OPERATIONS AND SUPPLY CHAIN MANAGEMENT

RUSSELL & TAYLOR

NINTH EDITION





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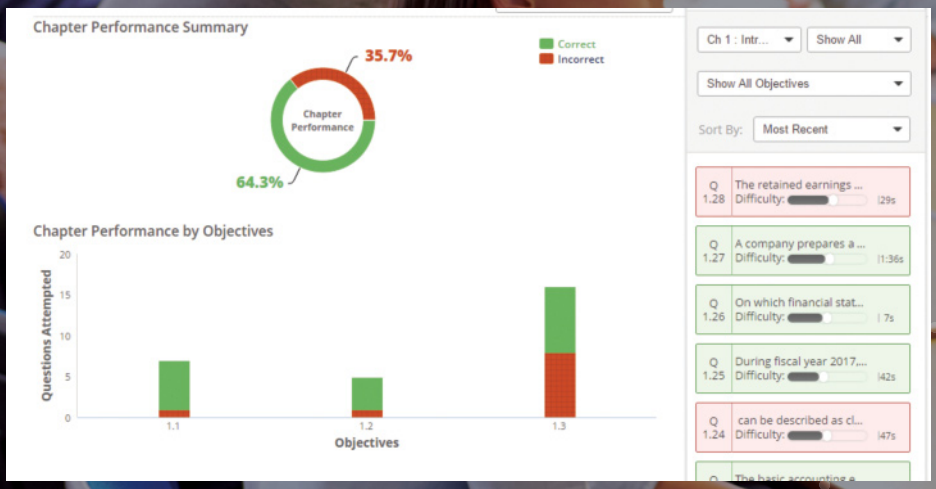

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Operations and Supply Chain Management

Ninth Edition

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WILEY

In memory of my parents, with appreciation
for their love and support throughout the years.

To my mother, Jean V. Taylor,
and in memory of my father, Bernard W. Taylor Jr.,
with love and appreciation.

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ISBN 13: 978-1-119-32097-5

The inside back cover will contain printing identification and country of origin if omitted from this page. In addition, if the ISBN on the back cover differs from the ISBN on this page, the one on the back cover is correct.

Printed in the United States of America.

10 9 8 7 6 5 4 3 2 1

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ROBERTA S. RUSSELL is a Professor of Business Information Technology in the Pamplin College of Business at Virginia Polytechnic Institute and State University. She received a Ph.D and a B.S. from Virginia Polytechnic Institute and State University and an M.B.A. from Old Dominion University. Dr. Russell's primary research and teaching interests are in the areas of operations and supply chain management, with special emphasis on humanitarian and healthcare operations. She has published in *Journal of Operations Management*, *Decision Sciences*, *IIE Transactions, International Journal of Production Research*, *IEEE Transactions*, *Annals of Operations Research*, and many others. She is also co-author of the text *Service Management and Operations.* In 2016, she received the Gyrna Award from the American Society of Quality (ASQ) for research that has made "the largest single contribution to the extension of understanding and knowledge in the philosophy, principles, or methods of quality management." Dr. Russell is a member of DSI, ASQ, POMS, and IIE. She is past President of the APICS Foundation, past Co-Chair of the Supply Chain Academic Talent Initiative (SCTAI), a Certified Fellow in Production and Inventory Management (CFPIM) and a Certified Supply Chain Management Professional (CSCP). She is past Vice President of POMS, past President of the Southwest Virginia Chapter of APICS and has held numerous offices in Southeast DSI. Her consulting experience with IBM, AT&T, Dupont, Courtaulds, Xaloy, Newport News Shipbuilding and others brings a practical perspective into the classroom. She has received the Pamplin College of Business Certificate of Teaching Excellence on two occasions, the University Certificate of Teaching Excellence, the Excellence in Diversity Award, and the MBA Association's Outstanding Professor Award. Dr. Russell teaches both undergraduate and graduate students in the classroom and online. She is frequently called upon to give workshops on teaching with technology, and has incorporated her experiences into the ancillary material that accompanies this text.

Preface

Changes in the Ninth Edition

This new ninth edition is organized around the important and prevalent topic of operations as the creation of value along the supply chain. We describe how every chapter topic fits within a supply chain framework in a company or organization in an increasingly global operating environment. Two chapters deal directly with supply chain management: Chapter 10, Supply Chain Management Strategy and Design, and Chapter 11, Global Supply Chain Procurement and Distribution. However, every chapter includes material relating the chapter topics to supply chain management in a global operating environment. In addition, Chapter 5, Service Design, reflects the expanding presence and importance of the service sector in operations management. We have also added new material throughout the book on the increasingly important OM topics of sustainability, corporate social responsibility, and risk and resilience. To help us show how the OM topics in this new edition fit together within a supply chain framework, we open each chapter with a specific example about one product group, electronics, and in particular, smartphones. Electronics and smartphones are ideal to use as examples to introduce all the various operations and supply chain management topics in this text because they are familiar and popular products to our readers, their supply chain is global, and their production process is complex and interesting.

In addition to opening each chapter with an electronics example, this new edition also includes 86 "Along the Supply Chain" boxes, 45 of which are new, that describe real-world business applications of OM topics at companies around the world. Many of these boxes focus on the increasingly important topics of sustainability and global supply chains. The boxes conclude with critical thinking questions that can be used for assignments and in-class or online discussion.

Chapter 1 focuses on examples of excellence in operations management, current issues in operations and supply chain management, and the strategic design of operations and supply chain management. Chapter 2, Quality Management, emphasizes the necessity and use of quality management systems throughout the supply chain, and includes an expanded section on ISO and its most recent updates. Chapter 3 introduces statistical process control as essential to ensuring quality along the supply chain.

Chapter 4 has sections on Design for the Environment and Collaborative Product Design Systems. Chapter 5 incorporates new statistics on the service economy, the blending of products and services, and expanded tools for service design. A streamlined waiting line analysis section is also included in the chapter. Chapter 6 emphasizes process analysis skills and includes revised material on the Internet of Things, 3D printing, and other new technologies. Chapter 7 incorporates strategies for capacity management, facility selection and design, green facilities, and examples of various service layouts.

Chapter 8, Human Resources, has an increased emphasis on sustainability in the workplace, especially among global suppliers of U.S. companies, as well as increased attention to employee cultural and diversity issues. Chapter 9, Project Management, has an increased focus on cultural and diversity issues in the management of global projects, plus sections on project risk and how to manage it. Chapter 10, Supply Chain Management Strategy and Design, has a section on risk and resilience in global supply chains, increased attention to global sustainability issues and an updated section on SCOR. Chapter 11, Global Supply Chain Procurement and Distribution, addresses spend analysis, global logistics, and additional issues in sustainability. Chapter 12, Forecasting, includes a section on the increasingly important IT topic of data mining, and Chapter 13, Inventory Management, emphasizes its important role in controlling costs along a global supply chain.

Chapter 14 emphasizes the need for effective Sales and Operations Planning, and includes a section on Revenue Management. Chapter 15, Resource Planning, updates resource planning with discussions of cloud computing, in-memory computing, big data, and analytics. Chapter 16 expands Lean Systems to lean services, including lean supply chain and lean and the environment. Chapter 17 incorporates employee scheduling, artificial intelligence, and theory of constraints, along with traditional scheduling methods.

Major Text Themes

Operations Strategy: Creating Value Along the Supply Chain

A company's plan for being competitive is its strategy. The success of a strategic plan is largely determined by how well a company coordinates all of its internal processes, including operations, with its suppliers and customers to produce products and services that provide value. Throughout this book, we try to show how the functions and processes described in each chapter fit into a company's strategic design for the creation of value. In each chapter, we emphasize the need for considering the overall strategic implications of particular operating decisions.

One way in which companies can gain a competitive edge is by deploying the basic functions of operations management in a more effective manner than their rivals, e.g., building a better supply chain. Therefore, we give literally dozens of examples that explain how companies deploy specific operations functions along their supply chain to provide value and make them successful. Throughout the book, "Along the Supply Chain" boxes describe how successful companies have gained a competitive edge through operations.

Focusing on Electronics Every edition of this text has focused on one product group as a continuing story for the introduction to each chapter topic. These introductory product themes for previous editions have included rice, coffee, chocolate, and denim jeans (and thus textiles and apparel). They all have a global supply chain in common. For this ninth edition, we focus on smartphones and the electronics industry that supports it. Electronics is an interesting, diverse industry that includes highly automated advanced manufacturing, low-tech manual assembly operations and a global supply chain. Product life is short and new technology makes previous product versions obsolete within the span of six months to two years. The pace is fast moving and challenging – the type of energy and environment that college students enjoy.

Global Operations

Companies and organizations today must increasingly compete in a global marketplace. The establishment of new trade agreements between countries, innovations in information technology, and improvements in transport and shipping are just a few of the factors that have enabled companies to develop global supply chains. The opening of the global marketplace has only served to introduce more competitors and make competition tougher, thus making strategic supply chain design even more important for achieving success. In this edition, we introduce this global aspect of operations into every chapter. In each chapter, we include examples that touch on the impact of global operations relative to the topic under discussion, and we discuss how globalization affects supply chain management.

Sustainability

Environmental concerns are changing every aspect of operations and supply chain management from product and service design, to supplier sourcing, to manufacture and delivery. In virtually every chapter of this text we address the impact of "sustainability" (i.e., meeting present needs without sacrificing future resources) and give examples of "green practices." For example, in Chapter 4 on product design, we discuss the design for environment lifecycle, eco-labeling, recycling and reuse, and sustainable operations. In Chapter 6 on processes we discuss green manufacturing; and in Chapter 7 on facilities we discuss LEED certified green buildings. In Chapter 8 we discuss how companies achieve a sustainable work place when they have suppliers around the world. In Chapter 10 on supply chain management we discuss sustainable sourcing in a global environment; and in Chapter 16 on lean systems we discuss lean and the environment.

Services and Manufacturing

We have attempted to strike a balance between manufacturing and service operations in this book. Traditionally, operations and supply chain management was thought of almost exclusively in a manufacturing context. However, in the United States and other industrialized nations, there has been a dramatic shift toward service industries. Thus, managing service operations is an important area of study. In many cases, operations and supply chain management processes and techniques are indistinguishable between service and manufacturing. However, in many other instances, service operations present unique situations and problems that require focused attention and unique solutions. We have tried to reflect the uniqueness of service operations by providing focused discussions on service operations throughout the text. For example, in Chapter 2 on quality management we specifically address the importance of quality management in service companies, in Chapter 5 on Service Design we emphasize the differences in design considerations between manufacturing and services, and in Chapter 14 we discuss aggregate planning in services. One type of service examined in virtually every chapter in the book is health care.

Qualitative and Quantitative Processes

We have also attempted to strike a balance between the qualitative (or managerial) aspects of operations management and the quantitative aspects. In the contemporary world of operations management, the quantitative and technological aspects are probably more important than ever. The ability to manage people and resources effectively, to motivate, organize, control, evaluate, and adapt to change, have become critical to competing in today's global markets. Thus, throughout this book we seek to explain and clearly demonstrate how the successful operations manager manages, and how to use quantitative techniques and technology when they are applicable.

However, we attempt to present these quantitative topics in a way that's not overly complex or mathematically intimidating. Above all, we want to show how the quantitative topics fit in with, and complement, the qualitative aspects of operations management. We want you to be able to see both "the forest and the trees."

Teaching and Learning Support Features

Russell & Taylor, 9th Edition, is supported by a comprehensive learning package that assists the instructor in creating a motivating and enthusiastic environment.

Pedagogy in the Textbook

"Along the Supply Chain" Boxes These boxes are located in every chapter in the text. They describe the application of operations in a real-world company, organization, or agency related to specific topics in each chapter. They emphasize how companies effectively compete with

operations management in the global marketplace. The descriptions of operations at actual companies in these boxes help the student understand how specific OM techniques and concepts are used by companies, which also make the topics and concepts easier to understand. In addition, we have added discussion questions to these boxes to help students and teachers "connect" the example to the chapter topics.

OM Dialogue Boxes These boxes include dialogues with recent college business school graduates who are working in operations management in the real world. They describe how they apply various OM topics in the text in their own jobs and the value of their own OM training in college. This provides students with a perspective on the benefit of studying operations management now and its future benefit.

Examples The primary means of teaching the various quantitative topics in this text is through examples. These examples are liberally distributed throughout the text to demonstrate how problems are solved in a clear, straightforward approach to make them easier to understand.

Solved Problems At the end of each chapter, just prior to the homework questions and problems, there is a section with solved examples to serve as a guide for working the homework problems. These examples are solved in a detailed, step-by-step manner.

Summary of Key Formulas These summaries at the end of each chapter and supplement include all of the key quantitative formulas introduced in the chapter in one location for easy reference.

Summary of Key Terms Located at the end of each chapter, these summaries provide a list of key terms introduced in that chapter and their definitions in one convenient location for quick and easy reference.

Homework Problems, Questions, and Cases
Our text contains a large number of end-of-chapter exercises for student assignments. There are almost 700 homework problems and 56 more advanced case problems. There are also 500 discussion questions including new questions. Answers to selected odd-numbered homework problems are included in the back of the book. As we mention in the following "Online Resources for Instructors" section, Excel spreadsheet solution files are available to the instructor for the majority of the end-of-chapter problems and cases.

Online Resources for Students

www.wiley.com/college/Russell

No other innovation has affected operations management in the past few years as much as digital technology and the Internet, and this is no less true in education. Therefore, we make full use of technology as a learning and teaching medium in the courses we teach and in our text. Students can link to the text website or WileyPLUS where an exciting set of Internet resources has been compiled.

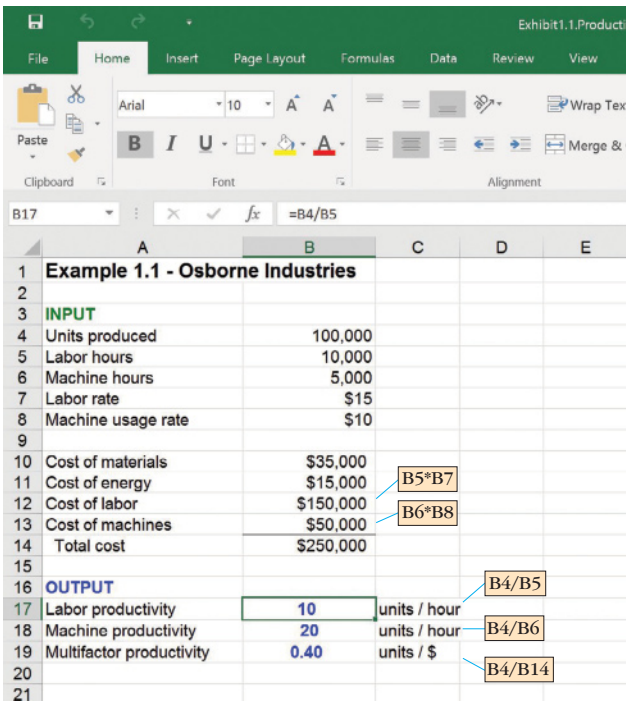
Dynamic resources include animated demo problems, interactive applications and exercises, and direct links to other sources on the Internet. These various resources and learning tools are organized by chapter and are flagged in the textbook with a web icon. Here are some of the items available to students:

- ***Web links*** for companies and concepts discussed in each chapter can be accessed online. These provide enrichment for those students who want to learn more about a topic, and serve as a valuable resource for student assignments and papers.
- ***Virtual Tours*** provided for each chapter bring operations management to life. Selected tours are accompanied by a set of questions directly related to concepts discussed in the chapter.
- ***Internet Exercises*** provide up-to-date access to current issues in operations. These add immediacy to classroom discussions and ensure that operations management topics remain relevant to the student.
- ***Practice Quizzes*** are provided online where students can get immediate feedback on their progress.

Excel Files of Exhibits Excel is used extensively throughout the text to solve various quantitative problems and many Excel illustrations are provided throughout the text.

Every Excel spreadsheet used to prepare the examples in the text is available on the text website for students and instructors. They are organized by chapter and are listed by their exhibit number. Below is an example of Exhibit 1.1 from Chapter 1. Notice the file name is simply the exhibit number plus the topic

EXHIBIT 1.1 Excel File



(i.e., Exhibit 1.1. Productivity). Please look in each file carefully. In many cases, several sheets in one file have been used to display different parts of a problem, such as a graphical solution as well as a numerical solution. Example files are also available for MS Project files in Chapter 9.

Online Resources for Instructors

www.wiley.com/college/russell

Instructor's Manual The Instructor's Manual, updated by the authors, features chapter outlines, teaching notes, experiential exercises, alternate examples to those provided in the text, pause and reflect questions for classroom discussion, and suggested online videos to use in class or assign for homework.

Test Bank Fully revised from the previous edition, this test bank consists of true/false, multiple-choice, short answer, and essay questions. All questions have been carefully accuracy-checked to ensure the highest quality of materials for our customers. The questions are also available electronically on the textbook support site. The Computerized Test Bank, for use on a PC running Windows, is from a test-generating program that allows instructors to modify and add questions in order to customize their exams.

PowerPoint Presentation Slides The PowerPoint presentation slides, revised by Lance Matheson of Virginia Tech, include outlines for every chapter, exhibits from the text, and additional examples, providing instructors with a number of learning opportunities for students. The PowerPoint slides can be accessed on the instructor's portion of the 9th edition website. Lecture notes accompany each slide.

Solutions Manual The Solutions Manual, updated by the authors, features detailed answers to end-of-chapter questions, homework problems, and case problems.

Excel Homework Solutions and Excel Exhibit Files This new edition includes almost 700 homework problems and 56 case problems. Excel solution files for the instructor are provided on the website for the majority of these problems. In addition, Microsoft Project solution files are provided for most of the homework problems in Chapter 9 (Project Management). Excel worksheets for class handouts or homework assignments are provided for QFD, process flow charts, MRP matrices, and others. Excel exhibit files for every example in the text solved with Excel are provided as templates for solving similar problems for both student and instructor and are available on the text website.

Web Quizzes These online quizzes, revised by Scott Hedin of Gonzaga University, vary in level of difficulty and are designed to help your students evaluate their individual progress through a chapter. Web quizzes are available on the student portion of the website. Here students will have the ability to test themselves with 15–20 questions per chapter that include true-false and multiple choice questions.

OM Tools OM Tools is an Excel add-in designed to accompany the Russell/Taylor, *Operations and Supply Chain Management*, 9th edition text. The software consists of 18 modules with over 60 problem types. OM Tools is easy to use and interpret, and is accompanied by a help file with text references. A new and updated version of OM Tools is available for this edition of the text.

Virtual Tours are online tours of service and production facilities. Selected tours are made available to students on the student portion of the website, along with questions that help students apply the concepts they've learned in the text to real-world companies. A Virtual Tours Master List, organized by industry, contains links to over 200 online tours that instructors may use for assignments or classroom presentation.

OM Student Videos Offered on the instructor companion website, we offer a collection of videos done by students that provide excellent examples of the concepts illustrated in the text. These videos can be accessed on the instructor companion website. Please go to www.wiley.com/college/russell, for more information.

Darden Business Cases Darden Business Publishing Cases delivered through the Wiley Custom Select website www.customselect.wiley.com.

Littlefield Technologies Operations Management Simulation Empowers students to make real world decisions and apply what they learn in the classroom. www.wileydifferenceinbusiness.com

WileyPLUS

WileyPLUS is a research-based online environment for effective teaching and learning.

WileyPLUS builds students' confidence because it takes the guess-work out of studying by providing students with a clear roadmap: what to do, how to do it, if they did it right. Students will take more initiative so you'll have greater impact on their achievement in the classroom and beyond.

Now with ORION, An Adaptive Learning Experience Based on cognitive science, *WileyPLUS* with ORION provides students with a personal, adaptive learning experience so they can build their proficiency on topics and use their study time most effectively.

ORION helps students learn by learning about them.

- Students BEGIN by taking a quick diagnostic for any chapter. This will determine their baseline proficiency on each topic in the chapter. A diagnostic report helps students decide what to do next.
- Students can either STUDY or PRACTICE. Study directs students to the specific topic they choose in *WileyPLUS*, where they can read from the e-textbook or use the variety of relevant resources. Student can also practice, using questions and feedback powered by ORION's adaptive learning engine.
- A number of reports and ongoing recommendations help students MAINTAIN their proficiency over time for each topic.

For more information, go to: www.wiley.com/college/sc/oriondemo.

WileyPLUS for Instructors WileyPLUS enables you to:

- Assign automatically graded homework, practice, and quizzes from the end of chapter and test bank.
- Track your students' progress in an instructor's grade book.

- Access all teaching and learning resources, including an online version of the text, and student and instructor supplements, in one easy-to-use website. These include full colour PowerPoint slides, teaching videos, case files, and answers and animations.
- Create class presentations using Wiley-provided resources, with the ability to customize and add your own materials.

WileyPLUS for Students In WileyPLUS, students will find various helpful tools, such as an ebook, the students, study manual, videos with tutorials by the author applets, Decision Dilemma and Decision Dilemma Solved animations, learning activities, flash cards for key terms, demonstration problems, databases in both Excel and Minitab, case data in both Excel and Minitab, and problem data in both Excel and Minitab.

Acknowledgments

The writing and revision of a textbook, like any large project, requires the help and creative energy of many people, and this is certainly not the exception. We especially appreciate the confidence, support, help, and friendship of our editor at Wiley. We also thank the Wiley staff members who helped with our book including:

Jennifer Manias, Sponsoring Editor; Darren LaLonde, Executive Editor; Rebecca Costantini, Product Design Associate; Chris DeJohn, Executive Marketing Manager; Sandra Rigby, Production Editor; and, numerous other people who work behind the scenes to whom we never saw or spoke. We are indebted to the reviewers of the text including: Robert Donnelly; Robert Aboolian, California State University San Marcos; Ajay Aggarwal, Millsaps College; Fred Anderson, Indiana University of Pennsylvania; Beni Asllani, University of Tennessee Chattanooga; Anteneh Ayanso, University of Connecticut, Storrs; Brent Bandy, University of Wisconsin, Oshkosh; Joe Biggs, California Polytechnic State University; Tom Bramorski, University of Wisconsin, Whitewater; Kimball Bullington, Middle Tennessee State University; Cem Canel, University of North Carolina, Wilmington; Janice Cerveny, Florida Atlantic University; Robert Clark, SUNY Stony Brook; Ajay Das, Baruch College CUNY; Kathy Dhanda, University of Portland; Susan Emens, Kent State University; Yee Fok, University of New Orleans; Phillip Fry, Boise State University; Mark Gershon, Temple University; Robert Greve, Oklahoma State University; Robert Frese, Maryville University; Jay Jayaram, University of South Carolina, Columbia; Vaidy Jayaraman, University of Miami; Serge Karalli, DePaul University; William Kime, University of New Mexico; Peter Klein, Ohio University; Howard Kraye, University of New Mexico, Albuquerque; John Kros, East Carolina University; Gopalan Kutty, Mansfield University; Bingguang Li, Albany State University; Royce Lorentz, Slippery Rock University; Sheldon Lou, California State University, San Marcos; Ken Mannino, Milwaukee School of Engineering; Lance Matheson, Virgina Tech; Duncan McDougall, Plymouth State University; Jaideep Motwani, Grand Valley State University; Hilary Moyes, University of Pittsburgh; Barin Nag, Towson University; Ozgur Ozluk, San Francisco State University; Amer Qureshi, University of Texas Arlington; Jim Robison, Sonoma State University; Raj Selladurai, Indiana University Northwest; Robert Setaputro, University of Wisconsin, Milwaukee; Jacob Simons, Georgia Southern University; Marilyn Smith, Winthrop University; Donna Stewart, University of Wisconsin, Stout; Donald Stout, St. Martin's College; Dothang Truong, Fayetteville State University; Elizabeth Trybus, California State University, Northridge; Ray Vankataraman, Pennsylvania State University, Erie; Timothy Vaughan, University of Wisconsin, Eau Claire; Mark Vrobelfski, University of Arizona; Gustavo Vulcano, New York University; Kevin Watson, University of New Orleans; Michel Whittenberg, University of Texas, Arlington; Hulya Yazici, University of Wisconsin, La Crosse; Jinfeng Yue, Middle Tennessee State University; and Xiaoqun Zhang, Pennsylvania State University, Harrisburg. We also thank the reviewers of the sixth edition including: Ajay Aggarwal, Millsaps College; Binguang Li, Albany State University; Christina McCart, Roanoke College; Cuneyt Altinoz, East Carolina University; Dana Johnson, Michigan Technical University; David Frantz, Indiana University; Donald Stout, St. Martin's University; Doug Hales, University of Rhode Island; Drew Stapleton, University of Wisconsin, LaCrosse; Fataneh Taghaboni-Dutta, University of Michigan, Flint; Ike Ehie, Kansas State University; John Hebert, University of Akron; John Kros, East Carolina University; Kaushik Sengupta, Hofstra University; Larry White, Eastern Illinois University; Lewis Coopersmith, Rider University; Mohammad Sedaghat, Fairleigh Dickinson University; Morgan Henrie, University of Alaska, Anchorage; Phil Fry, Boise State University; Robert Aboolian, California State University, San Marcos; Robert Clark, SUNY, Stony Brook; Scott Hedin, Gonzaga University; Susan Emens, Kent State University, Trumbull; Tom Wilder, California State University, Chico; Zhiwei Zhu, University of Louisiana, Lafayette.

They contributed numerous suggestions, comments, and ideas that dramatically improved and changed this book over several editions. We offer our sincere thanks to these colleagues and hope that they can take some satisfaction in their contribution to our final product. We wish to thank our students who have class-tested, critiqued, and contributed to the first eight editions and this ninth edition from a consumer's point of view. We thank colleagues Michelle Seref, Virginia Tech, for creating a new version of OM Tools; Laura Clark, Virginia Tech, for her help with WileyPLUS; Ronny Richardson, Southern Polytechnic State University, who accuracy checked all of the supplements for this text; and graduate student Yuhong Li for her assistance in numerous capacities. We are especially grateful to Tracy McCoy and Sylvia Seavey at Virginia Tech for their unstinting help, hard work, and patience.

R.S.R and B.W.T

Brief Contents

Contents

CHAPTER 1

Introduction to Operations and Supply Chain Management

Christopher Futcher/Getty Images

LEARNING OBJECTIVES

After reading this chapter, you will be able to:

- Describe what the operations function is and how it relates to other business functions.
- Discuss the key factors that have contributed to the evolution of operations and supply chain management.
- Discuss how and why businesses operate globally, and the importance of globalization in supply chain management.
- Calculate and interpret productivity measures used for measuring competitiveness.
- Discuss the importance of operations and supply chain management to a firm's strategy, and the process of developing, aligning, and deploying strategy.

The Cell Is the Thing

What is the most important product in your life? I'm betting most of you would say your smartphone. Smartphones (see photo) allow us to communicate with our friends, our family, and the world. They organize our lives and tell us where to go and what to do. They connect us to each other and share what is important, what is trending, who is who, and how we can participate. We will be following the design, manufacture, use and re-use of cell phones in this book as background for decisions in operations and supply chain management. Our journey will take us from the desert sands, through the most advanced and automated factories on the planet, across oceans to massive assembly lines of workers, and through high-tech design centers and logistics hubs. We will crisscross the world several times before landing in a retail store or website and arriving at your door. And when the next latest and greatest technology is available and you opt for an upgrade, we'll follow the disposal, recycling, and reuse of your old unit and muse about what might be next on the horizon.

Operations management designs, operates, and improves productive systems—systems for getting work done. Operations managers are found in banks, hospitals, factories, and government. They design systems, ensure quality, produce products, and deliver services. They work with customers and suppliers, the latest technology, and global partners. They solve problems, reengineer processes, innovate, and integrate. Operations is more than planning and controlling; it's doing. Whether it's superior quality, speed-to-market, customization, or low cost, excellence in operations is critical to a firm's success.

Operations management The design, operation, and improvement of productive systems.

Along the Supply Chain

What Do Operations and Supply Chain Managers Do?

Operations and supply chain managers are the *improvement people*, the realistic, hard-nosed, make-it-work, get-it-done people; the planners, coordinators, and negotiators. They perform a variety of tasks in many different types of businesses and organizations.

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Let's meet Claire Thielen, director of informatics for a healthcare system; Ada Liu, division manager for Li & Fung Trading Company; and Erin Hiller, food technologist at a major branded food manufacturer.

Claire Thielen is a healthcare professional who specializes in decision support, process improvement, and organizational performance. She facilitates interdisciplinary teams as they pursue continuous quality improvement projects and analyzes methods and systems for managing information. Her projects include determining staffing patterns and workflow for computerized scheduling systems; consolidating policies, procedures, and practices for hospital mergers; developing and implementing balanced scorecards and benchmarking reports; designing clinical studies of new medication effectiveness; and conducting training sessions on process mapping and analysis (see photo). Claire Thielen improves quality, productivity, and information in the healthcare industry.

Ada Liu is a division manager for Li & Fung, a global sourcing company. She coordinates global production and distribution for major players in the garment industry (see photo). For one particular trouser order, she had the fabric woven in China (for their unique dyeing process), chose fasteners from Hong Kong and Korea (for their durability), and sent the raw materials to Guatemala for sewing (for their basic skills, low cost, and proximity to the United States). If problems should arise, Liu can reroute the order to one of its 7500 suppliers in 37 countries. Ada Liu is a supply chain expert for Li & Fung.

Erin Hiller is a food technologist at a major branded food manufacturer. She works in research and development (R&D) devising, developing, and testing new products, as shown in the photo. For part of her job, she travels to manufacturing plants across the country to monitor the ramp-up of production for consumer food products with new formulas or ingredients. She verifies that correct procedures are being followed, samples and tests output for quality and consistency, and revises formulaic recipes as required. She also evaluates new and emerging technologies and determines whether they would be beneficial to the product lines and manufacturing operations. Erin Hiller brings fresh designs to the market, keeps operations up to date, and ensures the safety and quality of the foods you eat every day.

Sources: Claire Theilen, LinkedIn, accessed January 10, 2010; Joanne Lee-Young, "Furiously Fast Fashions," *The Industry Standard Magazine,* (June 22, 2001); Interview with Erin Hiller (January 3, 2013).

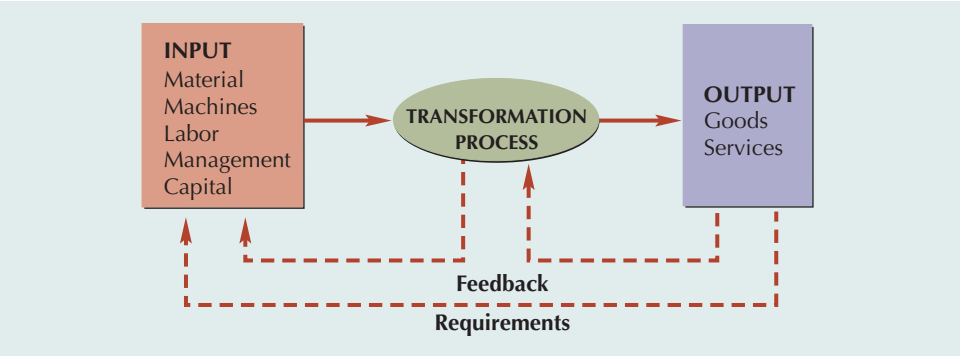


FIGURE 1.1 **Operations as a Transformation Process**

Operations is often defined as a transformation process. As shown in **Figure 1.1**, inputs (such as material, machines, labor, management, and capital) are transformed into outputs (goods and services). Requirements and feedback from customers are used to adjust factors in the transformation process, which may in turn alter inputs. In operations management, we try to ensure that the transformation process is performed efficiently and that the output is of greater *value* than the sum of the inputs. Thus, the role of operations is to create value. The transformation process itself can be viewed as a series of activities along a **value chain** extending from supplier to customer.

Operations A function or system that transforms inputs into outputs of greater value.

Value chain A series of activities from supplier to customer that add value to a product or service.

The input–transformation–output process is characteristic of a wide variety of operating systems. In an automobile factory, sheet steel is formed into different shapes, painted and finished, and then assembled with thousands of component parts to produce a working automobile. In an aluminum factory, various grades of bauxite are mixed, heated, and cast into ingots of different sizes. In a hospital, patients are helped to become healthier individuals through special care, meals, medication, lab work, and surgical procedures. Obviously, "operations" can take many different forms. The transformation process can be

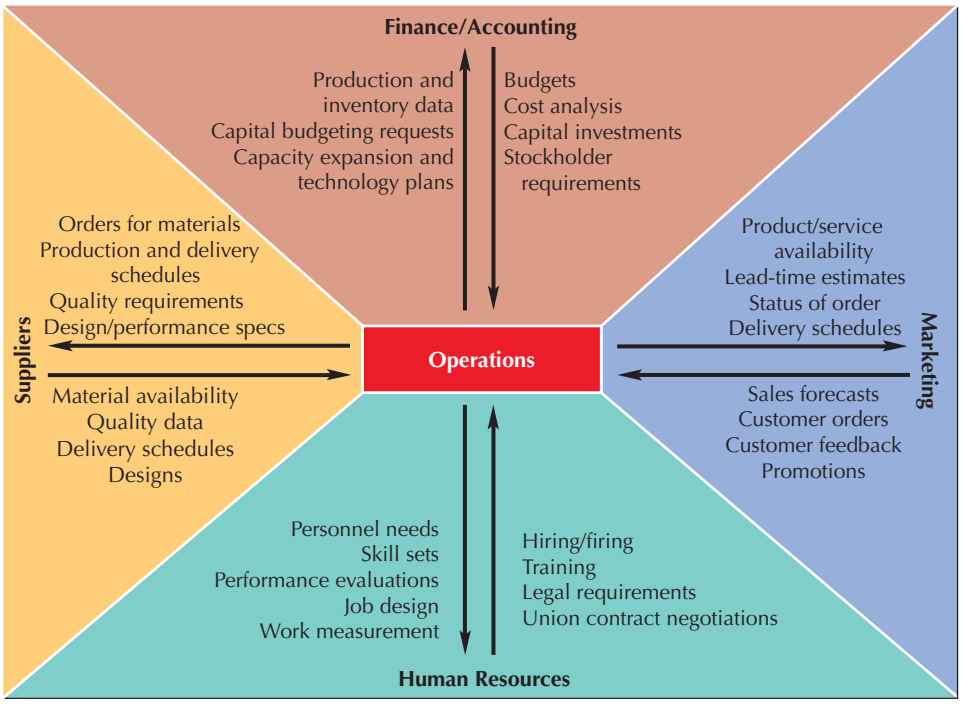
physical,	as in manufacturing operations;
locational,	as in transportation or warehouse operations;
exchange,	as in retail operations;
physiological,	as in healthcare;
psychological,	as in entertainment; or
informational,	as in communication.

The Operations Function

Activities in operations management (OM) include organizing work, selecting processes, arranging layouts, locating facilities, designing jobs, measuring performance, controlling quality, scheduling work, managing inventory, and planning production. Operations managers deal with people, technology, and deadlines. These managers need good technical, conceptual, and behavioral skills. Their activities are closely intertwined with other functional areas of a firm.

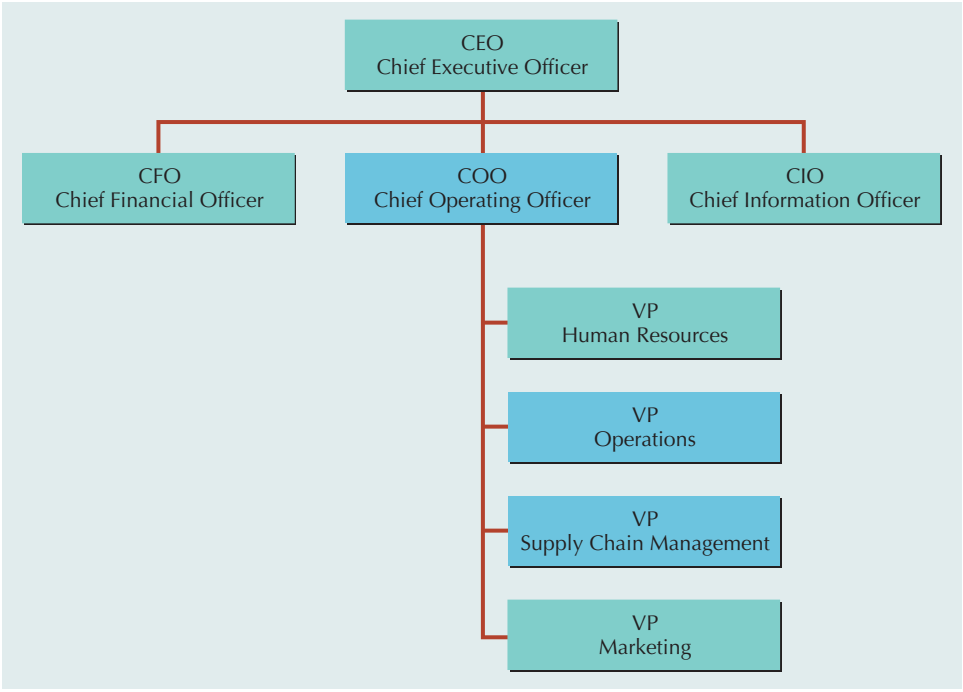
The four primary functional areas of a firm are marketing, finance, operations, and human resources. As shown in **Figure 1.2**, for most firms, operations is the technical core or "hub" of the organization, interacting with the other functional areas and suppliers to produce goods and provide services for customers. For example, to obtain monetary resources for production, operations provides finance and accounting with production and inventory data, capital budgeting requests, and capacity expansion and technology plans. Finance pays workers and suppliers, performs cost analyses, approves capital investments, and communicates requirements of shareholders and financial markets. Marketing provides operations with sales forecasts, customer orders, customer feedback, and information on promotions and product development. Operations, in turn, provides marketing with information on product or service availability, lead-time estimates, order status, and delivery schedules. For personnel needs, operations relies on human resources to recruit, train, evaluate, and compensate workers and to assist with legal issues, job design, and union activities. Outside the organization operations interacts with suppliers to order materials or services, communicate production and delivery requirements, certify quality, negotiate contracts, and finalize design specifications.

FIGURE 1.2 **Operations as the Technical Core**



As a field of study, operations brings together many disciplines and provides an integrated view of business organizations. Operations managers are in demand in business, industry, and government. Chief operating officers (COOs) run major corporations as shown in **Figure 1.3**, Vice-presidents of Operations and Supply Chain Management oversee scores of departments, facilities, and employees. Typical jobs for new college graduates include business process analyst, inventory analyst, project coordinator, unit supervisor, supply chain analyst, materials manager, quality assurance specialist, production scheduler, and logistics planner. Even if you do not pursue a career in operations and supply chain management, you'll be able to use the ideas you learn in this course to organize work, ensure quality, and manage processes. Regardless of your major, you can apply some aspect of operations and supply chain management to your future career—as did Mark, Nicole, John, Vignesh, Margie, and Anastasia, who tell their stories in **Figure 1.4** and the OM Dialogues dispersed throughout the text.

FIGURE 1.3 **Sample Organizational Structure**



Mark Jackson

Marketing Manager for Pizza Hut

Roberta Russell

As regional marketing manager for Pizza Hut, I'm responsible for 21 stores. It's my job to make sure each store is operating properly and, when new products come out, to see that they are given the attention they deserve. I also coach managers and employees about their job and their relationship with the customer.

You would think that a marketing manager's job would be concerned solely with advertising, special promotions, store signage, customer service, and the like. But we also deal with quality, forecasting, logistics, and other operational issues. Marketing and operations are almost inseparable in services. We can come out with a new product and spend megabucks advertising it, but if the product is not made or delivered properly, all is lost.

The most important aspect of quality is consistency—so that the customer gets the same pizza at any Pizza Hut from whichever cook happens to be on shift. We have exact standards and specifications for our products, and it's important that operating procedures be followed.

Scheduling is somewhat of a headache because of staff turnover and individual limitations on working hours. Some of that is alleviated in our new system where we allow employees to request days off up to six months in advance. They can put requests into the system when they clock in each day, and they can view upcoming schedules.

Our forecasting system keeps historical data on sales by hour and day of the week five years back. Forecasts are weighted averages of past demand—usually 60% of the past two weeks' sales and 40% of the past six weeks' sales. A manager can *freeze* the forecast and make manual adjustments, such as increasing demand during a home football game weekend or when a local festival is under way. Managers can also enter notes into the system when unusual occurrences affect demand, like a snowstorm. When the forecast is set, it generates a labor plan for the week, along with prep plans for salad, dough, breadsticks, and so forth. The labor plan just specifies the number of workers needed; it is up to the manager to do the detailed scheduling of individuals.

After quality, it's all about speed of delivery—whether to the customer's table or to the customer's home. We have initiatives such as *Ready for Revenue* where we pre-sauce and pre-cheese in anticipation of customer orders, and *Aces in Their Places* where we make sure the best people are scheduled and ready to go for peak demand periods. As for delivery, we keep track of percent of deliveries under 39 minutes and percent of deliveries to promise. We found we could significantly reduce the number of drivers needed (and keep the same customer satisfaction numbers) by promising delivery within 39 minutes rather than 30. We also are more efficient now that dispatching divides our delivery areas into delivery pods and uses computerized estimates of transit time.

FIGURE 1.4 How Is Operations Relevant to My Major?

Now that you are aware of how operations might relate to your interests, let's take a brief look at how the field of operations and supply chain management (OSM) has evolved to its present state.

The Evolution of Operations and Supply Chain Management

Although history is full of amazing production feats—the pyramids of Egypt, the Great Wall of China, the roads and aqueducts of Rome—the widespread production of consumer goods—and thus, operations management—did not begin until the Industrial Revolution in the 1700s. Prior to that time, skilled craftspersons and their apprentices fashioned goods for individual customers from studios in their own homes. Every piece was unique, hand-fitted, and made entirely by one person, a process known as **craft production**. Although *craft production* still exists today, the availability of coal, iron ore, and steam power set into motion a series of industrial inventions that revolutionized the way work was performed. Great mechanically powered machines replaced the laborer as the primary factor of production and brought workers to a central location to perform tasks under the direction of an "overseer" in a place called a "factory." The revolution first took hold in textile mills, grain mills, metalworking, and machine-making facilities.

Craft production The process of handcrafting products or services for individual customers.

Around the same time, Adam Smith's *Wealth of Nations* (1776) proposed the **division of labor**, in which the production process was broken down into a series of small tasks, each performed by a different worker. The specialization of the workers on limited, repetitive tasks allowed them to become very proficient at those tasks and further encouraged the development of specialized machinery.

Division of labor Dividing a job into a series of small tasks each performed by a different worker.

The introduction of **interchangeable parts** by Eli Whitney (1790s) allowed the manufacture of firearms, clocks, watches, sewing machines, and other goods to shift from customized one-at-a-time production to volume production of standardized parts. This meant the factory needed a system of measurements and inspection, a standard method of production, and supervisors to check the quality of the worker's production.

Interchangeable parts The standardization of parts initially as replacement parts enabled mass production.

Advances in technology continued through the 1800s. Cost accounting and other control systems were developed, but management theory and practice were virtually nonexistent.

In the early 1900s an enterprising laborer (and later chief engineer) at Midvale Steel Works named Frederick W. Taylor approached the management of work as a science. Based on observation, measurement, and analysis, he identified the best method for performing each job. Once determined, the methods were standardized for all workers, and economic incentives were established to encourage workers to follow the standards. Taylor's philosophy became known as **scientific management**. His ideas were embraced and extended by efficiency experts Frank and Lillian Gilbreth, Henry Gantt, and others. One of Taylor's biggest advocates was Henry Ford.

Scientific management The systematic analysis of work methods.

Henry Ford applied scientific management to the production of the Model T in 1913 and reduced the time required to assemble a car from a high of 728 hours to 1½ hours. A Model T chassis moved slowly down a conveyor belt with six workers walking alongside it, picking up parts from carefully spaced piles on the floor and fitting them to the chassis.[1] The short assembly time per car allowed the Model T to be produced in high volumes, or "en masse," yielding the name **mass production**.

Mass production The high-volume production of a standardized product for a mass market.

American manufacturers became adept at mass production over the next 50 years and easily dominated manufacturing worldwide. The human relations movement of the 1930s, led by Elton Mayo and the Hawthorne studies, introduced the idea that worker motivation, as well as the technical aspects of work, affected productivity. Theories of motivation were developed by Frederick Herzberg, Abraham Maslow, Douglas McGregor, and others. Quantitative models and techniques spawned by the operations research groups of World War II continued to develop and were applied successfully to manufacturing and services. Computers and automation led still another upsurge in technological advancements applied to operations. These events are summarized in **Table 1.1**.

[1]David Halberstam, *The Reckoning* (New York: William Morrow, 1986), pp. 79–81.

TABLE 1.1 Historical Events in Operations Management

ERA	EVENTS/CONCEPTS	DATES	ORIGINATOR
Industrial Revolution	Steam engine	1769	James Walt
	Division of labor	1776	Adam Smith
	Interchangeable parts	1790	Eli Whitney
Scientific Management	Principles of scientific management	1911	Frederick W. Taylor
	Time and motion studies	1911	Frank and Lillian Gilbreth
	Activity scheduling chart	1912	Henry Gantt
	Moving assembly line	1913	Henry Ford
Human Relations	Hawthorne studies	1930	Elton Mayo
	Motivation theories	1940s	Abraham Maslow
		1950s	Frederick Herzberg
		1960s	Douglas McGregor
Operations Research	Linear programming	1947	George Dantzig
	Digital computer	1951	Remington Rand
	Simulation, waiting line theory, decision theory, PERT/CPM	1950s	Operations research groups
	MRP	1960s	Joseph Orlicky, IBM, and others
	EDI, CIM	1970s	Auto industry, DARPA
Quality Revolution	JIT (just-in-time)	1970s	Taiichi Ohno (Toyota)
	TQM (total quality management)	1980s	W. Edwards Deming, Joseph Juran
	Strategy and operations		Wickham Skinner, Robert Hayes
	Reengineering	1990s	Michael Hammer, James Champy
	Six Sigma	1990s	GE, Motorola
Internet Revolution	Internet, WWW	1990s	ARPANET, Tim Berners-Lee
	ERP, supply chain management,		SAP, Oracle, Dell, Apple
	E-commerce, social networking	2000s	Amazon, Yahoo, eBay, Google, Facebook, YouTube, Twitter, etc.
Globalization	World Trade Organization	1990s	GATT
	European Union		Europe
	Global supply chains	2000s	China, India
	Outsourcing		Emerging economies
Sustainability	Global warming	2010s, Today	Numerous companies, scientists, statesmen and governments
	Carbon footprint		
	Green products		
	Corporate social responsibility (CSR)		World Economic Forum, Kyoto Protocol
	UN Global Compact		United Nations
Digital Revolution	Big data, Internet of Things (IoT), 3D printing, Smart cities, Autonomous vehicles, Drones	Today	Google, Apache, P&G, MIT, NSF, Amazon, and others

Along the Supply Chain

Feeding America

Each year, the Feeding America network helps provide food to more than 46 million people facing hunger in the United States, including 12 million children and 7 million seniors. Through 61,000 food pantries, 200 food banks, and innumerable community meal programs, the Feeding America network provides more than 3.7 billion meals to individuals and families in need. The non-profit accomplishes its goals by working closely with manufacturers, retailers, communities and farmers across the nation. The logistics of collecting, sorting and distributing donated food (with limited shelf life) to a widespread base of needy customers is challenging. To respond to this challenge, Feeding America has created several online connection tools to match donors and recipients, such as Produce MatchMakers and Online Marketplace (funded by Google), and has partnered with the Food Waste Reduction Alliance to divert 2.6 billion pounds of food headed to landfills to more than 2 billion meals for people in need. Feeding America has further partnered with organizations and government programs such as Kids Café and Summer Food Service Programs, School Backpack programs, the Rural Child Hunger Capacity Institute, and the Child Hunger Corps to distribute food to children in need. A peer-to-peer benchmarking report prepared by a store chain spurred a 14% increase in retail donations over the previous year.

Feeding America also provides monetary grants to local food pantries to support storing and distributing food, processing applicants, and educating recipients on how to prepare and serve the food in healthy ways. The group seeks to build the capacity of food banks to prepare for and respond to natural disasters and to aid in stabilizing communities post-disaster. For example, thousands of pounds of supplies were positioned along Hurricane Sandy's path to provide immediate access to food and water at food pantries, emergency shelters, and soup kitchens. Feeding America operates a high-volume, sophisticated food distribution network through its food banks with advanced technology and food distribution software from eSoftware Professionals. Even so, donor and recipient operations are staffed by more than 2 million volunteers in communities across the nation.

Feeding America excels on both the supply and demand side—exploring new food sourcing models and finding innovative ways to distribute the food where and when it is needed. The organization works with professional staff, volunteers, corporations, and community centers to source and deliver a better life to its constituents. This is an example of how operations and supply chain management tools can be used to alleviate major societal problems.

1. Is there a food bank for students in your community? Find out what challenges the group faces, and how food is collected and distributed.
2. What is difficult about balancing supply and demand for this non-profit? Looking at the range of topics covered in the textbook, what skills in operations and supply chain management would be useful?
3. Explore the software available for the food distribution industry. What kinds of data are kept on the warehoused food and food in transit? Why?
4. Explore how other organizations fight hunger across the globe. What is the scope of their efforts? How do they connect supply and demand? What innovative methods are used for food distribution? How is success measured?

Source: Feeding America Annual Report, 2015, www.feedingamerica.org (accessed January 4, 2016); "Feeding America Harnesses Food Distribution Software to Help Victims of Hurricane Sandy," http://www.erpsoftwareblog.com, November 1, 2012 (accessed January 5, 2016).

From the Industrial Revolution through the 1960s, the United States was the world's greatest producer of goods and services, as well as the major source of managerial and technical expertise. But in the 1970s and 1980s, industry by industry, U.S. manufacturing superiority was challenged by lower costs and higher quality from foreign manufacturers, led by Japan. Several studies published during those years confirmed what the consumer already knew—U.S.-made products of that era were inferior and could not compete on the world market. Early rationalizations that the Japanese success in manufacturing was a cultural phenomenon were disproved by the successes of Japanese-owned plants in the United States, such as the Matsushita purchase of a failing Quasar television plant in Chicago from Motorola. Part of the purchase contract specified that Matsushita had to retain the entire hourly workforce of 1000 persons. After only two years, with the identical workers, half the management staff, and little or no capital investment, Matsushita doubled production, cut assembly repairs from 130% to 6%, and reduced warranty costs from $16 million a year to $2 million a year. You can bet Motorola took notice, as did the rest of U.S. industry.

Quality revolution An emphasis on quality and the strategic role of operations.

The **quality revolution** brought with it a realization that production should be tied to consumer demand. Product proliferation, shortened product lifecycles, shortened product development times, changes in technology, more customized products, and segmented markets did not fit mass production assumptions. Using a concept known as just-in-time, Toyota changed the rules of production from mass production to **lean production**, a system that prizes flexibility (rather than efficiency) and quality (rather than quantity).

Lean production An adaptation of mass production that prizes quality and flexibility.

The renewed emphasis on quality and the *strategic importance* of operations made some U.S. companies competitive again. Others continued to stagnate, buoyed temporarily by the expanding economies of the Internet era and globalization. Productivity soared as return on

investment in information technology finally came to fruition. New types of businesses and business models emerged, such as Amazon, Google, and eBay, and companies used the Internet to connect with customers and suppliers around the world. The inflated expectations of the dot-com era came to an end and, coupled with the terrorist attacks of 9/11 and their aftermath, brought many companies back to reality, searching for ways to cut costs and survive in a global economy. They found relief in the emerging economies of China and India, and began accelerating the outsourcing of not only goods production, but services, such as information technology, call centers, and other business processes. The outsourcing of business processes brought with it a new awareness of business-to-business (B2B) services.

With more and more activities taking place outside the enterprise in factories, distribution centers, offices and stores overseas, managers needed to develop skills in coordinating operations across a global supply chain. The field of **supply chain management** was born to manage the flow of information, products, and services across a network of customers, enterprises, and supply chain partners. In Figure 1.1, we depicted operations as a transformation process. Extending that analogy in **Figure 1.5**, supply chain management concentrates on the input and output sides of transformation processes. Increasingly, however, as the transformation process is performed by suppliers who may be located around the world, the supply chain manager is also concerned with the timeliness, quality, and legalities of the supplier's operations.

Supply chain management Managing the flow of information, products, and services across a network of customers, enterprises, and suppliers.

The era of globalization was in full swing in 2008 when a financial crisis brought on by risky loans, inflated expectations, and unsavory financial practices brought the global economy to a standstill. Operations and supply chain management practices based on assumptions of growth had to be reevaluated for declining markets and resources. Companies began to reassess the value of their business, their customers, and their suppliers with an eye toward focusing on the most critical factors to sustain their business through the downturn.

Thus began the *era of sustainability*, in which countries, companies, and industries evaluate what it takes to sustain the health of their enterprise or people in the long term. This is especially important in light of climate change, natural and man-made disasters, scarcity of resources, and the competitive landscape. Nike CEO Mark Parker calls sustainability the "defining issue for our generation."

A concept related to sustainability is **resilience**, the ability to bounce back, change, or adapt in response to a disaster, failure, or disruption. Globalization has increased the risk of

Resilience The ability to bounce back, change, or adapt in response to a disaster, failure, or disruption.

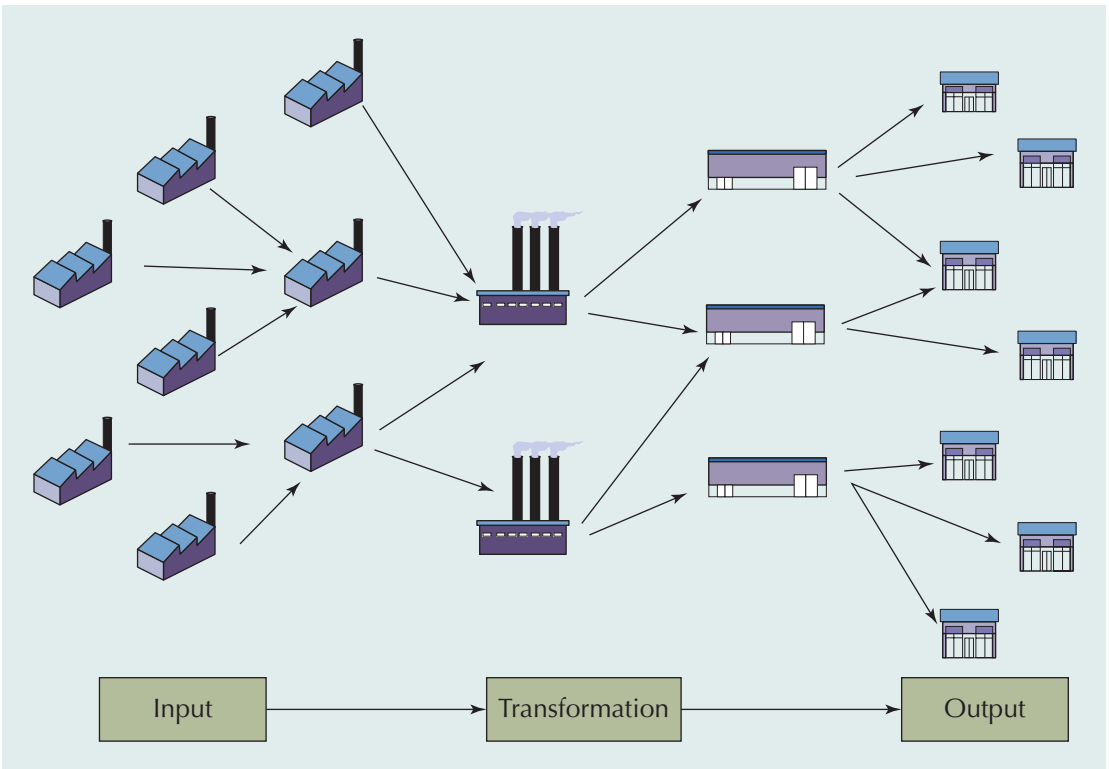


FIGURE 1.5 **Supply Chain Management**