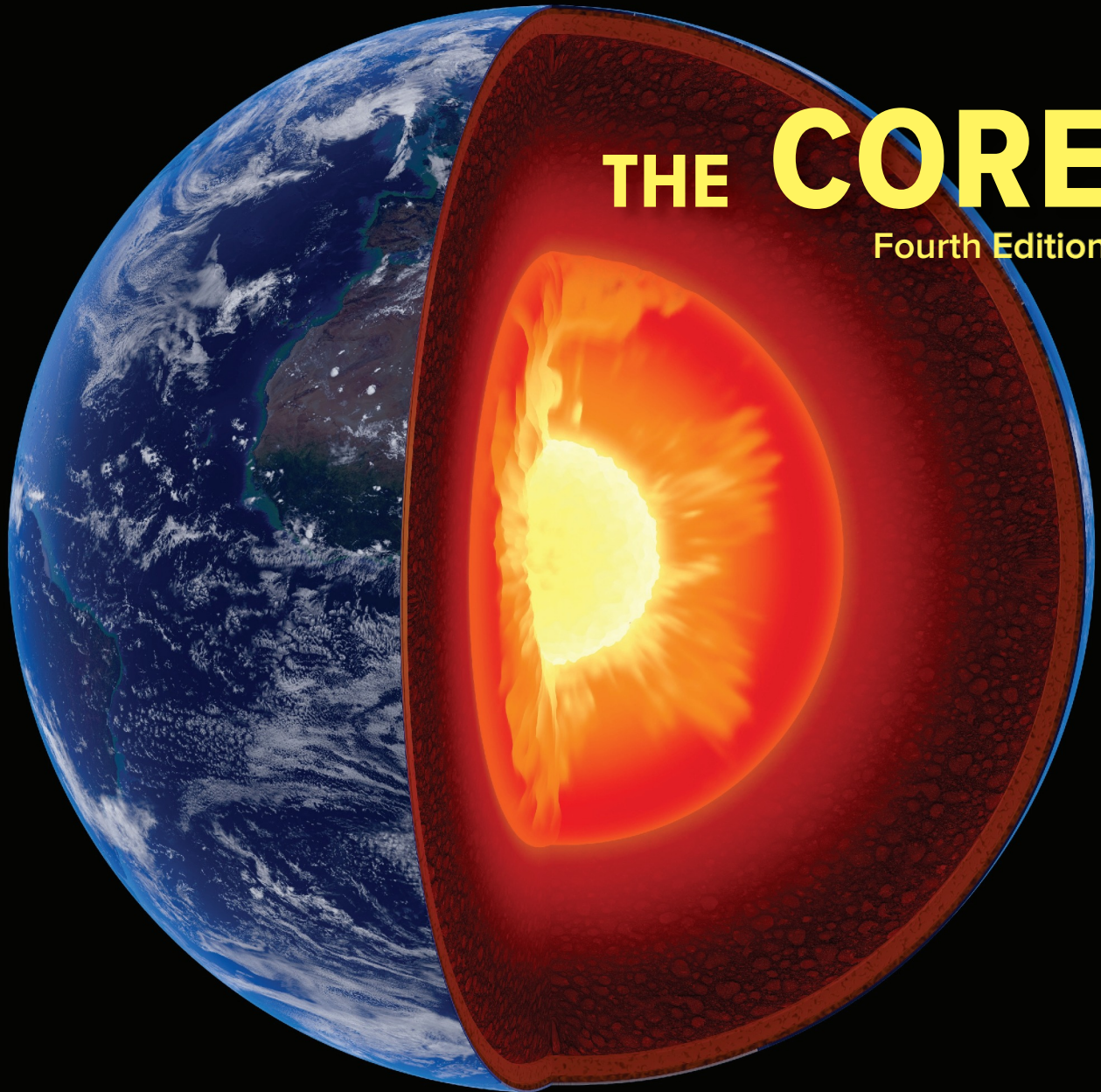


# OPERATIONS AND SUPPLY CHAIN MANAGEMENT

**THE CORE**

Fourth Edition



**Mc  
Graw  
Hill  
Education**

**F. ROBERTS JACOBS  
RICHARD B. CHASE**

# Operations and Supply Chain Management: The Core

---

# The McGraw-Hill Education Series Operations and Decision Sciences

## OPERATIONS MANAGEMENT

### **Beckman and Rosenfield**

Operations Strategy: Competing in the  
21st Century  
*First Edition*

### **Benton**

Purchasing and Supply Chain Management  
*Third Edition*

### **Bowersox, Closs, and Cooper**

Supply Chain Logistics Management  
*Fifth Edition*

### **Brown and Hyer**

Managing Projects: A Team-Based  
Approach  
*Second Edition*

### **Burt, Petcavage, and Pinkerton**

Supply Management  
*Ninth Edition*

### **Cachon and Terwiesch**

Operations Management  
*First Edition*

### **Cachon and Terwiesch**

Matching Supply with Demand: An  
Introduction to Operations Management  
*Fourth Edition*

### **Finch**

Interactive Models for Operations and  
Supply Chain Management  
*First Edition*

### **Fitzsimmons and Fitzsimmons**

Service Management: Operations, Strategy,  
Information Technology  
*Eighth Edition*

### **Gehrlein**

Operations Management Cases  
*First Edition*

### **Harrison and Samson**

Technology Management  
*First Edition*

### **Hayen**

SAP R/3 Enterprise Software: An Introduction  
*First Edition*

### **Hill**

Manufacturing Strategy: Text & Cases  
*Third Edition*

### **Hopp**

Supply Chain Science  
*First Edition*

### **Hopp and Spearman**

Factory Physics  
*Third Edition*

### **Jacobs, Berry, Whybark, and Vollmann**

Manufacturing Planning & Control  
for Supply Chain Management  
*Sixth Edition*

### **Jacobs and Chase**

Operations and Supply Chain Management  
*Fourteenth Edition*

### **Jacobs and Chase**

Operations and Supply Chain Management:  
The Core  
*Fourth Edition*

### **Jacobs and Whybark**

Why ERP?  
*First Edition*

### **Johnson, Leenders, and Flynn**

Purchasing and Supply Management  
*Fifteenth Edition*

### **Larson and Gray**

Project Management: The Managerial Process  
*Sixth Edition*

### **Schroeder, Goldstein, and Rungtusanatham**

Operations Management: Contemporary  
Concepts and Cases  
*Sixth Edition*

### **Simchi-Levi, Kaminsky, and**

### **Simchi-Levi**

Designing and Managing the Supply Chain:  
Concepts, Strategies, Case Studies  
*Third Edition*

### **Sterman**

Business Dynamics: Systems Thinking and  
Modeling for a Complex World  
*First Edition*

### **Stevenson**

Operations Management  
*Twelfth Edition*

### **Swink, Melnyk, Cooper, and Hartley**

Managing Operations Across the Supply Chain  
*Third Edition*

### **Thomke**

Managing Product and Service  
Development: Text and Cases  
*First Edition*

### **Ulrich and Eppinger**

Product Design and Development  
*Sixth Edition*

### **Zipkin**

Foundations of Inventory Management  
*First Edition*

## QUANTITATIVE METHODS AND MANAGEMENT SCIENCE

### **Hillier and Hillier**

Introduction to Management Science: A  
Modeling and Case Studies Approach with  
Spreadsheets  
*Fifth Edition*

### **Stevenson and Ozgur**

Introduction to Management Science with  
Spreadsheets  
*First Edition*

# Operations and Supply Chain Management: The Core

---

*Fourth Edition*

**F. ROBERT JACOBS**

*Indiana University*

**RICHARD B. CHASE**

*University of Southern California*





OPERATIONS AND SUPPLY CHAIN MANAGEMENT: THE CORE, FOURTH EDITION

Published by McGraw-Hill Education, 2 Penn Plaza, New York, NY 10121. Copyright © 2017 by McGraw-Hill Education. All rights reserved. Printed in the United States of America. Previous editions © 2013, 2010, and 2008. No part of this publication may be reproduced or distributed in any form or by any means, or stored in a database or retrieval system, without the prior written consent of McGraw-Hill Education, including, but not limited to, in any network or other electronic storage or transmission, or broadcast for distance learning.

Some ancillaries, including electronic and print components, may not be available to customers outside the United States.

This book is printed on acid-free paper.

1 2 3 4 5 6 7 8 9 0 DOW/DOW 1 0 9 8 7 6

ISBN 978-1-259-54972-4

MHID 1-259-54972-0

Senior Vice President, Products & Markets: *Kurt L. Strand*

Vice President, General Manager, Products & Markets: *Marty Lange*

Vice President, Content Design & Delivery: *Kimberly Meriwether David*

Managing Director: *James Heine*

Brand Manager: *Dolly Womack*

Director, Product Development: *Rose Koos*

Lead Product Developer: *Michele Janicek*

Product Developer: *Camille Corum*

Marketing Manager: *Britney Hermsen*

Director of Digital Content Development: *Douglas Ruby*

Digital Product Analyst: *Kevin Shanahan*

Director, Content Design & Delivery: *Linda Avenarius*

Program Manager: *Mark Christianson*

Content Project Managers: *Kathryn D. Wright, Kristin Bradley, and Karen Jozefowicz*

Buyer: *Sandy Ludovissy*

Design: *Debra Kubiak*

Content Licensing Specialists: *Beth Thole and Shawntel Schmitt*

Cover Image: *Earth core structure illustrated with geological layers according to scale—isolated on black (Texture maps from NASA); © Johan Swanepoel/Alamy*

Compositor: *Aptara®, Inc.*

Printer: *R. R. Donnelley*

All credits appearing on page or at the end of the book are considered to be an extension of the copyright page.

**Library of Congress Cataloging-in-Publication Data**

Names: Jacobs, F. Robert. | Chase, Richard B.

Title: Operations and supply chain management. The core / F. Robert Jacobs  
Indiana University, Richard B. Chase, University of Southern California.

Other titles: Operations and supply management. The core

Description: Fourth edition. | New York, NY : McGraw-Hill/Irwin, [2016] |

Originally published as: Operations and supply management. The core. |

Includes bibliographical references and indexes.

Identifiers: LCCN 2015046932 | ISBN 9781259549724 (alk. paper) |

ISBN 1259549720 (alk. paper)

Subjects: LCSH: Production management.

Classification: LCC TS155 .J273 2016 | DDC 658.5—dc23 LC record available at

<http://lcn.loc.gov/2015046932>

The Internet addresses listed in the text were accurate at the time of publication. The inclusion of a website does not indicate an endorsement by the authors or McGraw-Hill Education, and McGraw-Hill Education does not guarantee the accuracy of the information presented at these sites.

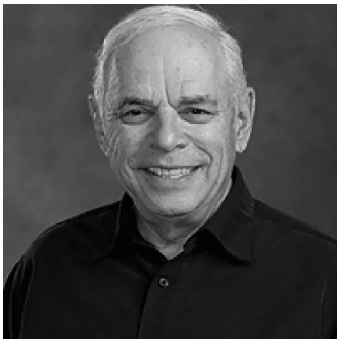
*To Rhonda, Jennifer, Suzy,  
and Jessica.*



## ABOUT THE AUTHORS



**F. Robert Jacobs** is Professor Emeritus of Operations and Decision Technologies at Indiana University. He received a B.S. in Industrial Engineering as well as Computer and Information Science, an MBA, and a Ph.D. in Operations Management all from The Ohio State University. He has also taught at the University of Houston and The Ohio State University. He has published 7 books and over 50 research articles on topics that include enterprise resource planning, inventory control, the design of manufacturing facilities, cellular manufacturing, and the scheduling of manufacturing operations. He is a Fellow of the Decision Sciences Institute and Past President and has received teaching honors such as MBA Teaching Award, Students Award for Teaching Excellence in International Business Issues, and Teaching Excellence in Operations Management.



**Richard B. Chase** is Justin B. Dart Professor Emeritus of Operations Management at the Marshall School of Business, University of Southern California. He received his Ph.D. in Operations Management, as well as an MBA and B.S. from UCLA. He has taught at the Harvard Business School, IMD (Switzerland), and the University of Arizona. His research examines service process design and service strategy. In 2006 he received a POMS Lifetime Achievement Award for his research in service operations and in 2004 received a Scholar of the Year Award by the Academy of Management. In 2009, he was honored in the *Production & Operations Management Journal* for his contributions to Operations Management. He is a Fellow of the Academy of Management, Production Operations Management Society, and the Decision Sciences Institute. He was also an Examiner for the Malcolm Baldrige National Quality Award. Dr. Chase has lectured/consulted recently on service and excellence to such organizations as Cisco Systems, Four Seasons Resorts, General Electric, and the Gartner Group.



# PREFACE

The goal of this book is to provide you with the essential information that every manager needs to know about operations and supply chain–related activities in a firm. Things have changed dramatically over the last few years. Organization structures are now much flatter, and rather than being functionally organized, companies often are organized by customer and product groups. Today’s manager cannot ignore how the real work of the organization is done. This book is all about how to get the real work done effectively. It makes little difference if you are officially in finance, marketing, accounting, or operations: The value-added work, the process of creating and delivering products, needs to be completed in a manner that is both high quality and maximally efficient. Many of the things you do, or will do, in your job are repetitive, even some of the most creative and high-profile activities. You should think of this course as preparing you to be your most productive and helping you help your organization be its most productive.

We can consider the importance of the material in this book on many levels, but let’s focus on three. First, consider your role as a business unit manager with people working under your supervision. Next, in the longer term, you probably have aspirations to become a senior executive with responsibility for multiple businesses or products. Finally, you may decide to specialize in operations and supply chain management as a long-term career.

In your role as a manager with people working under your supervision, one of your major duties will be to organize the way work is done. There needs to be some structure to the work process, including how information is captured and analyzed, as well as how decisions and changes and improvements are made. Without a logical or structured approach, even a small group may be subject to errors, inefficiencies, and even chaos.

Designing efficient process flows is an important element of getting a group to work together. If your group is involved in creative activities such as designing cars, buildings, or even stock portfolios, there still needs to be structure to how the work is done, who is responsible for what, and how progress is reported. The concepts of project management, manufacturing and service process design, capacity analysis, and quality in this text are all directly related to the knowledge you will need to be a great supervisor in your organization, and getting your group to work productively and efficiently will lead to success and more responsibility for you.

Next, think about becoming a senior executive. Making acquisitions, planning mergers, and buying and selling divisions will get your name and picture in business magazines. Deals are easily explained to boards, shareholders, and the media. They are newsworthy and offer the prospect of nearly immediate gratification, and being a deal maker is consistent with the image of the modern executive as someone who focuses on grand strategy and leaves operations details to others. Unfortunately, the majority of deals are unsuccessful. The critical element of success, even with the grandest deals, can still be found most often in the operational details.

Real success happens when operational processes can be improved. Productivity improvements from things such as sharing customer service processes, purchasing systems, distribution and manufacturing systems, and other processes can lead to great synergies and success. Operations accounts for 60 to 80 percent of the direct expenses that limit the profit of most firms. Without these operations synergies, designed and implemented by executives with a keen understanding of the concepts in this book, companies are often left with expensive debt, disappointed customers and shareholders, and pressure on the bottom line—on earnings.



Finally, you may be interested in a career in operations and supply chain management. Well, you are not alone. Professional organizations such as APICS, the Institute for Supply Management, and the Council of Supply Chain Management Professionals have well over 200,000 members participating in regular monthly meetings, annual conferences, and certification programs. Entry-level jobs might be as a forecast strategist, project manager, inventory control manager, production supervisor, purchasing manager, logistics manager, or warehouse specialist. In addition, top operations students may obtain their initial jobs with consulting firms, working as business process analysts and system design specialists.

We encourage you to talk to your instructor about what you want to get out of the course. What are your career aspirations, and how do they relate to the material in this course? Write your instructor a short e-mail describing what you want to do in the future—this is invaluable information for tailoring the material in the course to your needs. As you work through the text, share your experiences and insights with the class. Being an active student is guaranteed to make your experience more valuable and interesting.

## ACKNOWLEDGMENTS

Special thanks to Paul Schikora, Indiana State University, for his insight and work on the instructor's material for this edition of the book.

Also, special thanks to William Berry, Professor Emeritus, Queens College, for preparing the Test Bank and accuracy checking Connect material; Ronny Richardson, Kennesaw State University, for preparing narrated learning resources; Gregory DeYong, University of Michigan, Flint, for revising the PowerPoint slides and revising Learnsmart; and Larry White, Eastern Illinois University, for accuracy checking Connect material.

Thanks to the McGraw-Hill development and production team who made this possible—Camille Corum, Product Developer; Dolly Womack, Executive Brand Manager; Kathryn Wright, Core Project Manager; Kristin Bradley, Assessment Project Manager; Britney Hermsen, Marketing Manager; and Debra Kubiak, Senior Designer.

We appreciate our former executive editor, Dick Hercher. His brilliant guidance and unwavering dedication to working with us on early edition of the book, has been a constant motivator.

Last, but certainly not least, we thank our families. We have stolen countless hours away for this project; time that would otherwise be spent with them. We sincerely appreciate their support.

**F. Robert Jacobs**  
**Richard B. Chase**

# A NOTE TO INSTRUCTORS

*Operations and Supply Chain Management: The Core* derives its title from a combination of ideas and trends. The book is designed to be lean and focused, much in the tradition of the concepts taught in the book. The topics selected are the result of the study of the syllabi of dozens of representative U.S. universities. There are a wide variety of topics covered, many more than could be covered in a single course. Our “big book,” *Operations and Supply Chain Management*, is comprehensive and is intended for those who want to pick and choose topics that best fit the objectives of their course. The “Core” book covers the topics most commonly included in these courses and has material sufficient for a 12- to 15-week course.

As is well known in the field, success for companies today requires successfully managing the entire supply flow, from the sources of the firm, through the value-added processes of the firm, and on to the customers of the firm.

In *Operations and Supply Chain Management: The Core 4e*, we take students to the center of the business and focus on the core concepts and tools needed to ensure that these processes run smoothly.

## Discussion of Fourth Edition Revisions

Many of the revisions to the fourth edition have been driven by our focus on supply chain analytics. Supply chain analytics involves the analysis of data to better solve business problems. We recognize that this is not really new since data have always been used to solve business problems. But what *is* new is the reality that there are a great deal more data now available for decision making.

In the past, most analysis involved the generation of standard and ad hoc reports that summarized the current state of the firm. Software allowed query and “drill down” analysis to the level of the individual transaction, useful features for understanding what happened in the past. Decision making was typically left to the decision maker based on judgment or simple alerting rules. The new “analytics” movement takes this to a new level using statistical analysis, forecasting to extrapolate what to expect in the future, and even optimization, possibly in real time, to support decisions.

In this new edition we have refined the 11 Analytic Exercises that have proven to be so popular in our books. These Analytic Exercises use settings that are modern and familiar to students taking the course. They include Starbucks, cellphones, notebook computers, Taco Bell Restaurant, Toyota, a retail Website-based company, and industrial products that are sourced from China/Taiwan and sold globally.

In this book, all the of the chapters have been designed to be independent. We have put much effort into the organization of the book, but recognize that our organization might not align with the way you are using the material in your course. In addition, many of you may custom publish a version of the book to exactly meet your needs. The chapters have been design to allow this type of customization.

The chapters are all now tightly organized by special learning objectives. The learning objectives for the chapter are defined at the start. Special contiguous sections are designed to cover each objective. The chapter summary, discussion and objective questions are also organized by learning objective. This new organization allows material to be assigned at the level of learning objective. If the desire might be to skip some advanced techniques, for example, this can be easily done by not assigning the specific learning objective. This allows considerable flexibility in how the material is used in a class.

The material has also been adapted to work well with electronic media, since this is now becoming the media of choice at many universities.

# TECHNOLOGY

## McGraw-Hill Connect®



**connect**®

### **Less Managing. More Teaching. Greater Learning.**

McGraw-Hill Connect is an online assignment and assessment solution that connects students with the tools and resources they'll need to achieve success. McGraw-Hill Connect helps prepare students for their future by enabling faster learning, more efficient studying, and higher retention of knowledge.

### **McGraw-Hill Connect Features**

Connect offers a number of powerful tools and features to make managing assignments easier so faculty can spend more time teaching. With Connect, students can engage with their coursework anytime and anywhere making the learning process more accessible and efficient. Connect offers you the features described below.

#### **Simple Assignment Management**

With Connect, creating assignments is easier than ever, so you can spend more time teaching and less time managing. The assignment management function enables you to:

- Create and deliver assignments easily with selectable end-of-chapter questions and test bank items.
- Streamline lesson planning, student progress reporting, and assignment grading to make classroom management more efficient than ever.
- Go paperless with the eBook and online submission and grading of student assignments.

#### **Smart Grading**

When it comes to studying, time is precious. Connect helps students learn more efficiently by providing feedback and practice material when they need it, where they need it. When it comes to teaching, your time also is precious. The grading function enables you to:

- Have assignments scored automatically, giving students immediate feedback on their work and side-by-side comparisons with correct answers.
- Access and review each response; manually change grades or leave comments for students to review.
- Reinforce classroom concepts with practice tests and instant quizzes.

#### **Instructor Library**

The Connect Instructor Library is your repository for additional resources to improve student engagement in and out of class. You can select and use any asset that enhances your lecture. The Connect Instructor Library includes:

- PowerPoint Slides
- Text Figures
- Instructor's Solutions Manual
- Test Banks
- Excel Templates

### Student Study Center

The Connect Student Study Center is the place for students to access additional resources. The Student Study Center offers students quick access to study and review material.

### Student Progress Tracking

Connect keeps instructors informed about how each student, section, and class is performing, allowing for more productive use of lecture and office hours. The progress-tracking function enables you to:

- View scored work immediately and track individual or group performance with assignment and grade reports.
- Access an instant view of student or class performance relative to chapter headings.

### Tegrity Campus: Lectures 24/7



Tegrity Campus is a service that makes class time available 24/7 by automatically capturing every lecture in a searchable format for students to review when they study and complete assignments. With a simple one-click start-and-stop process, you capture all computer screens and corresponding audio. Students can replay any part of any class with easy-to-use browser-based viewing on a PC or Mac. Educators know that the more students can see, hear, and experience class resources, the better they learn. In fact, studies prove it. With Tegrity Campus, students quickly recall key moments by using Tegrity Campus's unique search feature. This search helps students efficiently find what they need, when they need it, across an entire semester of class recordings. Help turn all your students' study time into learning moments that are immediately supported by your lecture. To learn more about Tegrity, watch a two-minute Flash demo at [www.tegrity.com](http://www.tegrity.com).

## OPERATIONS MANAGEMENT AND THE AACSB

### Assurance of Learning Ready



Many educational institutions today are focused on the notion of *assurance of learning*, an important element of some accreditation standards. *Operations and Supply Chain Management* is designed specifically to support your assurance of learning initiatives with a simple yet powerful solution.

Each test bank question for *Operations and Supply Chain Management* maps to a specific chapter learning outcome/objective listed in the text. You can use our test bank software, EZ Test and EZ Test Online, or in *Connect Operations Management* to easily query for learning outcomes/objectives that directly relate to the learning objectives for your course. You can then use the reporting features of EZ Test to aggregate student results in similar fashion, making the collection, presentation, and assurance of learning data simple and easy.

### AACSB Statement



McGraw-Hill Education is a proud corporate member of AACSB International. Understanding the importance and value of AACSB accreditation, *Operations and Supply Chain Management* recognizes the curricula guidelines detailed in the AACSB standards for business accreditation by connecting selected questions in the test bank to the six general knowledge and skill areas in the AACSB standards Assessment of Learning Standards.

The statements contained in *Operations and Supply Chain Management* are provided only as a guide for the users of this textbook. The AACSB leaves content coverage and assessment within the purview of individual schools, the mission of the school, and the faculty. While *Operations and Supply Chain Management* and the teaching package make no claim of any specific AACSB qualification or evaluation, we have within the Test Bank labeled questions according to the six general knowledge and skill areas.

### McGraw-Hill Customer Experience Contact Information

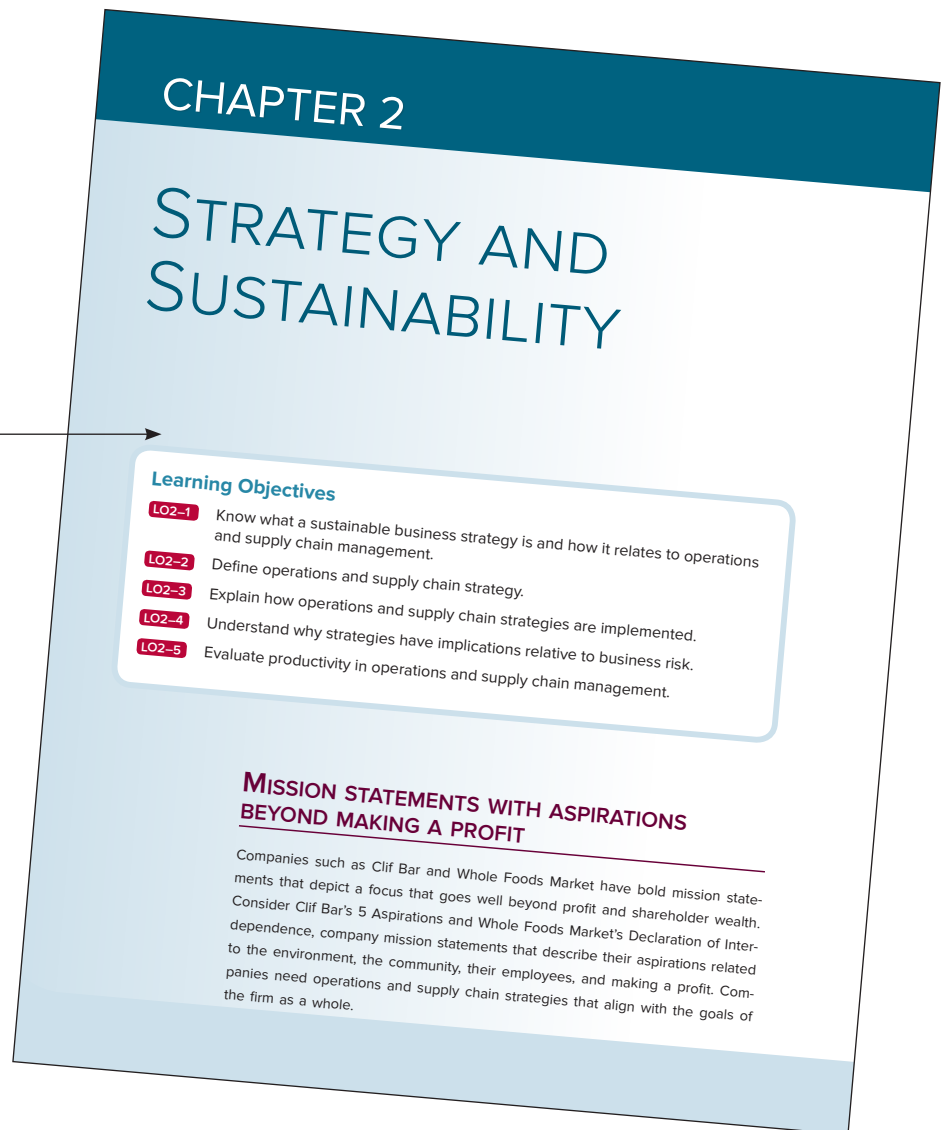
At McGraw-Hill, we understand that getting the most from new technology can be challenging. That's why our services don't stop after you purchase our products. You can e-mail our Product Specialists 24 hours a day to get product-training online. Or you can search our knowledge bank of Frequently Asked Questions on our support Website. For Customer Support, call **800-331-5094** or visit [mpss.mhhe.com](http://mpss.mhhe.com). One of our Technical Support Analysts will be able to assist you in a timely fashion.

# Walkthrough

## Major Study and Learning Features

The following section highlights the key features developed to provide you with the best overall text available. We hope these features give you maximum support to learn, understand, and apply operations concepts.

### Chapter Opener



## Opening Vignettes

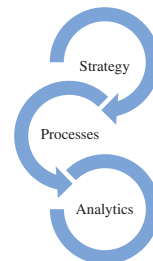
Each chapter opens with a short vignette to set the stage and help pique students' interest in the material about to be studied. A few examples include:

- Mission Statements with Aspirations Beyond Making a Profit, Chapter 2
- From Bean to Cup: Starbucks Global Supply Chain Challenge, Chapter 3
- Inside the iPad, Chapter 9
- The Factoryless Goods Producers, Chapter 13

In the context of major business functions, operations and supply chain management involves specialists in product design, purchasing, manufacturing, service operations, logistics, and distribution. These specialists are mixed and matched in many different ways depending on the product or service. For a firm that sells televisions, like Toshiba, these are the functions responsible for designing televisions, acquiring materials, coordinating equipment resources to convert material to products, moving the product, and exchanging the final product with the customer. Some firms are focused on services, such as a hospital. Here, the context involves managing resources, including the operating rooms, labs, and hospital beds used to nurse patients back to health. In this context, acquiring materials, moving patients, and coordinating resource use are keys to success. Other firms are more specialized, such as Amazon. Here, purchasing, Web site services, logistics, and distribution need to be carefully coordinated for success.

In our increasingly interconnected and interdependent global economy, the process of delivering finished goods, services, and supplies from one place to another is accomplished by means of mind-boggling technological innovation, clever new applications of old ideas, seemingly magical mathematics, powerful software, and old-fashioned concrete, steel, and muscle. This book is about doing this at low cost while meeting the requirements of demanding customers. Success involves the clever integration of a great operations-related strategy, processes that can deliver the products and services, and analytics that support the ongoing decisions needed to manage the firm. Our goal in this book is to introduce students to basic operations and supply chain concepts so they understand how things should be done and the importance of these functions to the success of the firm.

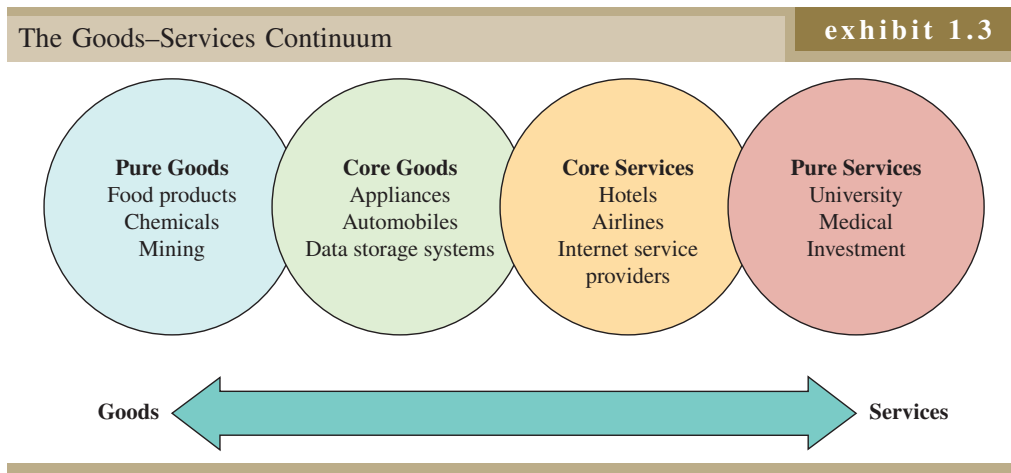
No matter what your major is in business, understanding operations and supply chain management is critical to your success. If you are interested in the study of finance, you will find that all of the concepts are directly applicable. Just convert all of those widgets to their value in the currency of your choice and you will





## Photos and Exhibits

Photos and exhibits in the text enhance the visual appeal and clarify text discussions. Many of the photos illustrate additional examples of companies that utilize the operations and supply chain concepts in their business.



MARSHMALLOW CANDY  
PEEPS CHICKS GET A  
QUALITY CONTROL  
CHECK AS THEY MOVE  
DOWN A CONVEYOR BELT  
INSIDE THE JUST BORN  
INC. MANUFACTURING  
FACILITY IN BETHLEHEM,  
PENNSYLVANIA.

© Mike Mergen/Bloomberg/Getty  
Images



## Concept Connections

Concept Connections draws together various end of chapter sections including Key Terms, Solved Problems, Discussion Questions, Objective Questions, Cases, Analytics Exercises, and Practice Exams.

### CONCEPT CONNECTIONS

**LO1-1** Identify the elements of operations and supply chain management (OSCM).

- Processes are used to implement the strategy of the firm.
- Analytics are used to support the ongoing decisions needed to manage the firm.

**Operations and supply chain management (OSCM)** Design, operation, and improvement of the systems that create and deliver the firm's primary products and services.

**Process** One or more activities that transform inputs into outputs.

**Product-service bundling** Building service activities into a firm's product offerings to create more value for the customer.

## Solved Problems

Representative problems are placed at the end of appropriate chapters. Each includes a worked-out solution giving students a review before solving problems on their own.

### SOLVED PROBLEMS

#### SOLVED PROBLEM 1

Quick Lube Inc. operates a fast lube and oil change garage. On a typical day, customers arrive at the rate of three per hour, and lube jobs are performed at an average rate of one every 15 minutes. The mechanics operate as a team on one car at a time.

Assuming Poisson arrivals and exponential service, find:

- The utilization of the lube team.
- The average number of cars in line.
- The average time a car waits before it is lubed.
- The total time it takes to go through the system (that is, waiting in line plus lube time).

#### Solution

$$\lambda = 3, \mu = 4$$

$$a. \text{ Utilization } \rho = \frac{\lambda}{\mu} = \frac{3}{4} = 75 \text{ percent.}$$

$$b. L_q = \frac{\lambda^2}{\mu(\mu - \lambda)} = \frac{3^2}{4(4 - 3)} = \frac{9}{4} = 2.25 \text{ cars in line.}$$

$$c. W_q = \frac{L_q}{\lambda} = \frac{2.25}{3} = .75 \text{ hour, or 45 minutes.}$$

$$d. W_s = \frac{L_s}{\lambda} = \frac{\lambda}{\mu - \lambda} / \lambda = \frac{3}{4 - 3} / 3 = 1 \text{ hour (waiting + lube).}$$

## Practice Exam

The practice exam includes many straightforward review questions, but also has a selection that tests for mastery and integration/application level understanding, that is, the kind of questions that make an exam challenging.

### PRACTICE EXAM

1. A strategy that is designed to meet current needs without compromising the ability of future generations to meet their needs.
2. The three criteria included in a triple bottom line.
3. The seven operations and supply chain competitive dimensions.
4. It is probably most difficult to compete on this major competitive dimension.
5. This occurs when a company seeks to match what a competitor is doing while maintaining its existing competitive position.
6. A criterion that differentiates the products or services of one firm from those of another.
7. A screening criterion that permits a firm's products to be considered as possible candidates for purchase.
8. A diagram showing the activities that support a company's strategy.
9. A measure calculated by taking the ratio of output to input.

Answers to Practice Exam 1. Sustainable 2. Social, economic, environmental 3. Cost, quality, delivery speed, delivery reliability, coping with changes in demand, flexibility and speed of new product introduction, other product-specific criteria 4. Cost 5. Straddling 6. Order winner 7. Order qualifier 8. Activity-system map 9. Productivity

## Cases

Cases allow students to think critically about issues discussed in the chapter. Cases include:

The Tao of Timbuk2, Chapter 2

Shouldice Hospital: A Cut Above, Chapter 4

Pro Fishing Boats: A Value Stream Mapping Exercise, Chapter 12

### CASE: THE TAO OF TIMBUK2\*

"Timbuk2 is more than a bag. It's more than a brand. Timbuk2 is a bond. To its owner, a Timbuk2 bag is a dependable, everyday companion. We see fierce, emotional attachments form between Timbuk2 customers and their bags all the time. A well-worn Timbuk2 bag has a certain patina—the stains and scars of everyday urban adventures. Many Timbuk2 bags are worn daily for a decade or more, accompanying the owner through all sorts of defining life events. True to our legend of 'indestructibility,' it's not uncommon for a Timbuk2 bag to outlive jobs, personal relationships, even pets. This is the Tao of Timbuk2."

What makes Timbuk2 so unique? Visit the Web site at [www.timbuk2.com](http://www.timbuk2.com) and see for yourself. Each bag is custom designed by the customer on the Web site. After the customer selects the basic bag configuration and size, colors for each of the various panels are presented; various lines, logos, pockets, and straps are selected so that the bag is tailored to the customer's specifications. A customer's specifications are sent to the

pocket, and strap options. The bag is tailored to the exact specifications of the customer on the Timbuk2 assembly line in San Francisco and sent via overnight delivery directly to the customer.

Recently, Timbuk2 has begun making some of its new products in China, which is a concern to some of its longstanding customers. The company argues that it has designed its new products to provide the best possible features, quality, and value at reasonable prices and stresses that these new products are designed in San Francisco. Timbuk2 argues that the new bags are much more complex to build and require substantially more labor and a variety of very expensive machines to produce. It argues that the San Francisco factory labor cost alone would make the retail price absurdly high. After researching a dozen factories in China, Timbuk2 found one that it thinks is up to the task of producing these new bags. Much as

## Analytics Exercises

There are so much more data now available for decision making. The analytics movement takes this to a new level using statistical analysis to extrapolate what to expect in the future to support operations and supply chain decisions. A series of 11 analytics exercises are spread through the chapters. These include

- Forecasting Supply Chain Demand: Starbucks Corporation, Chapter 3
- Designing a Manufacturing Process: Toshiba's Notebook Computer Assembly Line, Chapter 6
- Processing Customer Orders: Analyzing a Taco Bell Restaurant, Chapter 7
- Global Sourcing Decisions—Grainger: Reengineering the China/U.S. Supply Chain, Chapter 13

### ANALYTICS EXERCISE: DESIGNING A MANUFACTURING PROCESS

#### Toshiba's Notebook Computer Assembly Line

Toshihiro Nakamura, manufacturing engineering section manager, is examining the prototype assembly process sheet (shown in Exhibit 6.8) for the newest subnotebook computer model. With every new model introduced, management felt that the assembly line had to increase productivity and lower costs, usually resulting in changes to the assembly process. When a new model is designed, considerable attention is directed toward reducing the number of components and simplifying parts production and assembly requirements. This new computer was a marvel of high-tech, low-cost innovation and should give Toshiba an advantage during the upcoming fall/winter selling season.

Production of the subnotebook is scheduled to begin in 10 days. Initial production for the new model is to be 150 units per day, increasing to 250 units per day the following week (management thought that eventually production would reach 300 units per day). Assembly lines at the plant normally are staffed by 10 operators who work at a 14.4-meter-long

assembly line. The line is organized in a straight line with workers shoulder to shoulder on one side. The line can accommodate up to 12 operators if there is a need. The line normally operates for 7.5 hours a day (employees work from 8:15 A.M. to 5:00 P.M. and regular hours include one hour of unpaid lunch and 15 minutes of scheduled breaks). It is possible to run one, two, or three hours of overtime, but employees need at least three days' notice for planning purposes.

#### The Assembly Line

At the head of the assembly line, a computer displays the daily production schedule, consisting of a list of model types and corresponding lot sizes scheduled to be assembled on the line. The models are simple variations of hard disk size, memory, and battery power. A typical production schedule includes seven or eight model types in lot sizes varying from 10 to 100 units. The models are assembled sequentially: All the units of the first model are assembled, followed by all the units of the second, and so on. This computer screen also indicates how far along the assembly line is in completing its

# CONTENTS IN BRIEF

- 1** Operations and Supply Chain Management 2  
*Analytics Exercise: Comparing Companies Using Wall Street Efficiency Measures 23*
- 2** Strategy and Sustainability 24
- 3** Forecasting 44  
*Analytics Exercise: Forecasting Supply Chain Demand—Starbucks Corporation 92*
- 4** Strategic Capacity Management 94
- 4a** Learning Curves 116
- 5** Projects 128  
*Analytics Exercise: Product Design Project 166*
- 6** Manufacturing Processes 168  
*Analytics Exercise: Designing a Manufacturing Process 196*
- 6a** Break-Even Analysis 199
- 7** Service Processes 204  
*Analytics Exercise: Processing Customer Orders 237*
- 8** Sales and Operations Planning 240  
*Analytics Exercise: Developing an Aggregate Plan—Bradford Manufacturing 266*
- 9** Material Requirements Planning 268  
*Analytics Exercise: An MRP Explosion—Brunswick Motors 300*
- 10** Quality Management and Six Sigma 302  
*Analytics Exercise: Quality Management—Toyota 349*
- 11** Inventory Management 352  
*Analytics Exercise: Inventory Management at Big10Sweaters.com 396*
- 12** Lean Supply Chains 400
- 13** Global Sourcing and Procurement 432  
*Analytics Exercise: Global Sourcing Decisions—Grainger: Reengineering the China/U.S. Supply Chain 455*
- 14** Location, Logistics, and Distribution 458  
*Analytics Exercise: Distribution Center Location 482*
- APPENDICES**
- 
- A** Linear Programming Using the Excel Solver 485
- 
- B** Answers to Selected Objective Questions 508
- 
- C** Present Value Table 510
- 
- D** Negative Exponential Distribution: Values of  $e^{-x}$  511
- 
- E** Areas of the Cumulative Standard Normal Distribution 512
- 
- NAME INDEX 513**
- SUBJECT INDEX 514**



# CONTENTS

## 1 OPERATIONS AND SUPPLY CHAIN MANAGEMENT 2

- Strategy, Processes, and Analytics 2
- What Is Operations and Supply Chain Management? 4
  - Operations and Supply Chain Processes* 6
  - Differences between Services and Goods* 8
  - The Goods–Services Continuum* 9
  - Product–Service Bundling* 9
- Efficiency, Effectiveness, and Value 10
  - How Does Wall Street Evaluate Efficiency?* 11
- Careers in Operations and Supply Chain Management 14
  - Chief Operating Officer* 16
- Historical Development of Operations and Supply Chain Management 16
  - Current Issues in Operations and Supply Chain Management* 19
    - Concept Connections* 19
    - Discussion Questions* 21
    - Objective Questions* 21
  - Analytics Exercise: Comparing Companies Using Wall Street Efficiency Measures* 23
    - Practice Exam* 23

## 2 STRATEGY AND SUSTAINABILITY 24

- Mission Statements with Aspirations beyond Making a Profit 24
- A Sustainable Operations and Supply Chain Strategy 26
- What Is Operations and Supply Chain Strategy? 27
  - Competitive Dimensions* 28
  - The Notion of Trade-Offs* 30
  - Order Winners and Order Qualifiers: The Marketing–Operations Link* 31
- Strategies Are Implemented Using Operations and Supply Chain Activities—IKEA’s Strategy 32
- Assessing the Risk Associated with Operations and Supply Chain Strategies 33
  - Risk Management Framework* 34
- Productivity Measurement 36
  - Concept Connections* 38
  - Solved Problem* 39
  - Discussion Questions* 39
  - Objective Questions* 40
- Case: The Tao of Timbuk2* 42
  - Practice Exam* 43

## 3 FORECASTING 44

- From Bean to Cup: Starbucks Global Supply Chain Challenge 44
- Forecasting in Operations and Supply Chain Management 46
- Quantitative Forecasting Models 47
  - Components of Demand* 48
  - Time Series Analysis* 49
    - Simple Moving Average* 50
    - Weighted Moving Average* 52
    - Exponential Smoothing* 53
      - Exponential Smoothing with Trend* 55
    - Linear Regression Analysis* 57
    - Decomposition of a Time Series* 61
    - Forecast Errors* 67
    - Sources of Error* 67
    - Measurement of Error* 68
    - Causal Relationship Forecasting* 70
    - Multiple Regression Analysis* 72
  - Qualitative Techniques in Forecasting 73
    - Market Research* 73
    - Panel Consensus* 73
    - Historical Analogy* 73
    - The Delphi Method* 74
- Web-Based Forecasting: Collaborative Planning, Forecasting, and Replenishment (CPFR) 74
  - Concept Connections* 76
  - Solved Problems* 78
  - Discussion Questions* 83
  - Objective Questions* 83
- Analytics Exercise: Forecasting Supply Chain Demand—Starbucks Corporation* 92
  - Practice Exam* 93

## 4 STRATEGIC CAPACITY MANAGEMENT 94

- Shouldice Hospital: Hernia Surgery Innovation 95
- Capacity Management in Operations and Supply Chain Management 96
  - Capacity Planning Concepts* 97
  - Economies and Diseconomies of Scale* 97
  - Capacity Focus* 98
  - Capacity Flexibility* 98
- Capacity Planning 99
  - Considerations in Changing Capacity* 99
  - Determining Capacity Requirements* 101
- Using Decision Trees to Evaluate Capacity Alternatives 103



Planning Service Capacity 106

*Capacity Planning in Services versus  
Manufacturing* 106

*Capacity Utilization and Service Quality* 107

*Concept Connections* 108 *Solved Problem* 109

*Discussion Questions* 111 *Objective Questions* 111

*Case: Shouldice Hospital—A Cut Above* 113

*Practice Exam* 115

## 4A LEARNING CURVES 116

The Learning Curve 116

How Are Learning Curves Modeled? 118

*Concept Connections* 122 *Solved*

*Problems* 122 *Discussion Questions* 123

*Objective Questions* 126

## 5 PROJECTS 128

Can a 15-Story Hotel Be Built In  
Less Than a Week? 128

What Is Project Management? 129

*Organizing the Project Team* 131

*Pure Project* 131

*Functional Project* 131

*Matrix Project* 132

*Organizing Project Tasks* 133

Managing Projects 134

*Earned Value Management (EVM)* 136

Network-Planning Models 140

*Critical Path Method (CPM)* 140

*CPM with Three Activity Time Estimates* 144

*Time–Cost Models and Project Crashing* 147

Project Management Information Systems 152

*Concept Connections* 153 *Solved Problems* 154

*Discussion Questions* 159 *Objective Questions* 159

*Analytics Exercise: Product Design Project* 166

*Practice Exam* 167

## 6 MANUFACTURING PROCESSES 168

Three-Dimensional Printing—The Technology  
Could Be Used to Make Parts That Perform Better  
and Cost Less 168

Production Processes 169

Production Process Mapping and  
Little’s Law 172

How Production Processes Are Organized 175

*Designing a Production System* 177

*Project Layout* 177

*Workcenters* 177

*Manufacturing Cell* 178

*Assembly-Line and Continuous Process Layouts* 180

Assembly-Line Design 180

*Splitting Tasks* 184

*Flexible and U-Shaped Line Layouts* 184

*Concept Connections* 185 *Solved Problems* 187

*Discussion Questions* 190 *Objective Questions* 190

*Advanced Problem* 195

*Analytics Exercise: Designing a Manufacturing  
Process* 196

*Practice Exam* 198

## 6A BREAK-EVEN ANALYSIS 199

*Solved Problems* 200 *Objective Questions* 202

## 7 SERVICE PROCESSES 204

Paying with a Wave of Your Phone 204

The Nature of Services 205

*An Operational Classification of Services* 206

*Designing Service Organizations* 206

*Structuring the Service Encounter: Service–System  
Design Matrix* 207

*Virtual Service: The New Role of the Customer* 209

Service Blueprinting and Fail-Safing 210

Economics of the Waiting Line Problem 212

*The Practical View of Waiting Lines* 212

*The Queuing System* 214

*Customer Arrivals* 215

*Distribution of Arrivals* 215

*Waiting Lines and Servers* 218

*Waiting Line Models* 221

*Computer Simulation of Waiting Lines* 226

*Concept Connections* 229 *Solved Problems* 231

*Discussion Questions* 232 *Objective Questions* 233

*Analytics Exercise: Processing Customer Orders* 237

*Practice Exam* 239

## 8 SALES AND OPERATIONS PLANNING 240

What Is Sales and Operations Planning? 242

*Overview of Sales and Operations Planning  
Activities* 242

*The Aggregate Operations Plan* 244

*Production Planning Environment* 245

*Relevant Costs* 247

Aggregate Planning Techniques 248

*A Cut-and-Try Example: The JC Company* 248

*Aggregate Planning Applied to Services:*

*Tucson Parks and Recreation Department* 250

Yield Management 256  
*Operating Yield Management Systems* 257  
*Concept Connections* 258 *Solved Problem* 259 *Discussion Questions* 262  
*Objective Questions* 262  
*Analytics Exercise: Developing an Aggregate Plan—Bradford Manufacturing* 266  
*Practice Exam* 267

## 9 MATERIAL REQUIREMENTS PLANNING 268

Inside the iPad 268  
 Understanding Material Requirements Planning 269  
*Where MRP Can Be Used* 271  
*Master Production Scheduling* 271  
*Time Fences* 273  
 Material Requirements Planning System Structure 274  
*Demand for Products* 274  
*Bill-of-Materials* 275  
*Inventory Records* 277  
*The MRP Computer Program* 278  
 An Example Using MRP 279  
*Forecasting Demand* 279  
*Developing a Master Production Schedule* 280  
*Bill-of-Materials (Product Structure)* 280  
*Inventory Records* 281  
*Performing the MRP Calculations* 281  
 Lot Sizing in MRP Systems 285  
*Lot-for-Lot* 285  
*Economic Order Quantity* 286  
*Least Total Cost* 287  
*Least Unit Cost* 287  
*Choosing the Best Lot Size* 288  
*Concept Connections* 289 *Solved Problems* 290  
*Discussion Questions* 295 *Objective Questions* 296  
*Analytics Exercise: An MRP Explosion—Brunswick Motors* 300  
*Practice Exam* 301

## 10 QUALITY MANAGEMENT AND SIX SIGMA 302

GE Six Sigma Supply Chain Processes 302  
 Total Quality Management 304  
*Quality Specifications and Quality Costs* 305  
*Developing Quality Specifications* 305  
*Cost of Quality* 307  
 ISO 9000 and ISO 14000 309  
*External Benchmarking for Quality Improvement* 311

Six Sigma Quality 312  
*Six Sigma Methodology* 312  
*Analytical Tools for Six Sigma* 313  
 Statistical Quality Control 317  
*Understanding and Measuring Process Variation* 318  
*Process Capability* 320  
 Statistical Process Control Procedures 325  
*Process Control with Attribute Measurements: Using p-Charts* 327  
*Process Control with Attribute Measurements: Using c-Charts* 328  
*Process Control with Variable Measurements: Using  $\bar{X}$ - and R-Charts* 329  
*How to Construct  $\bar{X}$ - and R-Charts* 330  
 Acceptance Sampling 334  
*Design of a Single Sampling Plan for Attributes* 334  
*Operating Characteristic Curves* 336  
*Concept Connections* 337 *Solved Problems* 340  
*Discussion Questions* 343 *Objective Questions* 344  
*Analytics Exercise: Quality Management—Toyota* 349  
*Practice Exam* 351

## 11 INVENTORY MANAGEMENT 352

Will Warehouses Be Needed in the Future? 352  
 Understanding Inventory Management 354  
*Definition of Inventory* 356  
*Purposes of Inventory* 356  
*Inventory Costs* 357  
*Independent versus Dependent Demand* 358  
 Inventory Systems 359  
*A Single-Period Inventory Model* 359  
*Multiperiod Inventory Systems* 363  
*Fixed–Order Quantity Models* 364  
*Establishing Safety Stock Levels* 367  
*Fixed–Order Quantity Model with Safety Stock* 368  
*Fixed–Time Period Models* 372  
*Fixed–Time Period Model with Safety Stock* 372  
*Inventory Turn Calculations* 374  
*The Price-Break Model* 375  
 Inventory Planning and Accuracy 377  
*ABC Classification* 378  
*Inventory Accuracy and Cycle Counting* 379  
*Concept Connections* 381 *Solved Problems* 384  
*Discussion Questions* 387 *Objective Questions* 388  
*Analytics Exercise: Inventory Management at Big10Sweaters.com* 396  
*Practice Exam* 399

**12 LEAN SUPPLY CHAINS 400**

- From Lean Supply Chain to Lean Design 400
- Lean Production 401
- The Toyota Production System* 403
- Lean Supply Chains 404
- Value Stream Mapping 406
- Lean Supply Chain Design Principles 409
- Lean Concepts* 409
- Lean Production Schedules* 410
- Lean Supply Chains* 416
- Lean Services 417
  - Concept Connections* 419
  - Solved Problems* 420
  - Discussion Questions* 421
  - Objective Questions* 425
- Case: Quality Parts Company* 427
- Case: Value Stream Mapping* 428
- Case: Pro Fishing Boats—A Value Stream Mapping Exercise* 430
  - Practice Exam* 431

**13 GLOBAL SOURCING AND PROCUREMENT 432**

- The Factoryless Goods Producers 432
- Strategic Sourcing 433
- The Bullwhip Effect* 435
- Supply Chain Uncertainty Framework* 436
- Outsourcing 439
- Logistics Outsourcing* 440
- Framework for Supplier Relationships* 441
- Green Sourcing* 442
- Total Cost of Ownership 446
- Measuring Sourcing Performance 448
  - Concept Connections* 450
  - Discussion Questions* 452
  - Objective Questions* 453
- Analytics Exercise: Global Sourcing Decisions—Grainger: Reengineering the China/U.S. Supply Chain* 455
  - Practice Exam* 457

**14 LOCATION, LOGISTICS, AND DISTRIBUTION 458**

- Panama Canal Widening May Impact Flow of Goods to United States 458
- Logistics 459
- Decisions Related to Logistics 460
  - Transportation Modes* 461
  - Warehouse Design* 462
- Issues in Facility Location 462
  - Plant Location Methods* 464
  - Factor-Rating Systems* 465
  - Transportation Method of Linear Programming* 465
  - Centroid Method* 468
  - Locating Service Facilities* 470
    - Concept Connections* 473
    - Solved Problem* 474
    - Discussion Questions* 478
    - Objective Questions* 479
- Analytics Exercise: Distribution Center Location* 482
  - Practice Exam* 484

**APPENDICES**

- 
- A** Linear Programming Using the Excel Solver 485
- 
- B** Answers to Selected Objective Questions 508
- 
- C** Present Value Table 510
- 
- D** Negative Exponential Distribution: Values of  $e^{-x}$  511
- 
- E** Areas of the Cumulative Standard Normal Distribution 512
- 

**NAME INDEX 513****SUBJECT INDEX 514**

# Operations and Supply Chain Management: The Core

---

# CHAPTER 1

# OPERATIONS AND SUPPLY CHAIN MANAGEMENT

## Learning Objectives

- LO1-1** Identify the elements of operations and supply chain management (OSCM).
- LO1-2** Evaluate the efficiency of the firm.
- LO1-3** Know the potential career opportunities in operations and supply chain management.
- LO1-4** Recognize the major concepts that define the operations and supply chain management field.

## STRATEGY, PROCESSES, AND ANALYTICS

This book is about designing and operating processes that deliver a firm's goods and services in a manner that matches customers' expectations. Really successful firms have a clear and focused idea of how they intend to make money. Be it high-end products or services that are custom-tailored to the needs of a single customer or generic, inexpensive commodities that are bought largely on the basis of cost, competitively producing and distributing these products is a great challenge.

In the context of major business functions, operations and supply chain management involves specialists in product design, purchasing, manufacturing, service operations, logistics, and distribution. These specialists are mixed and matched in many different ways depending on the product or service. For a firm that sells televisions, like Toshiba, these are the functions responsible for designing televisions, acquiring materials, coordinating equipment resources to convert material to products, moving the product, and exchanging the final product with the

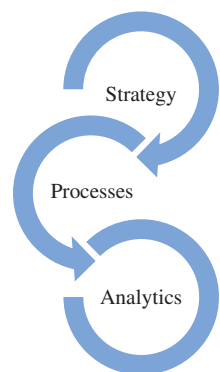
© Robyn Beck/AFP/Getty Images



customer. Some firms are focused on services, such as a hospital. Here, the context involves managing resources, including the operating rooms, labs, and hospital beds used to nurse patients back to health. In this context, acquiring materials, moving patients, and coordinating resource use are keys to success. Other firms are more specialized, such as Amazon. Here, purchasing, Web site services, logistics, and distribution need to be carefully coordinated for success.

In our increasingly interconnected and interdependent global economy, the process of delivering finished goods, services, and supplies from one place to another is accomplished by means of mind-boggling technological innovation, clever new applications of old ideas, seemingly magical mathematics, powerful software, and old-fashioned concrete, steel, and muscle. This book is about doing this at low cost while meeting the requirements of demanding customers. Success involves the clever integration of a great operations-related strategy, processes that can deliver the products and services, and analytics that support the ongoing decisions needed to manage the firm. Our goal in this book is to introduce students to basic operations and supply chain concepts so they understand how things should be done and the importance of these functions to the success of the firm.

No matter what your major is in business, understanding operations and supply chain management is critical to your success. If you are interested in the study of finance, you will find that all of the concepts are directly applicable. Just convert all of those widgets to their value in the currency of your choice and you will



realize that this is all about dollars and cents moving, being stored, and appreciating in value due to exchanges. What you study in finance class is exactly the same, but we look at things in very different ways due to the physical nature of goods and the intangible features of services. If you are interested in studying marketing, you will realize that the topics presented here are critical to your success. If the product or service cannot be delivered to the customer at an acceptable cost, then no matter how good your marketing program is, no one may buy it. And finally, for the accountants who keep score, the operations and supply chain processes generate most of the transactions used to track the financial health of the firm. Understanding why these processes operate the way they do is important to understanding the financial statements of the firm.

**LO1-1** Identify the elements of operations and supply chain management (OSCM).

### Operations and supply chain management (OSCM)

The design, operation, and improvement of the systems that create and deliver the firm's primary products and services.

## WHAT IS OPERATIONS AND SUPPLY CHAIN MANAGEMENT?

**Operations and supply chain management (OSCM)** is defined as the design, operation, and improvement of the systems that create and deliver the firm's primary products and services. Like marketing and finance, OSCM is a functional field of business with clear line management responsibilities. OSCM is concerned with the management of the entire system that produces a product or delivers a service. Producing a product such as the Men's Nylon Supplex Parka or providing a service, such as a cellular phone account, involves a complex series of transformation processes.

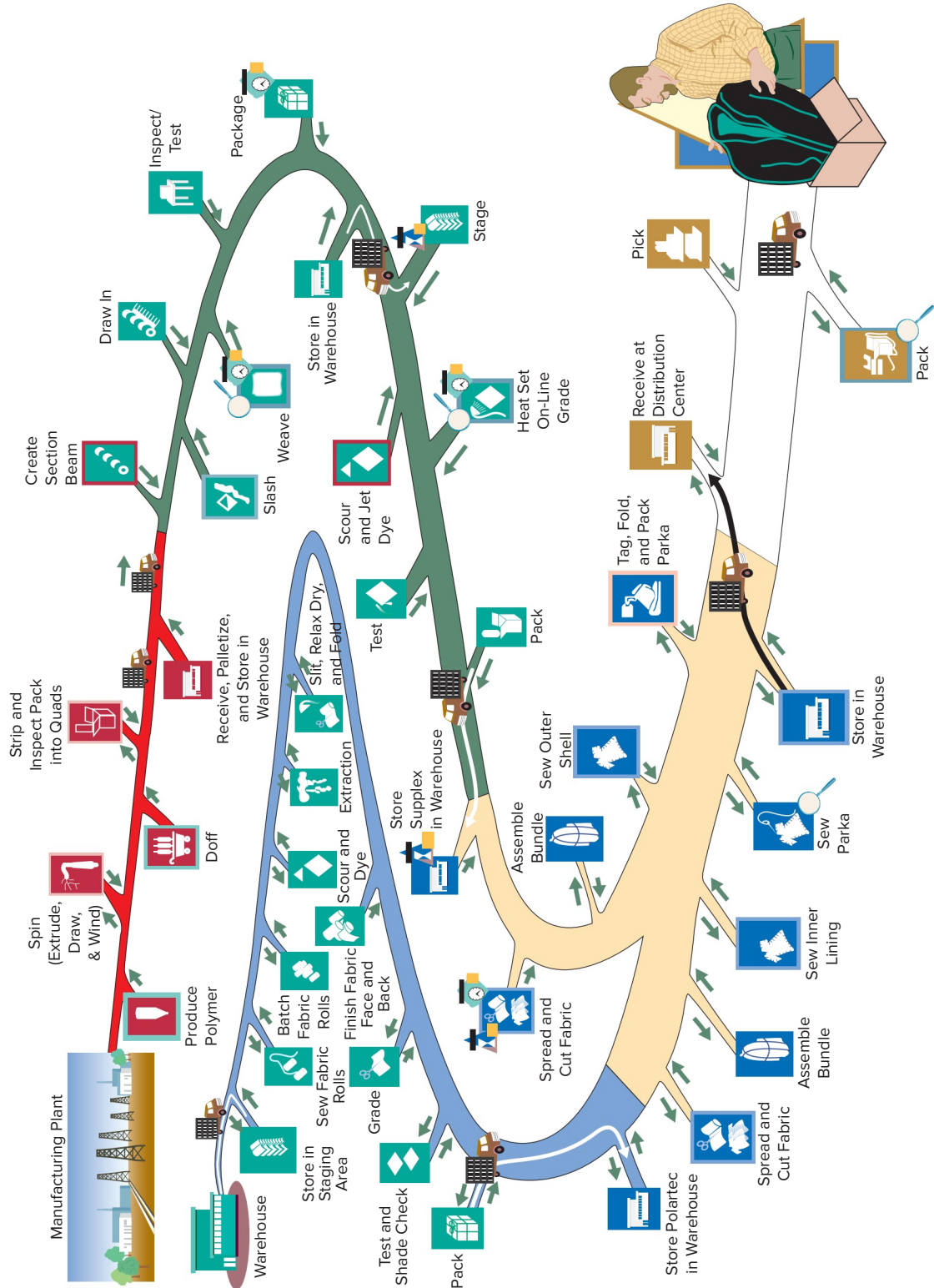
Exhibit 1.1 shows a supply network for a Men's Nylon Supplex Parka sold on Web sites such as L.L. Bean or Land's End. We can understand the network by looking at the four color-coded paths. The blue path traces the activities needed to produce the Polartec insulation material used in the parkas. Polartec insulation is purchased in bulk, processed to get the proper finish, and then dyed prior to being checked for consistency—or grading—and color. It is then stored in a warehouse. The red path traces the production of the nylon, Supplex, used in the parkas. Using a petroleum-based polymer, the nylon is extruded and drawn into a yarnlike material. From here the green path traces the many steps required to fabricate the clothlike Supplex used to make the parkas. The yellow path shows the Supplex and Polartec material coming together and used to assemble the lightweight and warm parkas. The completed parkas are sent to a warehouse and on to the retailer's distribution center. The parkas are then picked and packed for shipment to individual customers.

Think of the supply network as a pipeline through which material and information flow. There are key locations in the pipeline where material and information are stored for future use: Polartec is stored near the end of the blue pipeline; Supplex is stored near the end of the red pipeline. In both cases, fabric is cut prior to merging with the yellow pipeline. At the beginning of the yellow path, bundles of Supplex and Polartec are stored prior to their use in the fabrication of the parkas. At the end of the yellow path are





exhibit 1.1 Process Steps for Men's Nylon Supplex Parkas



the distribution steps, which involve storing to await orders, picking according to the actual customer order, packing, and finally shipping to the customer.

Networks such as this can be constructed for any product or service. Typically, each part of the network is controlled by different companies, including the nylon Supplex producer, the Polartec producer, the parka manufacturer, and the catalog sales retailer. All of the material is moved using transportation providers, ships and trucks in this case. The network also has a global dimension, with each entity potentially located in a different country.

Success in today's global markets requires a business strategy that matches the preferences of customers with the realities imposed by complex supply networks. A sustainable strategy that meets the needs of shareholders and employees and preserves the environment is critical.

In the context of our discussion, the terms *operations* and *supply chain* take on special meaning. *Operations* refers to manufacturing and service processes that are used to transform the resources employed by a firm into products desired by customers. For example, a manufacturing process would produce some type of physical product, such as an automobile or a computer. A service process would produce an intangible product, such as a call center that provides information to customers stranded on the highway or a hospital that treats accident victims in an emergency room. Planning the use of these processes involves analyzing capacity, labor, and material needs over time. Ensuring quality and making ongoing improvements to these processes are needed to manage these processes.

*Supply chain* refers to processes that move information and material to and from the manufacturing and service processes of the firm. These include the logistics processes that physically move product, as well as the warehousing and storage processes that position products for quick delivery to the customer. Supply chain in this context refers to providing products and service to plants and warehouses at the input end and also to the supply of products and service to the customer on the output end of the supply chain.

We consider the topics included in this book to be the foundation or "core" material. Many other topics could be included, but these cover the fundamental concepts. All managers should understand these basic principles that guide the design of transformation processes. This includes understanding how different types of processes are organized, how to determine the capacity of a process, how long it should take a process to make a unit, how the quality of a process is monitored, and how information is used to make decisions related to the design and operation of these processes.

The field of operations and supply chain management is ever changing due to the dynamic nature of competing in global business and the constant evolution of information technology. So while many of the basic concepts have been around for years, their application in new and innovative ways is exciting. Internet technology has made the sharing of reliable real-time information inexpensive. Capturing information directly from the source through such systems as point-of-sale, radio-frequency identification tags, bar-code scanners, and automatic recognition has shifted the focus to understanding not only what all the information is saying but how good the decisions are that will use it.

## Operations and Supply Chain Processes

Operations and supply chain **processes** can be conveniently categorized, particularly from the view of a producer of consumer products and services, as planning, sourcing, making, delivering, and returning. Exhibit 1.2 depicts where the processes are used in different parts of a supply chain. The following describes the work involved in each type of process.

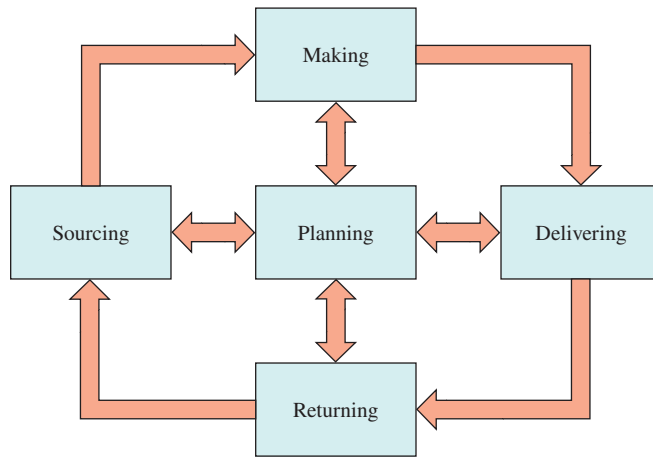
1. **Planning** consists of the processes needed to operate an existing supply chain strategically. Here, a firm must determine how anticipated demand will be met with available resources. A major aspect of planning is developing a set of metrics to

### Process

One or more activities that transform inputs into outputs.

## Supply Chain Processes

## exhibit 1.2



monitor the supply chain so that it is efficient and delivers high quality and value to customers.

2. **Sourcing** involves the selection of suppliers that will deliver the goods and services needed to create the firm's product. A set of pricing, delivery, and payment processes are needed together with metrics for monitoring and improving the relationships between partners of the firm. These processes include receiving shipments, verifying them, transferring them to manufacturing facilities, and authorizing supplier payments.
3. **Making** is where the major product is produced or the service is provided. The step requires scheduling processes for workers and coordinating material and other critical resources such as the equipment to support producing or providing the service. Metrics that measure speed, quality, and worker productivity are used to monitor these processes.
4. **Delivering** is also referred to as a logistics process. Carriers are picked to move products to warehouses and customers, coordinate and schedule the movement of goods and information through the supply network, develop and operate a network of warehouses, and run the information systems that manage the receipt of orders from customers and the invoicing systems that collect payments from customers.
5. **Returning** involves processes for receiving worn-out, defective, and excess products back from customers and support for customers who have problems with delivered products. In the case of services, this may involve all types of follow-up activities that are required for after-sales support.

To understand the topic, it is important to consider the many different players that need to coordinate work in a typical supply chain. The steps of planning, sourcing, making, delivering, and returning are fine for manufacturing and can also be used for the many processes that do not involve the discrete movement and production of parts. In the case of a service firm such as a hospital, for example, supplies are typically delivered on a daily basis from drug and health care suppliers and require coordination among drug companies, local warehouse operations, local delivery services, and hospital receiving. Patients need to be scheduled into the services provided by the hospital, such as

operations and blood tests. Other areas, such as the emergency room, need to be staffed to provide service on demand. The orchestration of all of these activities is critical to providing quality service at a reasonable cost.

## Differences between Services and Goods

Key Idea:

1. A service cannot be physically weighted or measured.
2. A service requires interaction with the customers.
3. A service varies depending on interaction with the customers.
4. A service cannot be stored.
5. A service is defined by a set of intangible features.

There are five essential differences between services and goods. The first is that a service is an *intangible* process that cannot be weighed or measured, whereas a good is a tangible output of a process that has physical dimensions. This distinction has important business implications since a service innovation, unlike a product innovation, cannot be patented. Thus, a company with a new concept must expand rapidly before competitors copy its procedures. Service intangibility also presents a problem for customers since, unlike with a physical product, customers cannot try it out and test it before purchase.

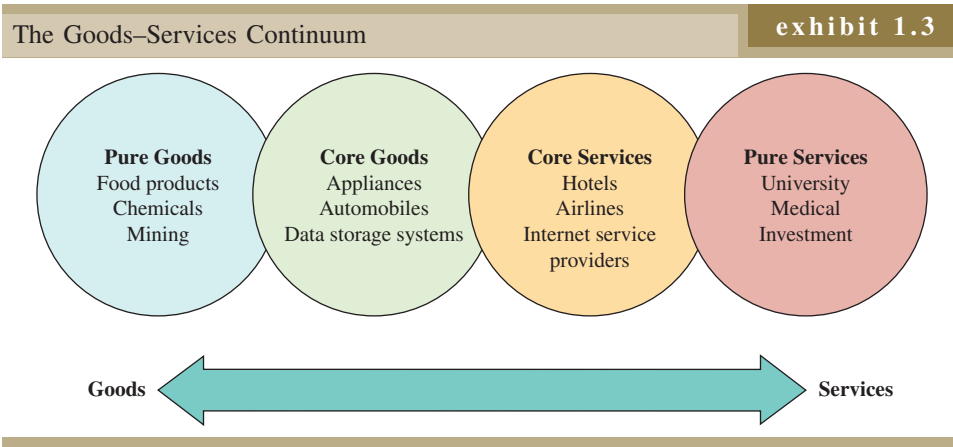
The second is that a service requires some degree of *interaction with the customer* for it to be a service. The interaction may be brief, but it must exist for the service to be complete. Where face-to-face service is required, the service facility must be designed to handle the customer's presence. Goods, on the other hand, are generally produced in a facility separate from the customer. They can be made according to a production schedule that is efficient for the company.

The third is that services, with the big exception of hard technologies such as automated teller machines (ATMs) and information technologies such as answering machines and automated Internet exchanges, are inherently *heterogeneous*—they vary from day to day and even hour by hour as a function of the attitudes of the customer and the servers. Thus, even highly scripted work, such as found in call centers, can produce unpredictable outcomes. Goods, in contrast, can be produced to meet very tight specifications day-in and day-out with essentially zero variability. In those cases where a defective good is produced, it can be reworked or scrapped.

The fourth is that services as a process are *perishable and time dependent*, and unlike goods, they can't be stored. You cannot "come back last week" for an air flight or a day on campus.

And fifth, the specifications of a service are defined and evaluated as a *package of features* that affect the five senses. These features are:

- Supporting facility (location, decoration, layout, architectural appropriateness, supporting equipment)
- Facilitating goods (variety, consistency, quantity of the physical goods that go with the service; for example, the food items that accompany a meal service)
- Explicit services (training of service personnel, consistency of service performance, availability and access to the service, and comprehensiveness of the service)
- Implicit services (attitude of the servers, atmosphere, waiting time, status, privacy and security, and convenience)



### The Goods–Services Continuum

Almost any product offering is a combination of goods and services. In Exhibit 1.3, we show this arrayed along a continuum of “pure goods” to “pure services.” The continuum captures the main focus of the business and spans from firms that just produce products to those that only provide services. Pure goods industries have become low-margin commodity businesses, and in order to differentiate, they are often adding some services. Some examples are providing help with logistical aspects of stocking items, maintaining extensive information databases, and providing consulting advice.

Core goods providers already provide a significant service component as part of their businesses. For example, automobile manufacturers provide extensive spare parts distribution services to support repair centers at dealers.

Core service providers must integrate tangible goods. For example, your cable television company must provide cable hookup and repair services and also high-definition cable boxes. Pure services, such as may be offered by a financial consulting firm, may need little in the way of facilitating goods, but what they do use—such as textbooks, professional references, and spreadsheets—are critical to their performance.

### Product-Service Bundling

**Product-service bundling** refers to a company building service activities into its product offerings for its customers. Such services include maintenance, spare part provisioning, training, and in some cases, total systems design and R&D. A well-known pioneer in this area is IBM, which treats its business as a service business and views physical goods as a small part of the “business solutions” it provides its customers. Companies that are most successful in implementing this strategy start by drawing together the service aspects of the business under one roof in order to create a consolidated service organization. The service evolves from a focus on enhancing the product’s performance to developing systems and product modifications that support the company’s move up the “value stream” into new markets. This type of strategy might not be the best approach for all product companies, however. A recent study found that while firms that offer product-service bundles generate higher revenues, they tend to generate lower profits as a percent of revenues when compared to focused firms. This is because they are often unable to generate revenues or margins high enough to cover the additional investment required to cover service-related costs.

#### Product-service bundling

When a firm builds service activities into its product offerings to create additional value for the customer.