM in Action box: "NBA's Scheduling Secret."
- Two new homework problems (15.31 and 15.32) on cyclical scheduling.

Chapter 16: Lean Operations

- New chapter-opening photo featuring a lean restaurant.
- New section covering the topic of Activity-Based Costing.

Chapter 17: Maintenance and Reliability

- · New chapter-opening photo spread featuring the importance of maintenance at four companies.
- New homework problem added.

In Every Chapter

There is a new section at the end of the Rapid Reviews titled "ADDITIONAL MYLAB OPERATIONS MANAGEMENT RESOURCES." Each of these can contain up to six topics: (1) Videos for Creating Your Own Excel Spreadsheets, (2) Additional Case Studies, (3) Southwestern University Integrated Case Studies, (4) Multiple Choice Case Questions, (5) Recent Graduate Videos, and (6) Simulations.

Solving Teaching and Learning Challenges

OM in Action Bitcoin Goes to Where the Power Is Cheap

Home to hydroelectric dams that harness the flow of the Columbia River, north central Washington has some of the cheapest power in the U.S. That has madu the largely rural area best known for its apple orchards a magnet for bitcoin miners, who use powerful specialized computers to generate new units of cryptocurrencies—a process that requires vast amounts of electricity to run and cool thousands of machines. "If you ask the guys at UPS or FedEx what they're delivering to Wenatchee, I think they'd tell you it's a whole bunch of bitcoin mining machines," says that town's mayor.

Mining operations can squeeze into small spaces. Shoebox-size computer servers that suck up as much power as 1,000 homes can be packed into a 25-by-25-ford room. Miners have poped up in unexpected places in the area an old bundromat, a former warehouse, and apartments. There are already at least 30 known cryptocurrency-mining operations in north central Washington These aren't the first businesses to come to the region for its cheap

power. Aluminum smelters once flocked here. In more recent years, companies including Microsoft and Dell have built data-storage centers. Electricity in the region costs 2 to 4 cents per kwh compared with more than 10 cents nationwide. Some residents and officials hope that mining will be the first step toward transforming the area into a business hub for *blockchain* technology, bringing new jobs.



Others worry these miners will drain the area of the surplus power that helps keep rates low. Here is why: Comparative power usage rates (per sq. ft. per year): school—10, home—12, hotel—18, hospital—32, grocery store— 40, computer data center—2,100! Our text is now in its 12th edition, meaning it has been educating and challenging students for over 40 years. We have served close to 2 million readers with the comprehensive learning package that has made the book the best-selling Operations Management text in the U.S. and global marketplaces. We created the learning system with the goal of teaching and preparing your students with employable skills. Here is how:

Real-world examples on page after page. Each chapter opens with a two-page "Global Company Profile" that describes how the featured firm, be it Boeing, Alaska Air, or NASCAR, achieves competitive advantage using the OM techniques and tools of that chapter. We con-

tinue with "OM in Action" boxes, each telling a short story about current OM issues and how an organization tackled them. Finally, every chapter concludes with one or more case studies, including 45 case studies of real companies with accompanying videos. Readers will deal with the cruise industry at Celebrity Cruises, the healthcare business at Arnold Palmer Hospital, boat manufacturing at Nautique Boats, and food/entertainment at Hard Rock Cafes, among many others. These cases help students connect the OM concepts to real-world scenarios.

A wealth of examples, solved problems, and homework problems. The only way to understand the analytics of OM are to practice them. Each of these examples contains an "added insight" feature to further understanding. In each chapter we provide numerous step-by-step examples of how to tackle a real problem. We also include a section called "Solved Problems" at the end of each chapter, which provides another look at the topic with similar, detailed solutions. In addition, these 91 Solved Problems are supplemented with "virtual office hour" videos (5 to 15 minutes each) with the authors carefully walking students through each problem. Then come the 850 homework problems, with answers to even-numbered problems in the appendix.

"Rapid Reviews" at the end of each chapter. Students often need an outline to help study what they have learned in the chapter. Our two-page Rapid Reviews contain a summary of all key points, formulas, definitions, and concepts in that chapter. The Rapid Reviews conclude with five or six multiple-choice questions (answers provided) to test students' understanding and help prepare them for a quiz.

Ethical dilemmas facing OM decision makers. Near the end of each chapter, we pose a tough question: What should a manager do when faced with an ethical dilemma (for ex-

The 10 OM strategy decisions. We have structured this text around the 10 Operations Management decisions that organizations make. For each of the decisions, we introduce the decision, its objective, and its relevant tools and techniques for successful decision making. Starting with Chapter 5 and continuing through Chapter 17, these decisions are:

- (1) What products or services our firm makes (Chapter 5) [clearly the first decision]
- (2) Then how we address quality (Chapter 6)

comfort zone.

- (3) How we create our goods or services (Chapter 7)
- (4) Where we locate our facilities (Chapter 8)
- (5) How we lay out our factory, warehouse, office, or retail store (Chapter 9)
- (6) How we design jobs, then train and evaluate our employees (Chapter 10)
- (7) How we establish and manage supply chains (Chapter 11)
- (8) How we control inventory (Chapters 12, 14 and 16)
- (9) How we schedule employees, machines, and operations (Chapters 13 and 15)
- (10) How we keep our operations up and running (Chapter 17)

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!

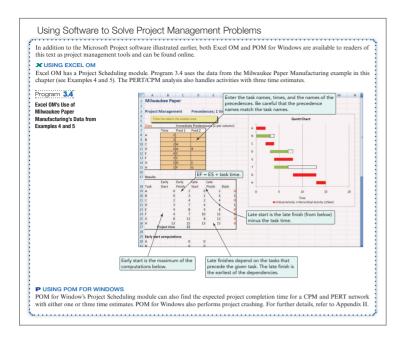
A Powerful Homework and Test Manager

Problems from the textbook can be assigned to students via a robust platform, which 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 such as Help Me Solve This, Videos from the authors of similar problems being solved, Ask My Instructor, and eText Pages. These all provide students feedback and assistance when they need it most.

24 PREFACE



Decision Support Software

We 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 at https://media.pearsoncmg.com/intl/ge/2023/ cws/ge_heizer_pom_12/cw/login/sign-in.php.

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. Over 1,000,000 visitors indicate that instructors have found the blog useful in their course.



Additional Resources

Resources available to instructors and students at https://media.pearsoncmg.com/ intl/ge/2023/cws/ge_heizer_pom_12/cw/ login/sign-in.php	Features of the Resource						
Online Tutorials	 These additional supplemental chapters cover the following topics: Statistical Tools for Managers Acceptance Sampling The Simplex Method of Linear Programming The MODI and VAM Methods of Solving Transportation Problems Vehicle Routing and Scheduling 						
Excel Data Files	The data files are prepared for specific examples and allow users to solve all the marked text examples without reentering any data.						
Excel OM	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 class-room demonstrations.						
POM for Windows	POM for Windows is a powerful tool for easily solving OM problems.						
Active Models	Active Models are Excel-based OM simulations, designed to help students understand the quantita- tive methods shown in the textbook examples. Students may change the data to see how the changes affect the answers.						

Additional instructor resources are available at www.pearson.com/en-gb.html. These include the following:

Instructor Resource	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 PowerPoint Slides discussion Additional Assignment Ideas Online 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 discus- sion questions, Ethical Dilemmas, Active Models, and cases in the text, as well as worked-out solu- tions to all the end-of-chapter problems, additional homework problems, and additional case studies.						
Test Bank	 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; Integration of Real-World Business Experiences; 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. New to this edition: Hundreds of multiple choice questions have been converted to <i>algorithmic</i> questions, with different answers for each student. 						
PowerPoints	An extensive set of ADA-compliant PowerPoint presentations is available for each chapter, with well over 2,000 slides in all.						

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In this edition, we were thrilled to be able to include one of the country's premier boat manufacturers, Nautique Boats, in our ongoing Video Case Study series. This was possible because of the wonderful efforts of President Greg Meloon and his superb management team. This included Kris Honigosky (VP, Operations), Steve Carlton (Chief Designer and Director of Product Design and Development), Paula Sleiman (Industrial Engineer Supervisor), Drew Pope (Materials and Supply Chain Manager), Tim Sochar (Customer Service Representative), and Erica Marrero (Project Manager). 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 Orlando headquarters.

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

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Operations and Productivity

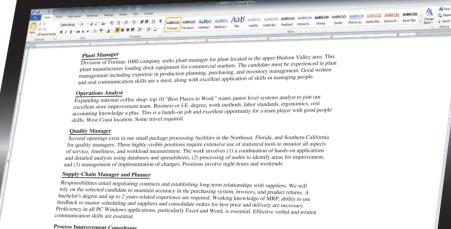
CHAPTER OUTLINE

GLOBAL COMPANY PROFILE: Hard Rock Cafe

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- Ethics, Social Responsibility, and Sustainability 51

About 40% of all jobs are in operations management.



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An expanding consulting firm is seeking consultants to design and implement lean production and cycle time eduction plans in both service and manufacturing processes. Our firm is currently working with an internation and to improve its back office operations, as well as with several manufacturing firms. A business dearee quired; APICS certification a plus.

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DECISIONS

- **Design of Goods and Services** •
- Managing Quality •
- **Process Strategies**
- Location Strategies
- Layout Strategies

- Human Resources
- Supply Chain Management
- Inventory Management
- Schedulina
- Maintenance

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GLOBAL COMPANY PROFILE Hard Rock Cafe

Operations Management at Hard Rock Cafe

perations 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.



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.

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.



Jenny/Alamy Stock Photo





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.

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.

Orlando-based Hard Rock Cafe opened its first restaurant in London in 1971, making it over 50 years old and the granddaddy of theme restaurants. Although other theme restaurants have come and gone, Hard Rock is still going strong, with 25 hotels, 185 restaurants, and 12 casinos in more than 74 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.

LO 1.1 LEARNING LO 1.2 **OBJECTIVES**

- Define operations management 36
- Identify the 10 strategic decisions of operations management 40
- LO 1.3 *Identify* career opportunities in operations management 40
- LO 1.4 Explain the distinction between goods and services 43
- LO 1.5 Explain the difference between production and productivity 45
- LO 1.6 **Compute** single-factor productivity 45
- LO 1.7 Compute multifactor productivity 46
 - *Identify* the critical variables in enhancing productivity 47

STUDENT TIP

LO 1.8

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

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

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.

What Is Operations Management?

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 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.

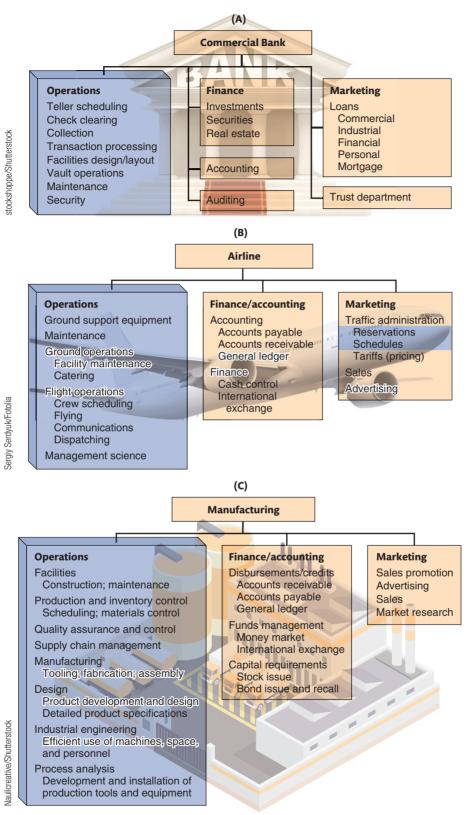


Figure 1.1

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.

A 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

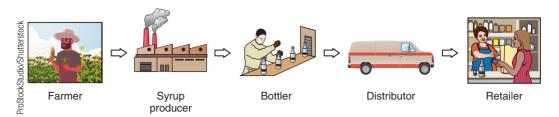
A supply chain for a bottle of Coke requires a beet or sugar cane farmer, a syrup producer, a bottler, a distributor, and a retailer, each adding value to satisfy a customer. Only with collaborations between all members of the supply chain can efficiency and customer satisfaction be maximized. The supply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

Supply chain

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

> **STUDENT TIP** Good OM managers are

scarce, and as a result. career opportunities and pay are excellent.



Universities, places of worship, and businesses all perform these functions. Even a volunteer group such as Meals on Wheels is organized to perform these three basic 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

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?

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 Incre	asing Contribution		
		MARKETING OPTION ^a	FINANCE/ ACCOUNTING OPTION ⁶	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		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

^aIncreasing sales 50% increases contribution by \$7,500, or 71% (7,500/10,500).

^bReducing finance costs 50% increases contribution by \$2,250, or 21% (2,250/10,500).

^cReducing production costs 20% increases contribution by \$12,000, or 114% (12,000/10,500).

^dContribution 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 **Ten strategic OM decisions** are introduced in Table 1.2. Successfully addressing each of these decisions requires planning, organizing, staffing, leading, and controlling.

Where Are the OM Jobs? How does one get started on a career in operations? The ten 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,

Ten 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 TABLE 1.2

STUDENT TIP 🌗	•
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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

DECISION	CHAPTER(S)
1. <i>Design of goods and services:</i> 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. <i>Managing quality and statistical process control:</i> Determines the customer's quality expectations and establishes policies and procedures to identify and achieve that quality.	6, Supplement 6
3. <i>Process and capacity strategies</i> : 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
 Location strategies: Requires judgments regarding nearness to customers, suppliers, and talent, while considering costs, infrastructure, logistics, and government. 	8
 Layout strategies: Requires integrating capacity needs, personnel levels, technology, and inventory requirements to determine the efficient flow of materials, people, and information. 	9
6. <i>Human resources, job design and work measurement:</i> 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. <i>Supply chain management:</i> 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. <i>Inventory management:</i> 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. <i>Scheduling:</i> Determines and implements intermediate- and short-term schedules that effectively and efficiently use both personnel and facilities while meeting customer demands.	13, 15
 Maintenance: Requires decisions that consider facility capacity, production demands, and personnel necessary to maintain a reliable and stable process. 	17

Ten Strategic Operations Management Decisions

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.

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

- Association for Supply Chain Management (ASCM/APICS) (www.ascm.org)
- American Society for Quality (ASQ) (www.asq.org)
- Institute for Supply Management (ISM) (www.ismworld.org)
- Project Management Institute (PMI) (www.pmi.org)
- Council of Supply Chain Management Professionals (www.cscmp.org)

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 1.3.

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

LO 1.3 *Identify* career opportunities in operations management



Cost 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)

(Ford/Sorensen) Statistical Sampling (Shewhart) Economic Order Quantity (Harris) Linear Programming (Dantzig)

Material Requirements

Planning (MRP)

Mass Production Era

Moving Assembly Line

1910-1980

Quality Focus

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

Customization Focus

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 Focus

Globalization Era 2005–2025 Global Supply Chains and Logistics Containerization of Shipping Growth of Transnational Organizations Sustainability Ethics in the Global Workplace Internet of Things (IoT) Digital Operations Industry 4.0

Figure **1.3**

Significant Events in Operations Management

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.

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 workers 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 digitalization, 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 the biological or physical sciences. In this textbook, we look at the diverse ways a student can prepare for a career in operations management.

STUDENT TIP Operations for Goods and Services

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.

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.

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 (iPads, earbuds)
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

Services are especially important because almost 80% of all jobs are

in service firms.

Services

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

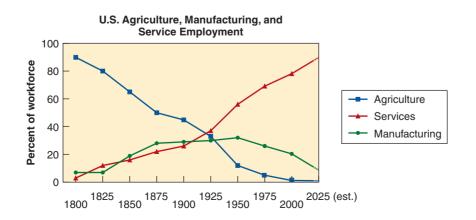
Growth of Services

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 1.4. Although the *number* of people employed in manufacturing has decreased since 1950, each person is now producing almost 20 times more than in 1950. Moreover, manufacturing's influence on employment and the economic system extends well beyond direct manufacturing to include the related advances in technology, as well as the warehousing and logistics necessary to move products through the supply chain to the ultimate consumer. The total manufacturing impact accounts for about 30% of gross domestic product (GDP).

Services became the dominant 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 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 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.



LO 1.4 *Explain* the distinction between goods and services

Service sector

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

Figure 1.4

U.S. Agriculture, Manufacturing, and Service Employment

Source: U.S. Bureau of Labor Statistics

TABLE 1.4

SECTOR	EXAMPLE	PERCENTAGE OF ALL JOBS	
Service Sector			
Education, Medical, Other	San Diego State University, Arnold Palmer Hospital	14.9	
Trade (retail, wholesale), Transportation, Utilities	Walgreen's, Walmart, Nordstrom, Alaska Airlines	17.0	
Information, Publishers, Broadcast	IBM, Bloomberg, Pearson, ESPN	1.8	
Professional, Legal, Business Services, Associations	Snelling and Snelling, Waste Management, American Medical Association, Ernst & Young	17.2 }	85.7
Finance, Insurance, Real Estate	Citicorp, American Express, Prudential, Aetna	10.8	
Leisure, Lodging, Entertainment	Red Lobster, Motel 6, Celebrity Cruises	10.2	
Government (Fed, State, Local)	U.S., State of Alabama, Cook County	13.8 J	
Manufacturing Sector	General Electric, Ford, U.S. Steel, Intel		7.9
Construction Sector	Bechtel, McDermott		4.6
Agriculture	King Ranch		1.4
Mining Sector	Homestake Mining		0.4
Grand Total			100.0

Examples of Organizations in Each Sector

Source: Bureau of Labor Statistics, 2020

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).

STUDENT TIP The Productivity Challenge

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 1.5). 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

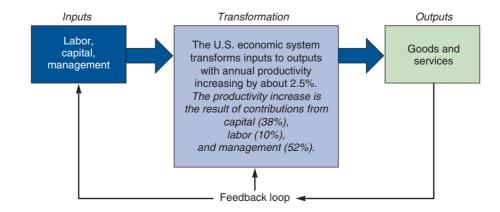


Figure 1.5

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.

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. 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.

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.

Productivity Measurement

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:

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

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

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

LO 1.5 *Explain* the difference between production and productivity

LO 1.6 Compute single-factor productivity

OM in Action Improving Productivity at Starbucks²

"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.



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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:

 $Multifactor productivity = \frac{Output}{Labor + Material + Energy + Capital + Miscellaneous}$ (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. SOLUTION ► Labor productivity with the old system: $\frac{8 \text{ titles per day}}{32 \text{ labor-hours}} = .25 \text{ title per labor-hour}$ LO 1.7 Compute Labor productivity with the new system: $\frac{14 \text{ titles per day}}{32 \text{ labor-hours}} = .4375 \text{ title per labor-hour}$ multifactor productivity Multifactor productivity with the old system: $\frac{8 \text{ titles per day}}{\$640 + \$400} = .0077 \text{ title per dollar}$ 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 b** 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 1.5, productivity increases are dependent on three productivity variables:

- 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.

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 1.6. 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. Productivity variables

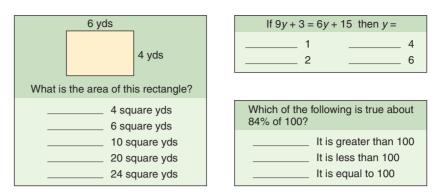
The three factors critical to productivity improvement—labor, capital, and the art and science of management.

LO 1.8 *Identify* the critical variables in enhancing productivity

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Figure 1.6

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

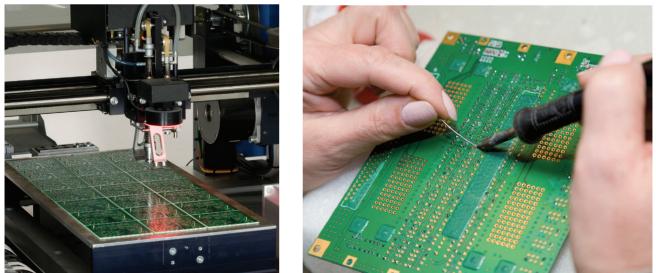


Capital Human beings are tool-using animals. Capital investment provides those tools. Capital investment has increased in the U.S. every year except during a few very severe recession periods. Annual capital investment in the U.S. has increased at an annual rate of 1.5% after allowances for depreciation.

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



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.

increase includes improvements made through the use of knowledge and the application of technology.

Using knowledge and technology is critical in postindustrial societies. Consequently, post-industrial 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 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.

Productivity of the service sector has proven difficult to improve because service-sector work is:

- 1. Typically labor intensive (e.g., counseling, teaching).
- 2. Frequently focused on unique individual attributes or desires (e.g., investment advice).
- 3. Often an intellectual task performed by professionals (e.g., medical diagnosis).
- 4. Often difficult to mechanize and automate (e.g., a haircut).
- 5. Often difficult to evaluate for quality (e.g., performance of a law firm).

The more intellectual and personal the task, the more difficult it is to achieve increases in productivity. Low-productivity improvement in the service sector is also attributable to the growth of low-productivity activities in the service sector. These include activities not previously a part of the measured economy, such as child care, food preparation, house cleaning, and laundry service. These activities have moved out of the home and into the measured economy as more and more women have joined the workforce. Inclusion of these activities

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.

Knowledge society

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

OM in Action Taco Bell Improves Productivity and Goes Green to Lower Costs⁴

Founded in 1962 by Glenn Bell, Taco Bell seeks competitive advantage via low cost. Like many other services, Taco Bell relies on its operations management to improve productivity and reduce cost.

Its menu and meals are designed to be easy to prepare. Taco Bell has shifted a substantial portion of food preparation to suppliers who could perform food processing more efficiently than a stand-alone restaurant. Ground beef is precooked prior to arrival and then reheated, as are many dishes that arrive in plastic boil bags for easy sanitary reheating. Similarly, tortillas arrive already fried and onions prediced. Efficient layout and automation has cut to 8 seconds the time needed to prepare tacos and burritos and has cut time in the drive-through lines by 1 minute. These advances have been combined with training and empowerment to increase the span of management from one supervisor for 5 restaurants to one supervisor for 30 or more.

Operations managers at Taco Bell have cut in-store labor by 15 hours per day and reduced floor space by more than 50%. The result is a store that can average 164 seconds for each customer, from drive-up to pull-out.

More recently, Taco Bell completed the rollout of its new Grill-to-Order kitchens by installing water- and energy-saving grills that conserve 300 million gallons of water and 200 million kilowatt hours of electricity each year. This "green"-inspired cooking method also saves the company's 5,800 restaurants \$17 million per year.

Effective operations management has resulted in productivity increases that support Taco Bell's low-cost strategy. Taco Bell is now the fast-food low-cost leader with a 58% share of the Mexican fast-food market.



has probably resulted in lower measured productivity for the service sector, although, in fact, actual productivity has probably increased because these activities are now more efficiently produced than previously.

However, despite the difficulty of improving productivity in the service sector, improvements are being made. And this text presents a multitude of ways to make these improvements. Indeed, what can be done when management pays attention to how work actually gets done is astonishing!

Although the evidence indicates that all industrialized countries have the same problem with service productivity, the U.S. remains the world leader in overall productivity *and* service productivity. Retailing is twice as productive in the U.S. as in Japan, where laws protect shop-keepers from discount chains. The U.S. telephone industry is at least twice as productive as Germany's. The U.S. banking system is also 33% more efficient than Germany's banking oligopolies. However, because productivity is central to the operations manager's job and because the service sector is so large, we take special note in this text of how to improve productivity in the service sector. (See, for instance, the *OM in Action* box, "Taco Bell Improves Productivity and Goes Green to Lower Costs.")

Current Challenges in Operations Management

Operations managers work in an exciting and dynamic environment. This environment is the result of a variety of challenging forces, from globalization of world trade to the transfer of ideas, products, and money at electronic speeds. Let's look at some of these challenges:

STUDENT TIP

One of the reasons OM is such an exciting discipline is that an operations manager is confronted with ever-changing issues, from technology, to global supply chains, to sustainability.

- *Globalization:* The rapid decline in the cost of communication and transportation has made markets global. Similarly, resources in the form of capital, materials, talent, and labor are also now global. As a result, countries throughout the world are contributing to globalization as they vie for economic growth. Operations managers are rapidly seeking creative designs, efficient production, and high-quality goods via international collaboration.
- Supply-chain partnering: Shorter product life cycles, demanding customers, and fast changes in technology, materials, and processes require supply-chain partners to be in tune with the needs of end users. And because suppliers may be able to contribute unique expertise, operations managers are outsourcing and building long-term partnerships with critical players in the supply chain.

- *Sustainability:* Operations managers' continuing battle to improve productivity is concerned with designing products and processes that are ecologically sustainable. This means designing green products and packaging that minimize resource use, can be recycled or reused, and are generally environmentally friendly.
- *Technological change:* Industry 4.0 is the name given to the new digital world. Some consider Industry 4.0 the fourth industrial revolution, hence the name. Why is this considered the fourth industrial revolution? The first industrial revolution included the harnessing of water and steam power in the late 1700s, leading to rapid mechanization and division of labor. This was followed quickly by electricity and the second industrial revolution's assembly lines and mass production. The third, in the 20th century, yielded communication between man and machine with computers, automation, and robots. Finally, the fourth, *Industry 4.0*, is the widespread use of precision sensors and digital signals—in a word, *digitalization*. From raw materials to design to manufacturing to logistics, services, and ultimately the end consumer, digital signals surround us. Moreover, digitalization suggests connecting this massive amount of data *in real time*. Harnessing the vast and growing array of digital signals is a huge opportunity for operations management, but it is also a significant challenge.
- Mass customization: Once managers recognize the world as the marketplace, the cultural
 and individual differences become quite obvious. In a world where consumers are increasingly aware of innovation and options, substantial pressure is placed on firms to respond in
 a creative way. And OM must rapidly respond with product designs and flexible production
 processes that cater to the individual whims of consumers. The goal is to produce customized products, whenever and wherever needed.
- Lean operations: Lean is the management model sweeping the world and providing the standard against which operations managers must compete. Lean can be thought of as the driving force in a well-run operation, where the customer is satisfied, employees are respected, and waste does not exist. The theme of this text is to build organizations that are more efficient, where management creates enriched jobs that help employees engage in continuous improvement, and where goods and services are produced and delivered when and where the customer desires them. These ideas are also captured in the phrase *Lean*.

These challenges must be successfully addressed by today's operations managers. This text will provide you with the foundations necessary to meet those challenges.

Ethics, Social Responsibility, and Sustainability

The systems that operations managers build to convert resources into goods and services are complex. And they function in a world where the physical and social environment is evolving, as are laws and values. These dynamics present a variety of challenges that come from the conflicting perspectives of **stakeholders**, such as customers, distributors, suppliers, owners, lenders, employees, and community. Stakeholders, as well as government agencies at various levels, require constant monitoring and thoughtful responses.

Identifying ethical and socially responsible responses while developing sustainable processes that are also effective and efficient productive systems is not easy. Managers are also challenged to:

- Develop and produce safe, high-quality green products
- Train, retain, and motivate employees in a safe workplace
- Honor stakeholder commitments

Managers must do all this while meeting the demands of a very competitive and dynamic world marketplace. If operations managers have a *moral awareness and focus on increasing productivity in this system*, then many of the ethical challenges will be successfully addressed. The organization will use fewer resources, the employees will be committed, the market will be satisfied, and the ethical climate will be enhanced. Throughout this text, we note ways in which operations managers can take ethical and socially responsible actions while successfully addressing these challenges of the market. We also conclude each chapter with an *Ethical Dilemma* exercise.

Industry 4.0

The fourth industrial revolution with widespread real-time digitalization.

Stakeholders

Those with a vested interest in an organization, including customers, distributors, suppliers, owners, lenders, employees, and community members.

Operations, marketing, and finance/accounting are the three functions basic to all organizations. The operations function creates goods and services. Much of the progress of operations management has been made in the twentieth century, but since the beginning of time, humankind has been attempting to improve its material well-being. Operations managers are key players in the battle to improve productivity.

Key Terms

Production (p. 36) Operations management (OM) (p. 36) Supply chain (p. 38) Ten strategic OM decisions (p. 39)

Summary

As societies become increasingly affluent, more of their resources are devoted to services. In the U.S., more than 85% of the workforce is employed in the service sector. Productivity improvements and a sustainable environment are difficult to achieve, but operations managers are the primary vehicle for making improvements.

Services (p. 42) Service sector (p. 43) Productivity (p. 44) Single-factor productivity (p. 46) Multifactor productivity (p. 46)

Productivity variables (p. 47) Knowledge society (p. 49) Industry 4.0 (p. 51) Stakeholders (p. 51)

Ethical Dilemma

The American car battery industry boasts that its recycling rate now exceeds 95%, the highest rate for any commodity. However, with changes brought about by specialization and globalization, parts of the recycling system are moving offshore. This is particularly true of automobile batteries, which contain lead. The Environmental Protection Agency (EPA) is contributing to the offshore flow with newly implemented standards that make domestic battery recycling increasingly difficult and expensive. The result is a major increase in used batteries going to Mexico, where environmental standards and control are less demanding than they are in the U.S. One in five batteries is now exported to Mexico. There is seldom difficulty finding buyers because lead is expensive and in worldwide demand. While U.S.

recyclers operate in sealed, mechanized plants, with smokestacks equipped with scrubbers and plant surroundings monitored for traces of lead, this is not the case in most Mexican plants. The harm from lead is legendary, with long-run residual effects. Health issues include high blood pressure, kidney damage, detrimental effects on fetuses during pregnancy, neurological problems, and arrested development in children.

Given the two scenarios below, what action do you take?

- a) You own an independent auto repair shop and are trying to safely dispose of a few old batteries each week. (Your battery supplier is an auto parts supplier who refuses to take your old batteries.)
- b) You are manager of a large retailer responsible for disposal of thousands of used batteries each day.

Discussion Questions

- 1. Why should one study operations management?
- 2. What are some career opportunities in the operations management discipline?
- 3. Identify four people who have contributed to the theory and techniques of operations management.
- 4. Briefly describe the contributions of the four individuals identified in the preceding question.
- 5. Figure 1.1 outlines the operations, finance/accounting, and marketing functions of three organizations. Prepare a chart similar to Figure 1.1 outlining the same functions for one of the following:
 - a) a newspaper
 - b) a drugstore
 - c) a college library
 - d) a summer camp
 - e) a small costume-jewelry factory
- 6. What are the three basic functions of a firm?
- 7. Identify the 10 strategic operations management decisions.
- 8. Apply the 10 OM decisions to Amazon. (Hint: As a starting point, read the Global Profile that begins Chapter 12.)
- 9. In an article titled "The Productivity Paradox," Wickham Skinner attributed failure in productivity to cost reduction

programs, which he said produce narrowness of vision. He recommended abandoning old-fashioned productivity as a goal in favor of setting a new objective of competitiveness.⁵ Discuss this historical and seminal viewpoint.

- 10. The U.S., and indeed much of the rest of the world, has been described as a "knowledge society." How does this affect productivity measurement and the comparison of productivity between the U.S. and other countries?
- 11. What are the measurement problems that occur when one attempts to measure productivity?
- 12. Mass customization and rapid product development were identified as challenges to modern manufacturing operations. What is the relationship, if any, between these challenges? Can you cite any examples?
- 13. What are the five reasons productivity is difficult to improve in the service sector?
- 14. Discuss the overlap among operations, marketing, and finance-the three functions basic to all organizations-for small and medium-sized enterprises.
- 15. As a library or Internet assignment, find the U.S. productivity rate (increase) last year for the (a) national economy, (b) manufacturing sector, and (c) service sector.

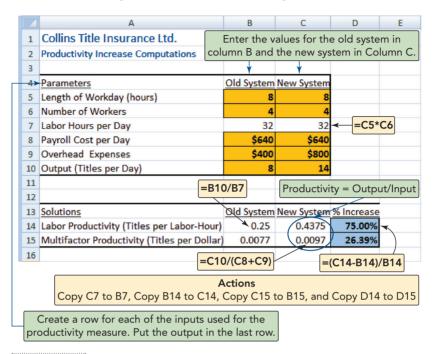


Using Software for Productivity Analysis

This section presents three ways to solve productivity problems with computer software. First, you can create your own Excel spreadsheets to conduct productivity analysis. Second, you can use the Excel OM software that comes with this text and can be found online. Third, POM for Windows is another program that is available with this text and can be found online.

CREATING YOUR OWN EXCEL SPREADSHEETS

Program 1.1 illustrates how to build an Excel spreadsheet for the data in Example 2.



Program 1.1

✗ USING EXCEL OM

Excel OM is an Excel "add-in" with 26 Operations Management decision support "Templates." To access the templates, double-click on the *Excel OM* tab at the top of the page; then in the menu bar choose the appropriate chapter (in this case Chapter 1) from either the "Chapter" or "Alphabetic" tab on the left. Each of Excel OM's 26 modules includes instructions for that particular module. The instructions can be turned on or off via the "instruction" tab in the menu bar.

P USING POM FOR WINDOWS

POM for Windows is decision support software that includes 25 Operations Management modules. The modules are accessed by double-clicking on *Module* in the menu bar, and then double-clicking on the appropriate (in this case *Productivity*) item. Instructions are provided for each module just below the menu bar. Please refer to Appendix II for further details.

Solved Problems

SOLVED PROBLEM 1.1

Productivity can be measured in a variety of ways, such as by labor, capital, energy, material usage, and so on. At Modern Lumber, Inc., Art Binley, president and producer of apple crates sold to growers, has been able, with his current equipment, to produce 240 crates per 100 logs. He currently purchases 100 logs per day, and each log requires 3 labor-hours to process. He believes that he can hire a professional buyer who can buy a better-quality log at the same cost. If this is the case, he can increase his production to 260 crates per 100 logs. His labor-hours will increase by 8 hours per day.

What will be the impact on productivity (measured in crates per labor-hour) if the buyer is hired?

SOLUTION

a) Current labor produc	tivity – 240 crates
a) Current labor produc	$\frac{100 \log \times 3 \text{ hours/log}}{100 \log \times 3 \text{ hours/log}}$
	$=\frac{240}{2}$
	300
	= .8 crates per labor-hour
b) Labor productivity	_ 260 crates
with buyer	$-\frac{1}{(100 \log \times 3 \text{ hours/log}) + 8 \text{ hours}}$
	_ 260
	$-\frac{1}{308}$
	= .844 crates per labor-hour

Using current productivity (.80 from [a]) as a base, the increase will be 5.5% (.844/.8=1.055, or a 5.5% increase).

SOLVED PROBLEM 1.2

Art Binley has decided to look at his productivity from a multifactor (total factor productivity) perspective (refer to Solved Problem 1.1). To do so, he has determined his labor, capital, energy, and material usage and decided to use dollars as the common denominator. His total labor-hours are now 300 per SOLUTION

CURRENT SYSTEM		
Labor:	300 hrs. @10 = 3,000	
Material:	100 logs/day 1,000	
Capital:	350	
Energy:	<u>150</u>	
Total Cost:	\$4,500	

Multifactor productivity of current system: = 240 crates/\$4,500 = .0533 crates/dollar day and will increase to 308 per day. His capital and energy costs will remain constant at \$350 and \$150 per day, respectively. Material costs for the 100 logs per day are \$1,000 and will remain the same. Because he pays an average of \$10 per hour (with fringes), Binley determines his productivity increase as follows:

SYSTEM WITH PROFESSIONAL BUYER		
308 hrs. @10 =	\$3,080	
	1,000	
	350	
	150	
	\$4,580	

Multifactor productivity of proposed system: = 260 crates/\$4,580 = .0568 crates/dollar

Using current productivity (.0533) as a base, the increase will be .066. That is, .0568/.0533 = 1.066, or a 6.6% increase.

Problems Note: **PX** means the problem may be solved with POM for Windows and/or Excel OM.

Problems 1.1 to 1.17 relate to The Productivity Challenge

• **1.1** Chuck Sox makes wooden boxes in which to ship motorcycles. Chuck and his three employees invest a total of 40 hours per day making the 120 boxes.

- a) What is their productivity?
- b) Chuck and his employees have discussed redesigning the process to improve efficiency. If they can increase the rate to 125 per day, what will be their new productivity?
- c) What will be their unit *increase* in productivity per hour?
- d) What will be their percentage change in productivity? \mathbf{PX}

• **1.2** Carbondale Casting produces cast bronze valves on a 10-person assembly line. On a recent day, 160 valves were produced during an 8-hour shift.

- a) Calculate the labor productivity of the line.
- b) John Goodale, the manager at Carbondale, changed the layout and was able to increase production to 180 units per 8-hour shift. What is the new labor productivity per labor-hour?
- c) What is the percentage of productivity increase?

• **1.3** A small electronics-manufacturing company that makes communication devices has determined its costs as follows (all value data are expressed in millions of euros):

	2013	2014
Output:	2	3
Inputs:		
Labor	1	1.8
Material and supplies	0.6	0.8
Capital equipment depreciation	0.07	0.12

- a) Calculate and compare all single-factor and multifactor productivity for 2013 and 2014.
- b) What conclusions do you draw?

• **1.4** Lori Cook produces "Final Exam Care Packages" for resale by her sorority. She is currently working a total of 5 hours per day to produce 100 care packages.

- a) What is Lori's productivity?
- b) Lori thinks that by redesigning the package, she can increase her total productivity to 133 care packages per day. What will be her new productivity?
- c) What will be the percentage increase in productivity if Lori makes the change? PX

•• **1.5** George Kyparisis makes bowling balls in his Miami plant. With recent increases in his costs, he has a newfound interest in efficiency. George is interested in determining the productivity of his organization. He would like to know if his organization is maintaining the manufacturing average of 3% increase in productivity per year. He has the following data representing a month from last year and an equivalent month this year:

	LAST YEAR	NOW
Units produced	1,000	1,000
Labor (hours)	300	275
Resin (pounds)	50	45
Capital invested (\$)	10,000	11,000
Energy (BTU)	3,000	2,850

Show the productivity percentage change for each category and then determine the improvement for labor-hours, the typical standard for comparison. **PX**

•• **1.6** George Kyparisis (using data from Problem 1.5) determines his costs to be as follows:

- Labor: \$10 per hour
- Resin: \$5 per pound
- ◆ Capital expense: 1% per month of investment
- Energy: \$0.50 per BTU

Show the percent change in productivity for one month last year versus one month this year, on a multifactor basis with dollars as the common denominator. \mathbf{PX}

• **1.7** Hokey Min's Kleen Karpet cleaned 65 rugs in October, consuming the following resources:

Labor:	520 hours at \$13 per hour
Solvent:	100 gallons at \$5 per gallon
Machine rental:	20 days at \$50 per day

a) What is the labor productivity per dollar?

b) What is the multifactor productivity? **PX**

•• **1.8** Lillian Fok is president of Lakefront Manufacturing, a producer of bicycle tires. Fok makes 1,000 tires per day with the following resources:

Labor:	400 hours per day @ \$12.50 per hour
Raw material:	20,000 pounds per day @ \$1 per pound
Energy:	\$5,000 per day
Capital costs:	\$10,000 per day

- a) What is the labor productivity per labor-hour for these tires at Lakefront Manufacturing?
- b) What is the multifactor productivity for these tires at Lakefront Manufacturing?
- c) What is the percent change in multifactor productivity if Fok can reduce the energy bill by \$1,000 per day without cutting production or changing any other inputs?

••• **1.9** Brown's, a local bakery, is worried about increased costs—particularly energy. Last year's records can provide a fairly good estimate of the parameters for this year. Wende Brown, the owner, does not believe things have changed much, but she did invest an additional \$3,000 for modifications to the bakery's ovens to make them more energy efficient. The modifications were supposed to make the ovens at least 15% more efficient. Brown has asked you to check the energy savings of the new ovens and also to look over other measures of the bakery's productivity to see if the modifications were beneficial. You have the following data to work with:

	LAST YEAR	NOW
Production (dozen)	1,500	1,500
Labor (hours)	350	325
Capital investment (\$)	15,000	18,000
Energy (BTU)	3,000	2,750

••1.10 Munson Performance Auto, Inc., modifies 375 autos per year. The manager, Adam Munson, is interested in obtaining a measure of overall performance. He has asked you to provide him with a multifactor measure of last year's performance as a benchmark for future comparison. You have assembled the following data. Resource inputs were labor, 10,000 hours; 500 suspension and engine modification kits; and energy, 100,000 kilowatt-hours. Average labor cost last year was \$20 per hour, kits cost \$1,000 each, and energy costs were \$3 per kilowatt-hour. What do you tell Mr. Munson?

••1.11 Lake Charles Seafood makes 500 wooden packing boxes for fresh seafood per day, working in two 10-hour shifts. Due to increased demand, plant manager Jasmine Hines-Allen has decided to operate three 8-hour shifts instead. The plant is now able to produce 650 boxes per day.

- a) Calculate the company's productivity before the change in work rules and after the change.
- b) What is the percentage increase in productivity?
- c) If production is increased to 700 boxes per day, what is the new productivity?

••••1.12 Charles Lackey operates a bakery in Idaho Falls, Idaho. Because of its excellent product and excellent location, demand has increased by 25% in the last year. On far too many occasions, customers have not been able to purchase the bread of their choice. Because of the size of the store, no new ovens can be added. At a staff meeting, one employee suggested ways to load the ovens differently so that more loaves of bread can be baked at one time. This new process will require that the ovens be loaded by hand, requiring additional manpower. This is the only thing to be changed. If the bakery makes 1,500 loaves per month with a labor productivity of 2.344 loaves per labor-hour, how many workers will Lackey need to *add?* (*Hint:* Each worker works 160 hours per month.)

••1.13 Mr. Achebe runs his photocopy business for 8 hours a day and processes 100 scripts during that period. He estimates his labor cost to be \notin 9 per hour. He has also estimated that the total material cost for each script is approximately \notin 2 and the daily expenses are \notin 28. Calculate the multifactor productivity. To increase the rate of photocopying to 150 scripts a day, he decides to change the quality of the ink used, thereby raising the material cost to \notin 2.5 per day. Is the new productivity better than before? If Mr. Achebe would like to increase the photocopying rate to 150 scripts without sacrificing the initial multifactor productivity, by what amount can the material costs be increased at most?

•••• **1.14** A production operation makes 150 pieces of a product by engaging 5 workers working a total of 300 hours together. However, 40% of the units appear to have various quality problems and the company decides to sell them as seconds at \in 50 each; the normal unit is sold for \in 150 each. What is the productivity of the company? To improve the situation, a number of initiatives were proposed, including a scheme where, for every improvement, 50% will be given to workers and the other 50% will be held by the company. This results in a significant drop in defects—only 10 units are faulty, out of an output of 130 units. What is the new productivity of the company, and what will be the earnings per hour of the workers under the bonus scheme if the cost per unit is \in 70 both before and after the scheme?

••1.15 A furniture-manufacturing company with a 40-hour working week makes 100 chairs. The sales price is \notin 70 each, and the company has the following costs:

- ◆ Direct materials: €700
- ◆ Direct labor: €300
- Overhead: €500
 - a) Calculate the productivity of the company.
 - b) What will the new productivity be if the company decides to make 135 chairs per week?
 - c) If the company decides to improve productivity through materials costs reduction only, by how much must these costs be reduced to achieve a 10% increase in total productivity?
 - d) If the company repeats the same exercise as in part (c) but through labor costs reduction, by how much must these costs be reduced to achieve a 10% increase in total productivity?

•• **1.16** A factory makes three different types of air conditioners: the ceiling type, the cassette type, and the wall-mounted type. Weekly sales of each type are 2, 4, and 6 units at a price of \notin 350, \notin 450, and \notin 500 each, respectively. The ceiling type can be assembled in 1.5 hours, the cassette type in 1 hour, and the

wall-mounted type in 45 minutes. The labor cost is \notin 40 per hour and the factory's current multifactor productivity is 2.2.

- a) Calculate the average cost per air conditioner based on current multifactor productivity.
- b) Calculate labor productivity (in euros per hour) for each type of air conditioner.
- c) Where should the company focus its efforts based on (i) labor productivity, and (ii) average cost?

••••1.17 As part of a study for the Department of Labor Statistics, Shakira Dominguez has been assigned the task of evaluating the improvement in productivity of small businesses. Data for one of the small businesses she is to evaluate are shown in the table. The data are the monthly average of last year and the monthly average this year. Determine the multifactor productivity with dollars as the common denominator for:

a) Last year.

b) This year.

- c) Then determine the percentage change in productivity for the monthly average last year versus the monthly average this year on a multifactor basis.
 - Labor: \$8 per hour
 - Capital: 0.83% per month of investment
 - Energy: \$0.60 per BTU

	LAST YEAR	THIS YEAR
Production (dozen)	1,500	1,500
Labor (hours)	350	325
Capital investment (\$)	15,000	18,000
Energy (BTU)	3,000	2,700

CASE STUDIES

Uber Technologies, Inc.

The \$100 billion firm Uber Technology, Inc., has unsettled the traditional taxi business. In over 84 countries and 900 cities around the world, Uber and similar companies are challenging the existing taxi business model. Uber and its growing list of competitors, Lyft and Curb in America, along with fledging rivals in Europe, Asia, and India, think their smartphone apps can provide a new and improved way to call a taxi. This disruptive business model uses an app to arrange rides between riders and cars, theoretically a nearby car, which is tracked by the app. The Uber system also provides a history of rides, routes, and fees as well as automatic billing for over 78 million monthly active users worldwide. In addition, driver and rider are also allowed to evaluate each other. The services are increasingly popular, worrying established taxi services in cities from New York to Berlin, and from Rio de Janeiro to Bangkok. In many markets, Uber has proven to be the best, fastest, and most reliable way to find a ride. Consumers worldwide are endorsing the system as a replacement for the usual taxi ride. As the most established competitor in the field, Uber is putting more cars on the road, meaning faster pickup times, which should attract even more riders, which in turn attracts even more drivers, and so on. This growth cycle may speed the demise of the existing taxi businesses as well as provide substantial competition for firms with a technology-oriented model similar to Uber's.

Uber is a software company. It does not own any cars, but it is the largest taxi company in the world. The Uber business model bypasses taxi ownership and a number of regulations, while at the same time offering better service and lower fees than traditional taxis. However, the traditional taxi industry is fighting back, and regulations are mounting. The regulations vary by country and

Frito-Lay: Operations Management in Manufacturing

city, but increasingly special licensing, testing, and inspections have been imposed. Part of the fee charged to riders does not go to the driver, but to Uber, as there are real overhead costs. Uber's costs, depending on the locale, may include insurance, background checks for drivers, vetting of vehicles, software development and maintenance, and centralized billing. Additionally, with 5 billion transactions per minute, computer costs are significant. How these overhead costs compare to traditional taxi costs is yet to be determined. Therefore, improved efficiency may not be immediately obvious, and contract provisions are significant (see www.uber.com/legal/terms/us).

In addition to growing regulations, a complicating factor in the model is finding volunteer drivers at inopportune times. A sober driver and a clean car at 1:00 a.m. New Year's Eve does cost more. Consequently, Uber has introduced a dynamic pricing model. Dynamic pricing means a higher price, sometimes much higher, than normal, but dynamic pricing has proven necessary to ensure that cars and drivers are available at unusual times. Customers are quoted the fares in advance.

Discussion Questions

- 1. The market has decided that Uber and its immediate competitors are adding efficiency to our society. How is Uber providing that added efficiency?
- **2.** Do you think the Uber model will work in the trucking industry?
- 3. In what other areas/industries might the Uber model be used?
- 4. What are some disadvantages of the Uber model?



Frito-Lay, the massive Dallas-based subsidiary of PepsiCo, has 55 plants and 55,000 employees in North America. Seven of Frito-Lay's 41 brands exceed \$1 billion in sales: Fritos, Lay's, Cheetos, Ruffles, Tostitos, Doritos, and Walker's Potato Chips. Operations is the focus of the firm—from designing products for new markets, to meeting changing consumer preferences, to adjusting to

rising commodity costs, to subtle issues involving flavors and preservatives—OM is under constant cost, time, quality, and market pressure. Here is a look at how the 10 decisions of OM are applied at this food processor.

In the food industry, product development kitchens experiment with new products, submit them to focus groups, and perform test marketing. Once the product specifications have been set, processes capable of meeting those specifications and the necessary quality standards are created. At Frito-Lay, quality begins at the farm, with onsite inspection of the potatoes used in Ruffles and the corn used in Fritos. Quality continues throughout the manufacturing process, with visual inspections and with statistical process control of product variables such as oil, moisture, seasoning, salt, thickness, and weight. Additional quality evaluations are conducted throughout shipment, receipt, production, packaging, and delivery.

The production process at Frito-Lay is designed for large volumes and small variety, using expensive special-purpose equipment, and with swift movement of material through the facility. Product-focused facilities, such as Frito-Lay's, typically have high capital costs, tight schedules, and rapid processing. Frito-Lay's facilities are located regionally to aid in the rapid delivery of products because freshness is a critical issue. Sanitary issues and necessarily fast processing of products put a premium on an efficient layout. Production lines are designed for balanced throughput and high utilization. Cross-trained workers, who handle a variety of production lines, have promotion paths identified for their particular skill set. The company rewards employees with medical, retirement, and education plans. Its turnover is very low.

The supply chain is integral to success in the food industry; vendors must be chosen with great care. Moreover, the finished food product is highly dependent on perishable raw materials. Consequently, the supply chain brings raw material (potatoes, corn, etc.) to the plant securely and rapidly to meet tight production schedules. For instance, from the time that potatoes are picked in St. Augustine, Florida, until they are unloaded at the Orlando plant, processed, packaged, and shipped from the plant is under 12 hours. The requirement for fresh product requires ontime, just-in-time deliveries combined with both low raw material and finished goods inventories. The continuous-flow nature of the specialized equipment in the production process permits little work-in-process inventory. The plants usually run 24/7. This means that there are four shifts of employees each week.

Tight scheduling to ensure the proper mix of fresh finished goods on automated equipment requires reliable systems and effective maintenance. Frito-Lay's workforce is trained to recognize problems early, and professional maintenance personnel are available on every shift. Downtime is very costly and can lead to late deliveries, making maintenance a high priority.

Discussion Questions*

- 1. From your knowledge of production processes and from the case and the video, identify how each of the 10 decisions of OM is applied at Frito-Lay.
- **2.** How would you determine the productivity of the production process at Frito-Lay?
- **3.** How are the 10 decisions of OM different when applied by the operations manager of a production process such as Frito-Lay versus a service organization such as Hard Rock Cafe? See the Hard Rock Cafe video case below.)

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

Hard Rock Cafe: Operations Management in Services

In its 50-plus years of existence, Hard Rock has grown from a modest London pub to a global power managing 185 restaurants, 25 hotels, and 12 casinos. This puts Hard Rock firmly in the service industry—a sector that employs over 75% of the people in the U.S. Hard Rock moved its world headquarters to Orlando, Florida, in 1988 and has expanded to more than 50 locations throughout the U.S., serving over 100,000 meals each day. Hard Rock chefs are modifying the menu from classic American—burgers and chicken wings—to include higher-end items such as stuffed veal chops and lobster tails. Just as taste in music changes over time, so does Hard Rock Cafe, with new menus, layouts, memorabilia, services, and strategies.

At Orlando's Universal Studios, a traditional tourist destination, Hard Rock Cafe serves more than 3,500 meals each day. The cafe employs about 400 people. Most are employed in the restaurant, but some work in the retail shop. Retail is now a standard and increasingly prominent feature in Hard Rock Cafes (since close to 48% of revenue comes from this source). Cafe employees include kitchen and waitstaff, hosts, and bartenders. Hard Rock employees are not only competent in their job skills but are also passionate about music and have engaging personalities. Cafe staff is scheduled down to 15-minute intervals to meet seasonal and daily demand changes in the tourist environment of Orlando. Surveys are done on a regular basis to evaluate quality of food and service at the cafe. Scores are rated on a 1-to-7 scale, and if the score is not a 7, the food or service is a failure. Hard Rock is adding a new emphasis on live music and is redesigning its restaurants to accommodate the changing tastes. Since Eric Clapton hung his guitar on the wall to mark his favorite bar stool, Hard Rock has become the world's leading collector and exhibitor of rock 'n' roll memorabilia, with changing exhibits at its cafes throughout the world. The collection includes 70,000 pieces, valued at \$40 million. In keeping with the times, Hard Rock also maintains a Web site, www.hardrock.com, which receives more than 100,000 hits per week, and a weekly cable television program on VH1. Hard Rock's brand recognition, at 92%, is one of the highest in the world.

Discussion Questions*

- From your knowledge of restaurants, from the video, from the Global Company Profile that opens this chapter, and from the case itself, identify how each of the 10 OM strategy decisions is applied at Hard Rock Cafe.
- **2.** How would you determine the productivity of the kitchen staff and waitstaff at Hard Rock?
- **3.** How are the 10 OM strategy decisions different when applied to the operations manager of a service operation such as Hard Rock versus an automobile company such as Ford Motor Company?

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



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-tothe-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

Endnotes

 Efficiency means doing the job well—with a minimum of resources and waste. Note the distinction between being efficient, which implies doing the job well, and effective, which means doing the right thing. A job well done—say, by applying the 10 strategic decisions of operations management—helps us be efficient; developing and using the correct strategy helps us be effective.

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.

- 2. Sources: *Businessweek* (August 23–30, 2012); *Fortune* (October 30, 2014); and **QZ.com/Starbucks**.
- 3. The quality and time period are assumed to remain constant.
- 4. Sources: *Businessweek* (May 5, 2011) and J. Hueter and W. Swart, *Interfaces* (Vol. 28, no. 1).
- 5. Source: Harvard Business Review (July 1986).

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Chapter 1 Rapid Review

Main Heading	Review Material	MyLab Operations Management
WHAT IS OPERATIONS MANAGEMENT?	 <i>Production</i>—The creation of goods and services <i>Operations management (OM)</i>—Activities that relate to the creation of goods and services through the transformation of inputs to outputs 	Concept Questions: 1.1–1.5 VIDEOS 1.1, 1.2 and 1.3 OM at Hard Rock OM at Frito-Lay Celebrity Cruises: Operations Management at Sea
ORGANIZING TO PRODUCE GOODS AND SERVICES	 All organizations perform three functions to create goods and services: 1. <i>Marketing</i>, which generates demand 2. <i>Production/operations</i>, which creates the product 3. <i>Finance/accounting</i>, which tracks how well the organization is doing, pays the bills, and collects the money 	Concept Questions: 2.1–2.6
THE SUPPLY CHAIN	 Supply chain—A global network of organizations and activities that supply a firm with goods and services 	Concept Questions: 3.1–3.4
WHY STUDY OM?	 We study OM for four reasons: 1. To learn how people organize themselves for productive enterprise 2. To learn how goods and services are produced 3. To understand what operations managers do 4. Because OM is a costly part of an organization 	Concept Questions: 4.1–4.2
WHAT OPERATIONS MANAGERS DO	 Ten strategic OM decisions are required of operations managers: 1. Design of goods and services 2. Managing quality 3. Process strategies 4. Location strategies 5. Layout strategies 6. Human resources 7. Supply chain management 8. Inventory management 9. Scheduling 10. Maintenance About 40% of <i>all</i> jobs are in OM. Operations managers possess job titles such as plant manager, quality manager, process improvement consultant, and operations analyst. 	Concept Questions: 5.1–5.6
THE HERITAGE OF OPERATIONS MANAGEMENT	1. Early concepts (1776–1880)—Labor specialization (Smith, Babbage),	
OPERATIONS FOR GOODS AND SERVICES	 Services—Economic activities that typically produce an intangible product (such as education, entertainment, lodging, government, financial, and health services). Almost all services and almost all goods are a mixture of a service and a tangible product. Service sector—The segment of the economy that includes trade, financial, lodging, education, legal, medical, and other professional occupations. Services now constitute the largest economic sector in postindustrial societies. The huge productivity increases in agriculture and manufacturing have allowed more of our economic resources to be devoted to services. Many service jobs pay very well. 	Concept Questions: 7.1–7.5

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Chapter 1 Rapid Review continued

Main Heading	Review Material	MyLab Operations Management
THE PRODUCTIVITY CHALLENGE	 Productivity—The ratio of outputs (goods and services) divided by one or more inputs (such as labor, capital, or management) High production means producing many units, while high productivity means producing units efficiently. Only through increases in productivity can the standard of living of a country improve. U.S. productivity has averaged a 2.5% increase per year for over a century. Single-factor productivity = Units produced (1-1) 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). Multifactor productivity 	Concept Questions: 8.1–8.6 Problems: 1.1–1.17 Virtual Office Hours for Solved Problems: 1.1, 1.2
	 Measurement problems with productivity include: (1) the quality may change, (2) external elements may interfere, and (3) precise units of measure may be lacking. Productivity variables—The three factors critical to productivity improvement are labor (10%), capital (38%), and management (52%). Knowledge society—A society in which much of the labor force has migrated from manual work to work based on knowledge 	
CURRENT CHALLENGES IN OPERATIONS MANAGEMENT	 Some of the current challenges for operations managers include: Globalization; international collaboration Supply-chain partnering; joint ventures; alliances Sustainability; green products; recycle, reuse Technological change; digitalization Mass customization; customized products Lean operations; continuous improvement and elimination of waste 	Concept Questions: 9.1–9.5
ETHICS, SOCIAL Responsibility, And Sustainability	 Among the many ethical challenges facing operations managers are (1) efficiently developing and producing safe, quality products; (2) maintaining a clean environment; (3) providing a safe workplace; and (4) honoring stakeholder commitments. Stakeholders—Those with a vested interest in an organization 	Concept Question: 10.1
ADDITIONAL MYLAB OPERATIONS MANAGEMENT RESOURCES	 Video for Creating Your Own Excel Spreadsheets (Example 2) Additional Case Studies (National Air Express and Zychol Chemicals Corp.) Multiple Choice Case Questions (Zychol Chemicals Corp.) Recent Graduate Video: Jeremy Knowles, Risk Analyst, Genesis Financial Solution 	ions

Self Test

 LO 1.1 Productivity increases when: a) inputs increase while outputs remain the same. b) inputs decrease while outputs remain the same. c) outputs decrease while inputs remain the same. d) inputs and outputs increase proportionately. e) inputs increase at the same rate as outputs. LO 1.2 A strategy that is <i>not</i> one of the 10 strategic operations management decisions is: a) maintenance. b) human resources, job design and work measurement. c) location strategies. d) design of goods and services. e) advertising strategies. LO 1.3 Operations management jobs comprise approximately% of all jobs. 	 c) increases at about 0.5% per year. d) is dependent upon labor, management, and capital. e) is the same thing as effectiveness. LO 1.6 Single-factor productivity: a) remains constant. b) is never constant. c) usually uses labor as a factor. d) seldom uses labor as a factor. e) uses management as a factor. LO 1.7 Multifactor productivity: a) remains constant. b) is never constant. c) uses management as a factor. e) uses management as a factor. LO 1.7 Multifactor productivity: a) remains constant. b) is never constant. c) usually uses substitutes as common variables for the factors of production. d) seldom uses labor as a factor.
 LO 1.4 Services often: a) are tangible. b) are standardized. c) are knowledge based. d) are low in customer interaction. e) have consistent product definition. LO 1.5 Productivity: a) can use many factors as the numerator. b) is the same thing as production. Answers: LO 1.1. b; LO 1.2. e; LO 1.3 40; LO 1.4. c; LO 1.5. d; LO 1.6. 	 e) always uses management as a factor. LO 1.8 Productivity increases each year in the U.S. are a result of three factors: a) labor, capital, management b) engineering, labor, capital c) engineering, capital, quality control d) engineering, labor, data processing e) engineering, capital, data processing c; LO 1.7. c; LO 1.8. a.

Operations Strategy in a Global Environment

CHAPTER Outline

GLOBAL COMPANY PROFILE: Boeing

- A Global View of Operations and Supply Chains 64
- Determining Missions and Strategies 67
- Achieving Competitive Advantage Through Operations *68*
- Issues in Operations Strategy 72
- Strategy Development and Implementation 73
- Strategic Planning, Core Competencies, and Outsourcing 76
- Global Operations Strategy Options 80



Ski Nautique practices a differentiation strategy based on innovation, performance, and looking forward. The company wants to create the marketplace and give consumers what they want before they even know they want it.

O H A

PTEF

GLOBAL COMPANY PROFILE *Boeing*

Boeing's Global Strategy Yields Competitive Advantage

oeing is the world's largest aerospace company and leading manufacturer of commercial jetliners, defense systems, and space systems. As America's biggest manufacturing exporter, the company supplies airlines and government customers in more than 150 countries. Boeing products include commercial and military aircraft, satellites, weapons, electronic and defense systems, launch and space exploration systems, and advanced communication systems.

Components from Boeing's worldwide supply chain come together on assembly lines in Charleston, South Carolina. Although components come from throughout the world, about 35% of the 787 structure comes from Japanese companies.



Some of the International Suppliers of Boeing 787 Components

SUPPLIER	HQ COUNTRY	COMPONENT
Latecoere	France	Passenger doors
Labinel	France	Wiring
Dassault	France	Design and product life cycle management software
Messier-Bugatti	France	Electric brakes
Thales	France	Electrical power conversion system
Messier-Dowty	France	Landing gear structure
Diehl	Germany	Interior lighting
Cobham	UK	Fuel pumps and valves
Rolls-Royce	UK	Engines
Smiths Aerospace	UK	Central computer system
BAE Systems	UK	Electronics
Alenia Aeronautica	Italy	Upper center fuselage
Toray Industries	Japan	Carbon fiber for wing and tail units
Fuji Heavy Industries	Japan	Center wing box
Kawasaki Heavy Ind.	Japan	Forward fuselage, fixed sections of wing
Teijin Seiki	Japan	Hydraulic actuators
Mitsubishi Heavy Ind.	Japan	Wing box
Chengdu Aircraft	China	Rudder
Hafei Aviation	China	Parts
Korean Airlines	South Korea	Wingtips
Saab	Sweden	Cargo and access doors

Boeing has a long tradition of aerospace leadership and innovation. It has been the premier manufacturer of commercial jetliners for decades. Today, the company manufactures the 737, 777, and 787 airplane families and the Boeing Business Jet. More than 10,000 Boeing-built commercial jetliners are in service worldwide, which is almost half the world fleet. The company also offers the most complete family of planes designed for freight. About 90 percent of the world's cargo is carried on board Boeing planes.

Its broad portfolio includes KC-46 aerial refueling aircraft, AH-64 Apache helicopters, the 702 family of satellites, CST-100 Starliner spacecraft, and the Echo Voyager.

With corporate offices in Chicago, Boeing employs more than 153,000 people. Its market





An Apache helicopter landing on a

U.S. aircraft carrier.

Boeing's Starliner spacecraft being launched by a NASA rocket.



Boeing's collaborative technology enables a "virtual workspace" that allows Washingtonbased engineers, as well as partners in Australia, Japan, Italy, and Canada and across the United States, to make concurrent design changes to aerospace vehicles in real time.

success plays a key role in supporting high-value aerospace jobs across its supply chain and across the U.S., working with more than 12,000 businesses creating 1,000,000-plus supplier-related jobs.

Boeing's supply chain is also global, with over 300 suppliers in dozens of countries. Its newest jet, the 787 Dreamliner, was designed in collaboration with 20 foreign suppliers, some of whom are shown in the table. The expectation is that countries that have a stake in the Dreamliner are more likely to buy from Boeing than from its European competitor, Airbus.

This enormous global supply chain delivers more than a billion parts and subassemblies to Boeing plants every year.

L E A R N I N G Objectives

LO 2.1

LO 2.2

LO 2.4

LO 2.5

Define mission and strategy 67

Identify and explain three strategic approaches to competitive advantage 68

LO 2.3 *Understand* the significance of key success factors and core competencies 74

Use factor rating to evaluate both country and outsource providers 79

Identify and explain four global operations strategy options 80

A Global View of Operations and Supply Chains

Today's successful operations manager has a global view of operations strategy. Since the early 1990s, nearly 3 billion people in developing countries have overcome the cultural, religious, ethnic, and political barriers that constrain productivity. And now they are all players on the global economic stage. As these barriers disappeared, simultaneous advances were being made in technology, tariff reductions, reliable shipping, and inexpensive communication. These changes mean that, increasingly, firms find their customers and suppliers located around the world. The unsurprising result is the growth of world trade (see Figure 2.1), global capital markets, and the international movement of people. This means increasing economic integration and interdependence of countries—in a word, globalization. In response, organizations are hastily extending their distribution channels and supply chains globally. The result is innovative strategies where firms compete not just with their own expertise but with the talent in their entire global supply chain. For instance:

- · Boeing is competitive because both its sales and supply chain are worldwide.
- Italy's Benetton moves inventory to stores around the world faster than its competition with rapid communication and by building exceptional flexibility into design, production, and distribution.
- Sony purchases components from a supply chain that extends to Thailand, Malaysia, and elsewhere around the world for assembly of its electronic products, which in turn are distributed around the world.
- Volvo, considered a Swedish company, was purchased by a Chinese company, Geely, but Volvo assembles cars in Sweden, Belgium, Malaysia, and China.
- China's Haier (pronounced "higher"), from its South Carolina plant, produces compact refrigerators (it has one-third of the U.S. market) and refrigerated wine cabinets (it has half of the U.S. market). Haier also controls 10% of the large appliance market worldwide and owns the GE appliance division, which employs 6,000 in Appliance Park, Kentucky.

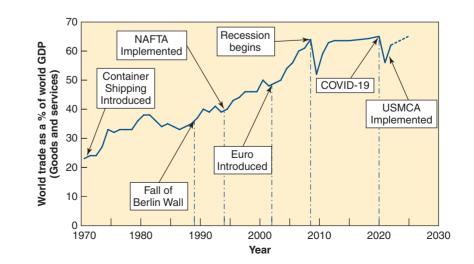


Figure 2.1

Growth of World Trade as a Percentage of World GDP Sources: World Bank; World Trade Organization: and IME Globalization means customers, talent, and suppliers are worldwide. The new standards of global competitiveness impact quality, variety, customization, convenience, timeliness, and cost. Globalization strategies contribute efficiency, adding value to products and services, but they also complicate the operations manager's job. Complexity, risk, and competition are intensified, forcing companies to adjust for a shrinking world.

We have identified six reasons domestic business operations decide to change to some form of international operation. They are:

- 1. Improve the supply chain.
- 2. Reduce costs and exchange rate risk.
- 3. Improve operations.
- 4. Understand markets.
- 5. Improve products.
- 6. Attract and retain global talent.

Let us examine, in turn, each of the six reasons.

Improve the Supply Chain The supply chain can often be improved by locating facilities in countries where unique resources are available. These resources may be human resource expertise, low-cost labor, or raw material. For example, auto-styling studios from throughout the world have migrated to the auto mecca of southern California to ensure the necessary talent in contemporary auto design. Similarly, a perfume manufacturer wants a presence in Grasse, France, where much of the world's perfume essences are prepared from the flowers of the Mediterranean.

Reduce Costs and Exchange Rate Risk Many international operations seek to reduce risks associated with changing currency values (exchange rates) as well as take advantage of the tangible opportunities to reduce their direct costs. Less stringent government regulations on a wide variety of operations practices (e.g., environmental control, health and safety) can also reduce indirect costs.

Shifting low-skilled jobs to another country has several potential advantages. First, and most obviously, the firm may reduce costs. Second, moving the lower-skilled jobs to a lower-cost location frees higher-cost workers for more valuable tasks. Third, reducing wage costs allows the savings to be invested in improved products and facilities (and the retraining of existing workers, if necessary) at the home location.

Many firms use *financial hedging* by purchasing currency options to protect against negative exchange rate changes. Firms can also pursue **operational hedging** by intentionally building extra capacity in different countries and then shifting production from country to country as costs or exchange rates vary. This allows them to finesse currency risks and costs as economic conditions dictate.

The United States and Mexico have created maquiladoras (free trade zones) that allow manufacturers to cut their costs by paying only for the value added by Mexican workers. If a U.S. manufacturer, such as Caterpillar, brings a \$1,000 engine to a maquiladora operation for assembly work costing \$200, tariff duties will be charged only on the \$200 of work performed in Mexico.

Trade agreements also help reduce tariffs and thereby reduce the cost of operating facilities in foreign countries. The **World Trade Organization (WTO)** has helped reduce tariffs from 40% in 1940 to less than 3% today. Two major trade agreements for North America are NAFTA and USMCA. These agreements seek to phase out all trade and tariff barriers among Canada, Mexico, and the U.S. Other trade agreements that are accelerating global trade include APEC (the Pacific Rim countries), SEATO (Australia, New Zealand, Japan, Hong Kong, South Korea, New Guinea, and Chile), MERCOSUR (Argentina, Brazil, Paraguay, and Uruguay), and CAFTA (Central America, Dominican Republic, and United States).

Another trading group is the European Union (EU).¹ The European Union has reduced trade barriers among the participating European nations through standardization and a common currency, the euro. However, this major U.S. trading partner, with over 450 million consumers, is also placing some of the world's most restrictive conditions on products sold in the EU. Everything from recycling standards to automobile bumpers to hormone-free farm products must meet EU standards, complicating international trade.

Operational hedging

Maintaining excess capacity in different countries and shifting production levels among those countries as costs and exchange rates change.

Maquiladoras

Mexican factories located along the U.S.–Mexico border that receive preferential tariff treatment.

World Trade Organization (WTO)

An international organization that promotes world trade by lowering barriers to the free flow of goods across borders.

NAFTA and USMCA

Free trade agreements between Canada, Mexico, and the United States.

European Union (EU)

A European trade group that has 27 member states.

Improve Operations Operations learn from better understanding of management innovations in different countries. For instance, the Japanese have improved inventory management, the Germans are aggressively using robots, and the Scandinavians have contributed to improved ergonomics throughout the world.

Another reason to have international operations is to reduce response time to meet customers' changing product and service requirements. Providing quick and adequate service is often improved by locating facilities in the customer's home country.

Understand Markets Because international operations require interaction with foreign customers, suppliers, and other competitive businesses, international firms inevitably learn about opportunities for new products and services. Europe led the way with cell phone innovations, and then the Japanese and Indians led with cell phone fads. Knowledge of markets not only helps firms understand where the market is going but also helps firms diversify their customer base, add production flexibility, and smooth the business cycle.

Another reason to go into foreign markets is the opportunity to extend the *life cycle* (i.e., stages a product goes through; see Chapter 5) of an existing product. While some products in the U.S. are in a "mature" stage of their product life cycle, they may represent state-of-the-art products in developing countries.

Improve Products Learning does not take place in isolation. Firms serve themselves and their customers well when they remain open to the free flow of ideas. For example, Toyota and BMW will manage joint research and share development costs on battery research for the next generation of green cars. Similarly, international learning in operations is taking place as South Korea's Samsung and Germany's Robert Bosch join to produce lithium-ion batteries to the benefit of both.

Attract and Retain Global Talent Global organizations can attract and retain better employees by offering more employment opportunities. They need people in all functional areas and areas of expertise worldwide. Global firms can recruit and retain good employees because they provide both greater growth opportunities and insulation against unemployment during times of economic downturn. During economic downturns in one country or continent, a global firm has the means to relocate unneeded personnel to more prosperous locations.

A worldwide strategy places added burdens on operations management. Because of economic and lifestyle differences, designers must target products to each market. For instance, clothes washers sold in northern countries must spin-dry clothes much better than those in warmer climates, where consumers are likely to line-dry them. Similarly, as shown here, Whirlpool refrigerators sold in Bangkok are manufactured in bright colors because they are often put in living rooms.



So, to recap, successfully achieving a competitive advantage in our shrinking world means maximizing all the possible opportunities, from tangible to intangible, that international operations can offer.

Cultural and Ethical Issues

While there are great forces driving firms toward globalization, many challenges remain. One of these challenges is reconciling differences in social and cultural behavior. With issues ranging from bribery, to child labor, to the environment, managers sometimes do not know how to respond when operating in a different culture. What one country's culture deems acceptable may be considered unacceptable or illegal in another. It is not by chance that there are fewer female managers in the Middle East than in India.

In the last decade, changes in international laws, agreements, and codes of conduct have been applied to define ethical behavior among managers around the world. The WTO, for example, helps to make uniform the protection of both governments and industries from foreign firms that engage in unethical conduct. Even on issues where significant differences between cultures exist, as in the area of bribery or the protection of intellectual property, global uniformity is slowly being accepted by many nations.

Despite cultural and ethical differences, we live in a period of extraordinary mobility of capital, information, goods, and even people. We can expect this to continue. The financial sector, the telecommunications sector, and the logistics infrastructure of the world are healthy institutions that foster efficient and effective use of capital, information, and goods. Globalization, with all its opportunities and risks, is here. It must be embraced as managers develop missions and strategies.

Determining Missions and Strategies

An effective operations management effort must have a *mission* so it knows where it is going and a *strategy* so it knows how to get there. This is the case for a small domestic organization as well as a large international organization.

Mission

Economic success, indeed survival, is the result of identifying missions to satisfy a customer's needs and wants. We define the organization's **mission** as its purpose—what it will contribute to society. Mission statements provide boundaries and focus for organizations and the concept around which the firm can rally. The mission states the rationale for the organization's existence. Developing a good strategy is difficult, but it is much easier if the mission has been well defined. Figure 2.2 provides examples of mission statements.

Once an organization's mission has been decided, each functional area within the firm determines its supporting mission. By *functional area* we mean the major disciplines required by the firm, such as marketing, finance/accounting, and production/operations. Missions for each function are developed to support the firm's overall mission. Then within that function lower-level supporting missions are established for the OM functions. Figure 2.3 provides such a hierarchy of sample missions.

Strategy

With the mission established, strategy and its implementation can begin. **Strategy** is an organization's action plan to achieve the mission. Each functional area has a strategy for achieving its mission and for helping the organization reach the overall mission. These strategies exploit opportunities and strengths, neutralize threats, and avoid weaknesses. In the following sections, we will describe how strategies are developed and implemented.

STUDENT TIP

Getting an education and managing an organization both require a mission and strategy.

Mission

The purpose or rationale for an organization's existence.

LO 2.1 *Define* mission and strategy

Strategy

How an organization expects to achieve its missions and goals.

68 PART 1 INTRODUCTION TO OPERATIONS MANAGEMENT

LO 2.2 Identify

and explain three strategic approaches to competitive advantage

VIDEO 2.1 Strategy at Nautique Boat Company Firms achieve missions in three conceptual ways: (1) differentiation, (2) cost leadership, and (3) response. This means operations managers are called on to deliver goods and services that are (1) *better*, or at least different, (2) *cheaper*, and (3) more *responsive*. Operations managers translate these *strategic concepts* into tangible tasks to be accomplished. Any one or combination of these three strategic concepts can generate a system that has a unique advantage over competitors. Much of the remainder of this text is devoted to the challenging task of translating strategy into execution.

Achieving Competitive Advantage Through Operations

Competitive advantage

The creation of a unique advantage over competitors.

STUDENT TIP

For many organizations, the operations function provides *the* competitive advantage.

Differentiation

Distinguishing the offerings of an organization in a way that the customer perceives as adding value.

Figure 2.2

Mission Statements for Three Organizations

Source: Mission statement from Merck. Copyright © by Merck & Co., Inc. Reprinted with permission. Each of the three strategies provides an opportunity for operations managers to achieve competitive advantage. **Competitive advantage** implies the creation of a system that has a unique advantage over competitors. The idea is to create customer value in an efficient and sustainable way. Pure forms of these strategies may exist, but operations managers will more likely be called on to implement some combination of them. Let us briefly look at how managers achieve competitive advantage via *differentiation*, *low cost*, and *response*.

Competing on Differentiation

Safeskin Corporation is number one in latex exam gloves because it has differentiated itself and its products. It did so by producing gloves that were designed to prevent allergic reactions about which doctors were complaining. When other glove makers caught up, Safeskin developed hypoallergenic gloves. Then it added texture to its gloves. Then it developed a synthetic disposable glove for those allergic to latex—always staying ahead of the competition. Safeskin's strategy is to develop a reputation for designing and producing reliable state-of-the-art gloves, thereby differentiating itself.

Differentiation is concerned with providing *uniqueness*. A firm's opportunities for creating uniqueness are not located within a particular function or activity but can arise in virtually everything the firm does. Moreover, because most products include some service, and most services include some product, the opportunities for creating this uniqueness are limited only by imagination. Indeed, differentiation should be thought of as going beyond both physical characteristics and service attributes to encompass everything about the product or service that influences the value that the customers derive from it. Therefore, effective operations managers

Merck

The mission of Merck is to provide society with superior products and services—innovations and solutions that improve the quality of life and satisfy customer needs—to provide employees with meaningful work and advancement opportunities and investors with a superior rate of return.

PepsiCo

Our mission is to be the world's premier consumer products company focused on convenient foods and beverages. We seek to produce financial rewards to investors as we provide opportunities for growth and enrichment to our employees, our business partners, and the communities in which we operate. And in everything we do, we strive for honesty, fairness, and integrity.

Arnold Palmer Hospital

Arnold Palmer Hospital for Children provides state of the art, family-centered healthcare focused on restoring the joy of childhood in an environment of compassion, healing, and hope.

CHAPTER 2 OPERATIONS STRATEGY IN A GLOBAL ENVIRONMENT 69

To manufacture and service an innovative, growing, and profitable worldwide microwave communications business that exceeds our customers' expectations.		
Samı	ble Operations Management Mission	
To produce products consist manufacturer.	ent with the company's mission as the worldwide low-cost	
S	ample OM Department Missions	
Product design	To design and produce products and services with outstanding quality and inherent customer value.	
Quality management	To attain the exceptional value that is consistent with our company mission and marketing objectives by close attention to design, supply chain, production, and field service opportunities.	
Process design	To determine, design, and develop the production process and equipment that will be compatible with low-cost product, high quality, and a good quality of work life.	
Location	To locate, design, and build efficient and economical facilities that will yield high value to the company, its employees, and the community.	
Layout design	To achieve, through skill, imagination, and resourcefulness in layout and work methods, production effectiveness and efficiency while supporting a high quality of work life.	
Human resources	To provide a good quality of work life, with well-designed, safe, rewarding jobs, stable employment, and equitable pay, in exchange for outstanding individual contribution from employees at all levels.	
Supply chain management	To collaborate with suppliers to develop innovative products from stable, effective, and efficient sources of supply.	
Inventory	To achieve low investment in inventory consistent with high customer service levels and high facility utilization.	
Scheduling	To achieve high levels of throughput and timely customer delivery through effective scheduling.	
Maintenance	To achieve high utilization of facilities and equipment by effective preventive maintenance and prompt repair of facilities and equipment.	

Figure 2.3

Sample Missions for a Company, the Operations Function, and Major OM Departments

assist in defining everything about a product or service that will influence the potential value to the customer. This may be the convenience of a broad product line, product features, or a service related to the product. Such services can manifest themselves through convenience (store location, curbside pickup, home delivery, etc.), training, product delivery and installation, or repair and maintenance services.

In the service sector, one option for extending product differentiation is through an *experience*. Differentiation by experience in services is a manifestation of the growing "experience economy." The idea of experience differentiation is to engage the customer—to use people's five senses so they become immersed, or even an active participant, in the product. Disney does this with the Magic Kingdom. People no longer just go on a ride; they are immersed in the Magic Kingdom—surrounded by dynamic visual and sound experiences that complement the physical ride. Some rides further engage the customer with virtual reality or changing air flow and smells, as well as having them steer the ride or shoot at targets or villains. Even movie theaters are moving in this direction with surround sound, moving seats, changing "smells," and mists of "rain," as well as multimedia inputs to story development.

Experience differentiation

Engaging a customer with a product through imaginative use of the five senses, so the customer "experiences" the product. VIDEO 2.2 Hard Rock's Global Strategy Theme restaurants, such as Hard Rock Cafe, likewise differentiate themselves by providing an "experience." Hard Rock engages the customer with classic rock music, big-screen rock videos, memorabilia, and staff who can tell stories. In many instances, a full-time guide is available to explain the displays, and there is always a convenient retail store so the guest can take home a tangible part of the experience. The result is a "dining experience" rather than just a meal. In a less dramatic way, both Starbucks and your local supermarket deliver an experience when they provide music and the aroma of fresh coffee or freshly baked bread.

Competing on Cost

Southwest Airlines has been a consistent moneymaker while other U.S. airlines have lost billions. Southwest has done this by fulfilling a need for low-cost and short-hop flights. Its operations strategy has included use of secondary airports and terminals, first-come, first-served seating, few fare options, smaller crews flying more hours, and snacks-only or no-meal flights.

In addition, and less obviously, Southwest has very effectively matched capacity to demand and effectively utilized this capacity. It has done this by designing a route structure that matches the capacity of its Boeing 737, the only plane in its fleet. Second, it achieves more air miles than other airlines through faster turnarounds—its planes are on the ground less.

One driver of a low-cost strategy is a facility that is effectively utilized. Southwest and others with low-cost strategies understand this and use financial resources effectively. Identifying the optimum size (and investment) allows firms to spread overhead costs, providing a cost advantage. For instance, Walmart continues to pursue its low-cost strategy with superstores, open 24 hours a day. For 20 years, it has successfully grabbed market share. Walmart has driven down store overhead costs, shrinkage, and distribution costs. Its rapid transportation of goods, reduced warehousing costs, and direct shipment from manufacturers have resulted in high inventory turnover and made it a low-cost leader.

Likewise, Franz Colruyt, a Belgian discount food retailer, is also an aggressive cost cutter. Colruyt cuts overhead by using converted factory warehouses, movie theaters, and garages as outlets. Customers find no background music, shopping bags, or bright lights: all have been eliminated to cut costs. Walmart and Colruyt are winning with a low-cost strategy.

Low-cost leadership entails achieving maximum *value* as defined by your customer. It requires examining each of the 10 OM decisions in a relentless effort to drive down costs while meeting customer expectations of value. A low-cost strategy does *not* imply low value or low quality.

Competing on Response

The third strategy option is response. Response is often thought of as *flexible* response, but it also refers to *reliable* and *quick* response. Indeed, we define **response** as including the entire range of values related to timely product development and delivery, as well as reliable scheduling and flexible performance.

Flexible response may be thought of as the ability to match changes in a marketplace where design innovations and volumes fluctuate substantially.

Hewlett-Packard is an exceptional example of a firm that has demonstrated flexibility in both design and volume changes in the volatile world of personal computers. HP's products often have a life cycle of months, and volume and cost changes during that brief life cycle are dramatic. However, HP has been successful at institutionalizing the ability to change products and volume to respond to dramatic changes in product design and costs—thus building a *sustainable competitive advantage*.

The second aspect of response is the *reliability* of scheduling. One way the German machine industry has maintained its competitiveness despite having the world's highest labor costs is through reliable response. This response manifests itself in reliable scheduling. German machine firms have meaningful schedules—and they perform to these schedules. Moreover, the results of these schedules are communicated to the customer, and the customer can, in turn,

Low-cost leadership

Achieving maximum value, as perceived by the customer.

Response

A set of values related to rapid, flexible, and reliable performance.



Response strategy wins orders at Super Fast Pizza. Using a wireless connection, orders are transmitted to \$20,000 kitchens in vans. The driver, who works solo, receives a printed order, goes to the kitchen area, pulls premade pizzas from the cooler, and places them in the oven—it takes about 1 minute. The driver then delivers the pizza—sometimes even arriving before the pizza is ready.

rely on them. Consequently, the competitive advantage generated through reliable response has value to the end customer.

The third aspect of response is *quickness*. Johnson Electric Holdings, Ltd., with headquarters in Hong Kong, makes 83 million tiny motors each month. The motors go in cordless tools, household appliances, and personal care items such as hair dryers; dozens are found in each automobile. Johnson's major competitive advantage is speed: speed in product development, speed in production, and speed in delivery.

Whether it is a production system at Johnson Electric or a pizza delivered in 5 minutes by Pizza Hut, the operations manager who develops systems that respond quickly and reliably can have a competitive advantage.

In practice, differentiation, low cost, and response can increase productivity and generate a sustainable competitive advantage. Proper implementation of the ten decisions by operations managers (see Figure 2.4) will allow these advantages to be achieved.

10 Operations Decisions	Strategy	Example	Competitive Advantage
	Broad product line After-sales service Experience COST LEADERSHIP: Low overhead Effective capacity use Inventory management RESPONSE: Flexibility		ation



Achieving Competitive Advantage Through Operations

Issues in Operations Strategy

Resources view

A method managers use to evaluate the resources at their disposal and manage or alter them to achieve competitive advantage.

Value-chain analysis

A way to identify those elements in the product/service chain that uniquely add value.

Five forces model

A method of analyzing the five forces in the competitive environment.

Whether the OM strategy is differentiation, cost, or response (as shown in Figure 2.4), OM is a critical player. Therefore, prior to establishing and attempting to implement a strategy, some alternate perspectives may be helpful. One perspective is to take a resources view. This means thinking in terms of the financial, physical, human, and technological resources available and ensuring that the potential strategy is compatible with those resources. Another perspective is Porter's value-chain analysis.² Value-chain analysis is used to identify activities that represent strengths, or potential strengths, and may be opportunities for developing competitive advantage. These are areas where the firm adds its unique *value* through product research, design, human resources, supply-chain management, process innovation, or quality management. Porter also suggests analysis of competitors via what he calls his five forces model.³ These potential competing forces are immediate rivals, potential entrants, customers, suppliers, and substitute products.

In addition to the competitive environment, the operations manager needs to understand that the firm is operating in a system with many other external factors. These factors range from economic, to legal, to cultural. They influence strategy development and execution and require constant scanning of the environment.

The firm itself is also undergoing constant change. Everything from resources, to technology, to product life cycles is in flux. Consider the significant changes required within the firm as its products move from introduction, to growth, to maturity, and to decline (see Figure 2.5). These internal changes, combined with external changes, require strategies that are dynamic.

	Introduction	Growth	Maturity	Decline
	Best period to increase market share	Practical to change price or quality image	Poor time to change image, price, or quality	Cost control critical
ssues	R&D engineering is critical	Strengthen niche	Competitive costs become critical Defend market position	
Company Strategy / Issues		3D printers Electric vehicles	Boeing 787	engine vehicles Printed textbooks
Comp	Life Cycle Curve Autonomous vehicles	Virtual reality		Cigarettes
	Product design and	Forecasting critical	Standardization	Little product
	development critical	Ũ		differentiation
es	Frequent product and process	Product and process reliability	Fewer rapid product changes, more minor changes	Cost minimization
lssu	design changes	Competitive product improvements and	Optimum capacity	Overcapacity in the industry
ategy /	Short production runs	options	Increasing stability	Prune line to
OM Strategy / Issues	High production costs	Increase capacity Shift toward product	of process Long production	eliminate items not returning good margin
	Limited models	focus	runs	Reduce capacity
	Attention to quality	Enhance distribution	Product improvement and cost cutting	

Figure 2.5

Strategy and Issues During a Product's Life Cycle

In this chapter's *Global Company Profile*, Boeing provides an example of how strategy must change as technology and the environment change. Boeing builds planes and rockets from carbon fiber, using a global supply chain. Like many other OM strategies, Boeing's strategy has changed with technology and globalization. Microsoft has also had to adapt quickly to a changing environment. Faster processors, new computer languages, changing customer preferences, increased security issues, the Internet, the cloud, and Google have all driven changes at Microsoft. These forces have moved Microsoft's product strategy from operating systems to office products, to Internet service provider, and now to integrator of computers, cell phones, games, and television via the cloud. Also notice, as discussed in the *OM In Action box*, "Amazon Updates Sears' Strategy," how Sears has languished while Amazon has embraced the new digital world to build a new worldwide multi-billion dollar business.

The more thorough the analysis and understanding of both the external and internal factors, the more likely that a firm can find the optimum use of its resources. Once a firm understands itself and the environment, a SWOT analysis, which we discuss next, is in order.

Strategy Development and Implementation

A SWOT analysis is a formal review of internal strengths and weaknesses and external opportunities and threats. Beginning with SWOT analyses, organizations position themselves, through their strategy, to have a competitive advantage. A firm may have excellent design skills or great talent at identifying outstanding locations. However, it may recognize limitations of its manufacturing process or in finding good suppliers. The idea is to maximize opportunities and minimize threats in the environment while maximizing the advantages of the organization's strengths and minimizing the weaknesses. Any preconceived ideas about mission are then reevaluated to ensure they are consistent with the SWOT analysis. Subsequently, a strategy for achieving the mission is developed. This strategy is continually evaluated against the value provided customers and competitive realities. The process is shown in Figure 2.6. From this process, key success factors are identified.

OM in Action

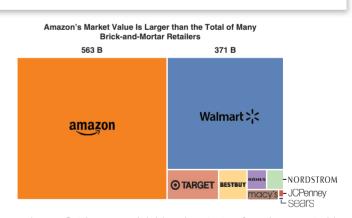
Amazon Updates Sears' Strategy⁴

A century ago, a retail giant that shipped millions of products by mail moved swiftly into the brick-and-mortar business, changing retail forever. Is that happening again? A look at Sears' strategy predicts nearly everything Amazon is doing.

In the last few years, Amazon has opened numerous physical bookstores. It bought Whole Foods and its 400 grocery locations, and it announced a partnership with Kohl's to allow returns at the physical retailer's stores. Amazon's corporate strategy is following a familiar playbook—that of Sears. Sears might seem like a zombie today, but it's easy to forget how transformative the company was 100 years ago. To understand Amazon's evolution, strategy, and future, can we look to Sears?

Mail was an internet before the Internet. After the Civil War, the telegraph, rail, and parcel delivery made it possible to shop via catalog at home and have items delivered to your door. Americans browsed catalogs for everything from food, to books, to houses. Merchants sent the parcels by rail. Then Sears made the successful transition to a brick-and-mortar giant. Like Amazon among its online rivals, Sears was not the country's first mail-order retailer, but it became the largest. Like Amazon, it started with a single product category—watches, rather than books. Like Amazon, the company grew to include a range of products, including guns, gramophones, cars, and groceries.

By building a large base of fiercely loyal consumers, Sears was able to buy more cheaply from manufacturers. It managed its deluge of orders with massive



warehouses. But the company's brick-and-mortar transformation was astonishing. At the start of 1925, there were no Sears stores. By 1929, there were 300. Like Amazon today, the company used its position to enter adjacent businesses. To supplement its huge auto-parts business, Sears started selling car insurance under the Allstate brand. Perhaps Sear's shift from selling products to services is analogous to the creation of Amazon Web Services—or Amazon's TV shows. The growth of both companies was the result of a strategic vision and a focus on operations efficiency, with an eye on the changes in demographics, technology, and logistics. But Sears failed to adjust to a rapidly changing environment. Will Amazon fair better?

STUDENT TIP

A SWOT analysis provides an excellent model for evaluating a strategy.

SWOT analysis

A method of determining internal strengths and weaknesses and external opportunities and threats.



Key Success Factors and Core Competencies

Key success factors (KSFs)

Activities or factors that are *key* to achieving competitive advantage.

Core competencies

Figure 2.6

Strategy Development Process

A set of outstanding skills, talents, and capabilities that differentiates an organization from its competition.

LO 2.3 Understand the significance of key success factors and core competencies Because no firm does everything exceptionally well, a successful strategy requires determining the firm's key success factors and core competencies. Key success factors (KSFs) are those activities that are necessary for a firm to achieve its goals. Key success factors can be so significant that a firm must get them right to survive. A KSF for McDonald's, for example, is layout. Without an effective drive-through and an efficient kitchen, McDonald's cannot be successful. KSFs are often necessary, but not sufficient for competitive advantage. On the other hand, core competencies are the set of unique skills, talents, and capabilities that a firm does at a world-class standard. They allow a firm to set itself apart and develop a competitive advantage. Organizations that prosper identify their core competencies and nurture them. While McDonald's KSFs may include layout, its core competency may be consistent quality. Honda Motors' core competence is gas-powered engines—engines for automobiles, motorcycles, lawn mowers, generators, snow blowers, and more. The idea is to build KSFs and core competencies that provide a competitive advantage and support a successful strategy and mission. A core competency may be the ability to perform the KSFs or a combination of KSFs. The operations manager begins this inquiry by asking:

- "What tasks must be done particularly well for a given strategy to succeed?"
- "Which activities provide a competitive advantage?"
- "Which elements contain the highest likelihood of failure, and which require additional commitment of managerial, monetary, technological, and human resources?"

Only by identifying and strengthening key success factors and core competencies can an organization achieve sustainable competitive advantage. In this text we focus on the 10 strategic OM decisions that typically include the KSFs. These decisions, plus major decision areas for marketing and finance, are shown in Figure 2.7.



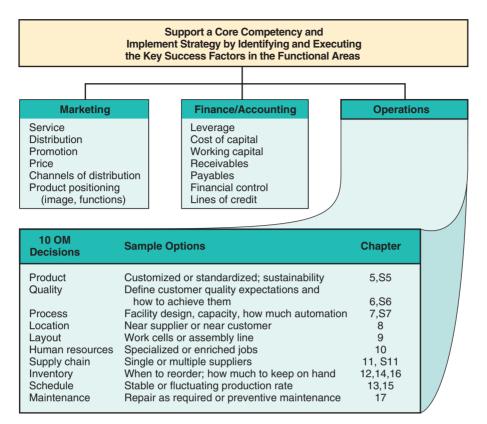


Figure 2.7

Implement Strategy by Identifying and Executing Key Success Factors That Support Core Competencies

STUDENT TIP

These 10 decisions are used to implement a specific strategy and yield a competitive advantage.

Integrating OM with Other Activities

Whatever the KSFs and core competencies, they must be supported by the related activities. One approach to identifying the activities is an **activity map**, which links competitive advantage, KSFs, and supporting activities. For example, Figure 2.8 shows how Southwest Airlines, whose core competency is operations, built a set of integrated activities to support its low-cost competitive advantage. Notice how the KSFs support operations and in turn are supported by other activities. The activities fit together and reinforce each other. In this way, all of the areas support the company's objectives. For example, short-term scheduling in the airline industry is dominated by volatile customer travel patterns. Day-of-week preference, holidays, seasonality, college schedules, and so on all play roles in changing flight schedules. Consequently, airline scheduling, although an OM activity, is tied to marketing. Effective scheduling in the truck-ing industry is reflected in the amount of time trucks travel loaded. But maximizing the time trucks travel loaded requires the integration of information from deliveries completed, pickups pending, driver availability, truck maintenance, and customer priority. Success requires integration of all of these activities.

The better the activities are integrated and reinforce each other, the more sustainable the competitive advantage. By focusing on enhancing its core competence and KSFs with a supporting set of activities, firms such as Southwest Airlines have built successful strategies.

Building and Staffing the Organization

Once a strategy, KSFs, and the necessary integration have been identified, the second step is to group the necessary activities into an organizational structure. Then, managers must staff the organization with personnel who will get the job done. The manager works with subordinate managers to build plans, budgets, and programs that will successfully implement strategies that achieve missions. Firms tackle this organization of the operations function in a variety of ways. The organization charts shown in Chapter 1 (Figure 1.1) indicate the way some firms have organized to perform the required activities. *The operations manager's job is to implement an OM strategy, provide competitive advantage, and increase productivity*.

Activity map

A graphical link of competitive advantage, KSFs, and supporting activities.