Operations and Supply Chain Management

fourteenth edition

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OPERATIONS AND SUPPLY CHAIN MANAGEMENT, FOURTEENTH EDITION

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To my mother, Joan

To my wife, Harriet, and to our children
Laurie, Andy, Glenn, Robb, and Christine

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Preface

Operations and supply chain management (OSCM) is a key element in the improvement in productivity in business around the world. Establishing a *competitive advantage* through operations requires an understanding of how the operations and supply chain functions contribute to productivity growth. However, our intent in this book is to do more than just show you what companies are doing to create a competitive advantage in the marketplace, by conveying to you a set of skills and tools that you can actually apply.

Hot topics in business today that relate to operations and supply chain management are sustainability, lean supply chains, and improving the efficiency of supply chain processes. These topics are studied in the book with up-to-date, high-level managerial material to clarify the "big picture" of what these topics are and why they are so important to business today.

A significant new feature of this book is the organization of each chapter by concise learning objectives. Each objective relates to a block of knowledge that should be studied as a unit. The objectives are carried through the end-of-chapter material that includes Concept Connections, Discussion Questions, Objective Questions, and a Practice Exam. The material is organized to ease understanding of each topic.

Success in OSCM requires a data-driven view of a firm's business. Every chapter in the book has *analytic* content that ties decisions to relevant data. Mathematical models are used to structure the data for making decisions. Given the facts that are supported by data, success in OSCM requires using a *strategy* that is consistent with the operations-related priorities of a firm. Different approaches can often be used, and usually trade-offs related to cost-and-flexibility-related criteria exist. Strategies are implemented through *processes* that define exactly how things are done. Processes are executed over and over again as the firm conducts business, so they must be designed to operate efficiently to minimize cost while meeting quality related standards. To emphasize this relationship between analytics, strategy, and process we use special icons in the margin to point out each type of material. Great managers are analytic in their approach to decision making, understand and select the appropriate strategy, and then execute the strategy through great processes. We develop this pattern throughout the topics in this book.

The reality of global customers, global suppliers, and global supply chains has made the global firm recognize the importance of being both lean and green to ensure competitiveness. Applications that range from high-tech manufacturing to high-touch service are used in the balanced treatment of the traditional topics of the field. Success for companies today requires successfully managing the entire supply flow, from the sources of the firm, through the value-added process of the firm, and on to the customers of the firm.

Each chapter includes information about how operations and supply chain–related problems are solved. There are concise treatments of the many decisions that need to be made in designing, planning, and managing the operations of a business. Many spreadsheets are available from the book website to help clarify how these problems are quickly solved. We have indicated those spreadsheets with an Excel icon in the margin.

OSCM should appeal to individuals who want to be directly involved in making products or providing services. The entry-level operations specialist is the person who determines how best to design, supply, and run the processes. Senior operations managers are responsible for setting the strategic direction of the company from an operations and supply chain standpoint, deciding what technologies should be used and where facilities should be located, and managing the facilities that make the products or provide the services. OSCM is an interesting mix of managing people and applying sophisticated technology. The goal is to efficiently create wealth by supplying quality goods and services.

Features to aid in your understanding of the material include the following:

- Solved problems at the end of chapters to serve as models that can be reviewed prior to attempting problems.
- Key terms highlighted in the chapter with their definitions in the margin.
- Objective questions at the end of chapters that cover each concept and problem. These are organized by the chapter learning objectives.
- Practice exam questions at the end of each chapter. These are special questions designed to require a deeper understanding of the material in the chapter. They are similar to the type of short-answer questions that might be given on a test.
- Answers to selected problems in Appendix D.
- The book website, which includes PowerPoint slide outlines of each chapter, Excel spreadsheets for the solved problems and other examples, practice quizzes, ScreenCam tutorials, Internet links, and video segments that illustrate the application of operations concepts in companies such as Xerox, Zappos.com, Six Flags, Caterpillar, Burton Snowboards, Honda, Disney, Ford, and many others.
- OSCM at Work boxes provide short overviews of how leading-edge companies are applying OSCM concepts today.

Our aim is to cover the latest and the most important issues facing OSCM managers as well as basic tools and techniques. We supply many examples of leading-edge companies and practices. We have done our best to make the book interesting reading and give you a competitive advantage in your career.

We hope you enjoy it.

PLAN OF THE BOOK

This book is about methods to effectively produce and distribute the goods and services sold by a company. To develop a better understanding of the field, this book is organized into five major sections: Strategy, Products and Capacity; Manufacturing and Service Processes; Supply Chain Processes; Supply and Demand Planning and Control; and Special Topics. In the following paragraphs, we quickly describe the major topics in the book.

Strategy and sustainability are important and recurring topics in the book. Any company must have a comprehensive business plan that is supported by a marketing strategy, operations strategy, and financial strategy. It is essential for a company to ensure that the three strategies support each other. Strategy is covered from a high-level view in Chapter 2 (Strategy); and more details that relate to economies of scale and learning are covered in Chapters 5 and 6.

The lifeline of the company is a steady stream of innovative products that are offered to the marketplace at the lowest cost possible. Design of Products and Services (Chapter 3) includes a view of how products are designed in the context of having to actually produce and distribute the product over its life cycle. The chapter includes material on how to manage and analyze the economic impact of a stream of products that are developed over time. Projects (Chapter 4) are used to implement change in a firm be it a change in strategy, a new product introduction, or a new process.

The second section of the book, titled Manufacturing and Service Processes, focuses on the design of internal processes. Chapters 7 and 9 cover the unique characteristics of production and service processes. Important technical material that relates to design activities is covered in Chapters 8 (Facility Layout) and 10 (Waiting Line Analysis and Simulation).

Chapter 11, Process Design and Analysis, is a nuts-and-bolts chapter on process flow charting and static process analysis using some easily understood real-life examples.

An essential element of process design is quality. Six Sigma Quality is the topic of Chapter 12. Here we cover total quality management concepts, Six Sigma tools, and ISO 9000 and 14000. Technical details covering all the statistical aspects of quality are in Chapter 13 (Statistical Quality Control).

The third section of the book, titled Supply Chain Processes, expands our focus to the entire distribution system from the sourcing of material and other resources to the distribution

of products and services. We discuss the concepts behind lean manufacturing and just-in-time processes in Chapter 14. These are ideas used by companies throughout the world and are key drivers for efficient and quick-responding supply systems. Many different transformation processes are needed to put together a supply chain. There are critical decisions such as: Where should we locate our facility? What equipment should we buy or lease? Should we outsource work or do it in-house? These are the topics of Chapters 15 and 16 that relate to sourcing, procurement, location of facilities, and distribution. All of these decisions have a direct financial impact on the firm.

Section Four, titled Supply and Demand Planning and Control, covers the techniques required to actually run the system. This is at the heart of OSCM. The basic building blocks are Forecasting (Chapter 18), Sales and Operations Planning (Chapter 19), Inventory Management (Chapter 20), Material Requirements Planning (Chapter 21), and Workcenter Scheduling (Chapter 22). These daily processes are often partially automated with computer information systems. Coverage of Enterprise Resource Planning Systems is the topic of Chapter 17.

In the final section of the book titled Special Topics we show how the concepts in the book are applied to special business situations. Here we have selected two types of businesses, Health Care (Chapter 24) and Operations Consulting (Chapter 25). We know that many of you may be interested in working for hospitals and similar specialized care facilities, a growing segment of the world economy. In addition, we know that many of those interested in OSCM are also interested in consulting as a profession.

Making fact-based decisions is what OSCM is all about, so this book features extensive coverage of decision-making approaches and tools. One useful way to categorize decisions is by the length of the planning horizon, or the period of time that the decision maker must consider. For example, building a new plant would be a long-term decision that a firm would need to be happy with for 10 to 15 years into the future. At the other extreme, a decision about how much inventory for a particular item should be ordered for tomorrow typically has a much shorter planning horizon of a few months or, in many cases, only a few days. Such short-term decisions are usually automated using computer programs. In the intermediate term are decisions that a company needs to live with for only 3 to 12 months. Often these decisions correspond to yearly model changes and seasonal business cycles.

As you can see from this discussion, this material is all interrelated. A company's strategy dictates how operations are designed. The design of the operation dictates how it needs to be managed. Finally, because businesses are constantly being presented with new opportunities through new markets, products, and technologies, a business needs to be very good at managing change.

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F. Robert Jacobs

NOTE TO INSTRUCTORS

DISCUSSION OF FOURTEENTH EDITION REVISIONS

The revisions to the fourteenth edition have been driven by two major objectives. First, each chapter is now organized around a short set of learning objectives. These learning objectives define the major sections of each chapter. A complete set of Discussion Questions together with new Objective Questions, which include concepts and problems, are now included. The many new questions added to each chapter are all available for use in *Connect®,* the automated assignment grading system available to adopters of the book.

The second objective is the increased focus on supply chain analytics. Supply chain analytics involve the analysis of data to better solve business problems. We recognize that this is not really a new concept since data has always been used to solve business problems. But what is new is the reality that there is so much 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 simply being alert to 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, our goal is to recapture this spirit of using integrated analytic and strategic criteria in making operations and supply chain decisions. We have done this in two major ways. First, we have reorganized the material in the book by integrating the strategic and analytic material. Next, we have written a series of eleven Analytics Exercises that are spread through the chapters. Eight of the eleven exercises are totally new in this edition.

These new Analytics Exercises use settings that are modern and familiar to students taking the course. They include Starbucks, cell phones, notebook computers, Taco Bell Restaurant, Toyota, a retail website-based company, and industrial products that are sourced from China/Taiwan and sold globally. The book has been reorganized into five major sections: Strategy, Products, and Capacity; Manufacturing and Service Processes; Supply Chain Processes; Supply and Demand Planning and Control; and Special Topics. Our strategy is to weave analytics into the managerial material so that students see the important role of data analysis in making operations and supply chain management decisions.

In the first section, Strategy, Products, and Capacity, our chapters cover Strategy, the Design of Products and Services, Project Management, Strategic Capacity Management, and Learning Curves. The key themes of operations strategy, product design to support the strategy, and strategic capacity are a good foundation for learning about operations and supply chain management. Since most strategic plans are implemented using projects, we include this topic in the first section as well. In the project management chapter, we introduce a good amount of material on product design through examples and exercises, emphasizing the strategic importance of these projects to the success of the firm.

The second section, Manufacturing and Service Processes, gets into the nuts and bolts of operations management. The section introduces the ways that manufacturing and service systems are organized and includes new Analytics Exercises for assembly line design and queuing. The Six Sigma and Statistical Quality Control chapters cover topics that would be appropriate for a green-belt program and include good coverage of the popular value-stream mapping technique.

The third section, Supply Chain Processes, discusses processes that source material for internal operations and then distribute products to the customers. The analytic models involved with location/transportation are included here. The topics are tied together in the Lean Supply

Chain chapter, which now stresses the cost versus disruption risk trade-offs that are involved in such tactics as single sourcing and just-in-time inventory.

The fourth section, Supply and Demand Planning and Control, covers the techniques that are typically implemented in Enterprise Resource Planning Systems. These include Forecasting, Sales and Operations Planning, Inventory Management, Material Requirements Planning, and Workcenter Scheduling. We also include a chapter on the Theory of Constraints, a set of thought-provoking concepts.

Finally, the fifth section titled Special Topics covers two industries where operations and supply chain management concepts are being applied with great success. The first is Health Care, with the majority of our material on hospital and special care facilities. We also discuss Operations Consulting since this is an area where many of our students find jobs.

The following are a list of the major revisions in selected chapters:

- *Chapter 1* Introduction to operations and supply chain management—Here our focus on integrating analytics is introduced in the opening section. We have moved and expanded the material on how Wall Street measures efficiency, which was in the strategy chapter, to this chapter. The material has been expanded to show the leveraging impact of a reduction in the cost of raw material on profit and return on investment. An interesting Analytics Exercise where students must compare similar companies relative to their efficiency is now included in the chapter. We have made a number of other changes to better explain the history of the topic and its tie to employment opportunities.
- *Chapter 2* Strategy—We have written a new introduction that shows how many companies are expanding their focus beyond just making a profit. We include more examples and better explanations of order winning and qualifying criteria to help students better understand these important concepts. A new section on assessing the risk associated with operations and supply chain strategies now includes material on categorizing risk and a risk management process.
- *Chapter 4* Project Management—The vignette has been changed and describes how a Chinese construction company builds 30-story hotels in only 15 days. We have written a new Analytics Exercise that is much better than the old one. The theme is still cell phone design, but the tasks and the design of the initial network are much easier to understand. There are a series of changes in the project and students are asked to assess the impact of these changes. The last change involves a complete flipping of the project in which vendors are selected at the beginning of the project and work directly with project teams to its completion (much like Apple designs the iPhone).
- *Chapter 5* Strategic Capacity Management—A new and much clearer summary of strategic capacity planning has been added to the chapter.
- *Chapters 7 and 8* Manufacturing Processes and Facility Layout—The "positioning inventory in the supply chain" (decoupling point) exhibit has been changed to make it easier to understand, and the explanation of assembly line balancing has been revised. Many new problems have been added to these chapters, and a completely revised Analytics Exercise is included that involves the design of a notebook computer assembly line.
- *Chapters 9 and 10* Service Processes and Waiting Line Analysis and Simulation—A new Analytics Exercise has been added to the Waiting Line chapter. The scenario is a Taco Bell drive-thru where the students are asked to analyze the system using queuing models. The problem is set up in a general way, and students should be able to see how these models can be applied to many real-world settings. The chapter now includes concise coverage of simple simulations that can be developed with spreadsheets. The Simulation appendix that was included in the last edition has been removed. Many new problems have been added to the chapter.
- *Chapters 12 and 13* Six Sigma Quality and Statistical Quality Control—Information on ISO standards are updated to include ISO 26000, which offers guidance on socially

responsible behavior. An all new Analytics Exercise replaces the Hank Kolb Case and relates to the issues that Toyota has dealt with in its recent recalls. The first part deals with managerial issues and processes that Toyota has changed in reaction to the problem, and the second is a capability analysis for a part in the accelerator pedal mechanism used in cars.

- *Chapter 14* Lean Supply Chains—The opening vignette is new and shows how dramatically inventories have been reduced by companies over the past 20 years. The vignette also describes how this reduction makes companies vulnerable to disruptions in the supply chains. We have revised the material on using lean concepts to explain how the differences in uncertainty and variability are much more difficult to control in the services field than they are in manufacturing. The value-stream mapping material has been streamlined a little. An example of a "freeze window" has been included in the "Lean Production Schedules" section.
- *Chapter l5* Logistics, Distribution, and Transportation—A new opening vignette that describes the logistics operations of a global cement company has been added. The vignette highlights the impact of logistics on the goals the company has related to sustainability. The use of regression for locating facilities has been revised to make the example more understandable. A new Analytics Exercise has been added that involves the location of U.S. distribution centers for an industrial supplier.
- *Chapter 16* Global Sourcing and Procurement—The opening vignette is new and is about the cost of batteries for electric cars. Some additional material has been added to the "Total Cost of Ownership" section that discusses other factors that may need to be considered including exchange rates, risk of doing business in a particular region of the world, and other factors. A new Analytics Exercise centered on Global Sourcing Decisions is included in the chapter. The case involves shipping goods from suppliers in China and Taiwan to a distribution center in the United States. Costs related to the shipping of large and small containers of items, running consolidation centers, and packing efficiency are considered in the case. This exercise and the one used in Chapter 15 are related.
- *Chapter 17* Enterprise Resource Planning Systems—This chapter has been totally rewritten and it is now less centered on SAP and includes material on "cloud" technologies.
- *Chapter 18* Forecasting—We have a new opening vignette on Starbucks, which is tied to a new Analytics Exercise at the end of the chapter. The material is fresh and relates to the significant forecasting challenges a growing company like Starbucks has. Based on feedback from reviewers, the material has been reorganized, starting with simpler time series analysis, progressing to linear regression, decomposition of time series, and, finally, error measurement. We have put much work into improving the explanations of the models in the chapter and have added a new solved problem.
- *Chapter 19* Sales and Operations Planning—The Bradford Manufacturing Case has been updated to an Analytics Exercise.
- *Chapter 20* Inventory Management—A new Analytics Exercise titled "Inventory Management at Big10Sweaters.com" was added that discusses a new startup company that sells custom sweaters on a website. Decisions related to purchasing the sweaters from an overseas supplier need to be made prior to the start of football season. Ten new problems were also added to the chapter.
- *Chapter 21* Materials Requirements Planning—A new opening vignette that shows the bill of materials for the iPad was added to this chapter. This includes data on the cost of the various items needed to build the iPad. The material was resequenced by moving "Where MRP Can Be Used" ahead of "Master Production Scheduling." This gives a better flow where "Master Production Scheduling" immediately precedes the start of the MRP logic material. Some changes were made to the exhibits to make them easier to understand. A new solved problem was also added to the chapter. Brunswick Motors was converted to an Analytics Exercise.

- *Chapters 22 and 23* Workcenter Scheduling and Theory of Constraints—We have updated these chapters to the new Learning Objectives format and have added three new solved problems together with many new Discussion and Objective Questions.
- *Chapters 24 and 25* Health Care and Operations Consulting—We have included a new opening vignette that covers Health Care optimization to the former and have added many new Discussion and Objective Questions to both chapters.

F. Robert Jacobs
November 2012

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- Access an instant view of student or class performance relative to learning objectives.
- Collect data and generate reports required by many accreditation organizations, such as AACSB and AICPA.

Lecture Capture

Increase the attention paid to lecture discussion by decreasing the attention paid to note taking. For an additional charge Lecture Capture offers new ways for students to focus on the in-class discussion, knowing they can revisit important topics later. Lecture Capture enables you to:

- Record and distribute your lecture with a click of a button.
- Record and index PowerPoint presentations and anything shown on your computer so it is easily searchable, frame by frame.
- Offer access to lectures anytime and anywhere by computer, iPod, or mobile device.
- Increase intent listening and class participation by easing students' concerns about note taking. Lecture Capture will make it more likely you will see students' faces, not the tops of their heads.

McGraw-Hill *Connect® Plus Operations Management*

McGraw-Hill reinvents the textbook learning experience for the modern student with *Connect® Plus Operations Management*. A seamless integration of an eBook and *Connect® Operations Management*, *Connect® Plus Operations Management* provides all of the *Connect Operations Management* features plus the following:

- An integrated eBook, allowing for anytime, anywhere access to the textbook.
- Dynamic links between the problems or questions you assign to your students and the location in the eBook where that problem or question is covered.
- A powerful search function to pinpoint and connect key concepts in a snap.

In short, *Connect® Operations Management* offers you and your students powerful tools and features that will optimize your time and energies, enabling you to focus on course content, teaching, and student learning. *Connect® Operations Management* also offers a wealth of content resources for both instructors and students. This state-of-the-art, thoroughly tested system supports you in preparing students for the world that awaits.

For more information about *Connect,* go to **www.mcgrawhillconnect.com**, or contact your local McGraw-Hill sales representative.

COURSESMART

CourseSmart is a new way to find and buy eTextbooks. At CourseSmart you can save up to 50 percent of the cost of your print textbook, reduce your impact on the environment, and gain access to powerful web tools for learning. Try a free chapter to see if it's right for you. Visit **www.CourseSmart.com** and search by title, author, or ISBN.

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 as 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 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, immediately supported by your lecture

To learn more about Tegrity watch a 2-minute Flash demo at **http://tegritycampus.mhhe.com**.

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

McGRAW-HILL CUSTOMER CARE 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**, e-mail **hmsupport@mcgraw-hill.com**, or visit **www.mhhe.com/support**. One of our Technical Support Analysts will be able to assist you in a timely fashion.

Walkthrough

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

7 MANUFACTURING PROCESSES

Learning Objectives

LO7–1 Understand what a manufacturing process is.
LO7–2 Explain how manufacturing processes are organized.
LO7–3 Analyze simple manufacturing processes.

GE AND EADS TO PRINT PARTS FOR AIRPLANES

The Technology Could be Used to Make Parts That Perform Better and Cost Less.

GE is starting a new lab at its global research headquarters in Niskayuna, New York, that is devoted to turning three-dimensional printing technology into a viable means of manufacturing functional parts for a range of its businesses, including those involving health care and aerospace. The company aims to take advantage of the technology's potential to make parts that are lighter, perform better, and cost less than parts made with conventional manufacturing techniques.

LIGHTER LOAD: A CONVENTIONAL HINGE FOR THE COVER OF A JET ENGINE (TOP) COULD BE REPLACED BY THE MORE INTRICATE ONE AT BOTTOM, WHICH IS JUST AS STRONG BUT WEIGHS HALF AS MUCH. THE NEW DESIGN, CREATED BY EADS, IS MADE PRACTICAL BY THREE-DIMENSIONAL PRINTING TECHNOLOGY.

Technology for printing three-dimensional objects has existed for decades, but its applications have been largely limited to novelty items and specialized custom fabrication, such as in making personalized prosthetics. But the technology has now improved to the point that these printers can make intricate objects out of durable materials, including ceramics and metals such as titanium and aluminum, with resolution on the scale of tens of micrometers.

As a result, companies such as GE and the European defense and aerospace giant EADS are working to apply it in situations more akin to conventional manufacturing, where large numbers of the same part are needed.

Source: Kevin Bullis, "GE and EADS to Print Parts for Airplanes," *Technology Review* (MIT), May 9, 2011.

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:

- Boeing, Chapter 6, page 129
- United Parcel Service (UPS), Chapter 11, page 262
- Starbucks, Chapter 18, page 442

UNITED PARCEL SERVICE DRIVE FOR EFFICIENCY

United Parcel Service, Inc., designs its delivery routes to avoid left turns, so as not to waste time waiting for a break in oncoming traffic. And the company requires drivers to walk at a "brisk pace," which it defines as 2.5 paces a second, to keep things moving fast.

UPS drivers have had to toss their keys and replace them with a digital-remote fob to turn on the ignition and unlock the bulkhead door. The company will save $70 million a year by going to a keyless system in which drivers start their vehicle with a fob hooked to their belt. That automatic door opening saves 1.75 seconds per stop, or 6.5 minutes per driver per day, while also reducing motion and fatigue. The company is "obsessive." Each night, when drivers return from deliveries, UPS industrial engineers study data from computers aboard each truck. The data show details such as how much drivers are idle, how often they back up, whether they are wearing seatbelts, or even seem to be going out of their way for lunch. The information helps shape new procedures.

A UNITED PARCEL SERVICE (UPS) DRIVER DELIVERS PACKAGES IN GLENDALE, CALIFORNIA. UPS SAID ITS SECOND QUARTER PROFIT NEARLY DOUBLED POSTING A NET PROFIT OF $845 MILLION, OR 84 CENTS A SHARE, COMPARED TO $445 MILLION OR 44 CENTS, A YEAR AGO.

Source: Adapted from Jennifer Levitz, "Delivery Drivers to Pick Up Pace by Surrendering Keys," *The Wall Street Journal*, September 16, 2011, B6.

OSCM AT WORK

Mr. Rounder Is On-Call at Hackensack University Medical Center

The Remote Presence Robot (RP-7) from InTouch Health is a mobile telemedicine unit that connects physicians and specialists with patients and other doctors in real time through computers equipped with cameras and microphones.

It's the day after surgery, you're lying in bed and the nurse informs you the doctor will be in shortly. Good news—just the person you're hoping to see will be in soon. Sure enough in rolls your doctor, all 5 feet, 4 inches and 215 pounds and you can't believe your eyes. Not because the doctor is there as promised, but because your doctor is housed within a remote-controlled adult-sized robot. Does this sound a bit like science fiction? It isn't.

The sophisticated mechanical physician made its debut at Hackensack University Medical Center. As part of an initiative to improve the quality and efficiency of patient care, the medical center introduced InTouch Health's RP-6 for Remote Presence, "Mr. Rounder," dubbed affectionately by staff, as part of the services available to patients. Physician-to-patient communication is now possible regardless of whether a physician is out of town or out of the country for that matter. Garth H. Ballantyne, M.D., chief of Minimally Invasive Surgery at the medical center and Professor of Surgery at the University of Medicine and Dentistry of New Jersey (UMDNJ), is the first to "test drive" Mr. Rounder at Hackensack University Medical Center. Dr. Ballantyne is able to make his rounds off-site or from his office anytime of the day via a laptop computer connected to the Internet via broadband and a wireless network. The robot has a two-way video and 24 infrared sensors to navigate its travels. Dr. Ballantyne's image is displayed on a flat-screen computer monitor mounted on top of the robot. The screen rotates 340 degrees and pivots up and down creating personalized mechanical affectations. He views the patient and surroundings through a video camera located above the monitor allowing live interactive communication. Of course in the meantime, patients continue to be monitored by the medical center's Magnet award–winning nursing staff.

"The robot is remarkably personal. It provides virtual communication and patients really like him. It has received an enthusiastic response," said Dr. Ballantyne. "In essence, we are providing extra coverage patients might not ordinarily get. I am now able to connect and see my patients when family members are visiting. Driving the robot into the room is more personal than a phone call from my office." Mr. Rounder also provides access to electronic patient files. "I can view vital signs, CT scans, blood tests—much of the technical data needed for patient care," noted Dr. Ballantyne. As you watch Mr. Rounder humming through the halls, you get a sense he's become a familiar face around Hackensack University Medical Center as staff passing by quickly greet Dr. Ballantyne as though he's really there—physically that is!

Source: Hackensack University Medical Center press release, December 2004, www.intouchhealth.com/prhumc.pdf.

OSCM at Work Boxes

The boxes provide examples or expansions of the topics presented by highlighting leading companies practicing new, breakthrough ways to run their operations. Examples include:

- Efficiency: It's the Details That Count, Chapter 1, page 15
- What's It Like Working on an Assembly Line?, Chapter 8, page 174
- J. D. Power and Associates Initial Quality Study of New Cars, Chapter 12, page 298
- Mr. Rounder Is On-Call at Hackensack University Medical Center, Chapter 24, page 664

EXAMPLE 13.3

The owners of a lumberyard want to design a control chart to monitor the quality of 2×4 boards that come from their supplier. For their medium-quality boards they expect an average of four knotholes per 8-foot board. Design a control chart for use by the person receiving the boards using three-sigma (standard deviation) limits.

SOLUTION

For this problem, $\bar{c} = 4$, $s_p = \sqrt{\bar{c}} = 2$

$$\text{UCL} = \bar{c} + z\sqrt{\bar{c}} = 4 + 3(2) = 10$$

$$\text{LCL} = \bar{c} - z\sqrt{\bar{c}} = 4 - 3(2) = -2 \rightarrow 0 \text{ (Zero is used since it is not possible to have a negative number of defects.)}$$

For a step-by-step walkthrough of this example, visit www.mhhe.com/jacobs14e_sbs_ch13.

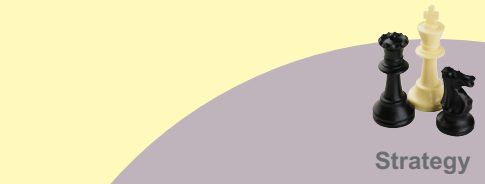
Examples with Solutions

Examples follow quantitative topics and demonstrate specific procedures and techniques. Clearly set off from the text, they help students understand the computations.

A series of detailed, worked-out solutions for every example in the text can be found on the text website, which provides another level of detailed support for students. QR codes provide links to the step-by-step content.

Strategy

Strategy icons are used to highlight material that describes alternative approaches that usually involve trade-offs.



Process

Process icons identify material that describes how things are done.

Analytics

Analytics icons identify content that ties decision models to relevant data.

Step by Step

Every example and solved problem in the book includes a step-by-step QR code. These draw students' attention and provide students with a direct link to detailed, worked-out solutions on the text website.

For a step-by-step walkthrough of this example, visit www.mhhe.com/jacobs14e_sbs_ch11.

Excel

Excel icons point out concepts where Excel templates are available on the text website.

eXcel

For the excel template, please visit www.mhhe.com/jacobs14e

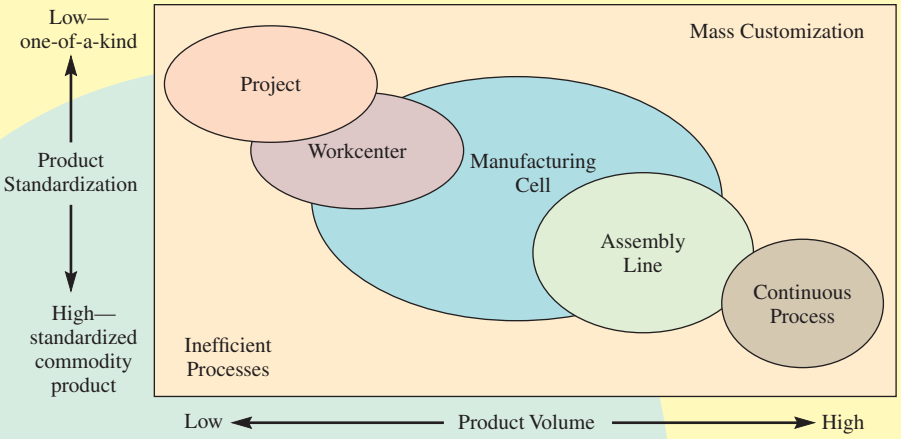
Tutorials

The tutorial QR codes direct students to the ScreenCam tutorials on the text website.

To view a tutorial on break-even analysis, visit www.mhhe.com/jacobs14e_tutorial_ch07.

Photos and Exhibits

Over 60 photos and 200 exhibits are included in the text to 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.



Key Ideas

Important points in the text are called out and summarized in the margins.

KEY IDEA

Individual learning can vary greatly across different employees. This can create challenges when estimating expected production rates.

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 PROBLEM 2

Items purchased from a vendor cost $20 each, and the forecast for next year's demand is 1,000 units. If it costs $5 every time an order is placed for more units and the storage cost is $4 per unit per year,

a. What quantity should be ordered each time?
b. What is the total ordering cost for a year?
c. What is the total storage cost for a year?

Solution

a. The quantity to be ordered each time is

$$Q = \sqrt{\frac{2DS}{H}} = \sqrt{\frac{2(1{,}000)5}{4}} = 50 \text{ units}$$

b. The total ordering cost for a year is

$$\frac{D}{Q}S = \frac{1{,}000}{50}(\$5) = \$100$$

c. The storage cost for a year is

$$\frac{Q}{2}H = \frac{50}{2}(\$4) = \$100$$

Concept Connections

The Concept Connections grid appears at the end of every chapter. This tool draws students' attention to the main points, key terms, and formulas for each learning objective. The organization of the Concept Connections gives students a quick and effective reference when applying the chapter content.

CONCEPT CONNECTIONS

LO10–1 Understand what a waiting line problem is.

Summary

The study of waiting in line is the essence of this problem. Queuing theory is the mathematical analysis of the waiting line. A queuing (or waiting line) system is decomposed into three major parts: (1) the customers arriving to the system, (2) the servicing of the customers, and (3) how customers exit the system. Queuing theory assumes that customers arrive according to a Poisson arrival distribution and are served according to an exponential service time distribution. These are specific probability distributions that often match well with actual situations.

Key Terms

Queues, 222
Queuing system, 223
Arrival rate, 225
Exponential distribution, 225
Poisson distribution, 226
Service rate, 228

Key Formulas

Exponential distribution

[10.1] $f(t) = \lambda e^{-\lambda t}$

Poisson distribution

[10.2] $P_T(n) = \frac{(\lambda T)^n e^{-\lambda T}}{n!}$

Practice Exam

The Practice Exams are designed to allow students to see how well they understand the material using a format that is similar to what they might see in an exam. This feature includes many straightforward review questions, but also has a selection that tests for mastery and integration/application level understanding, i.e., the kind of questions that make an exam challenging. The practice exams include short answers at the bottom so students can see how they perform.

Practice Exam

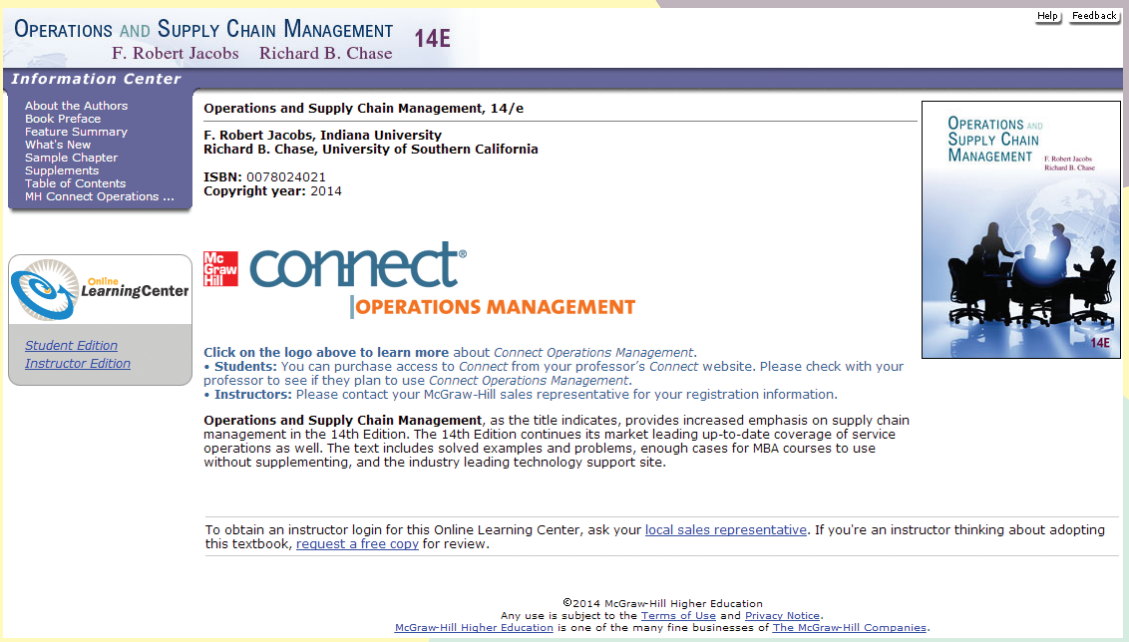
1. This is the currently used term for a system that schedules, dispatches, tracks, monitors, and controls production.
2. This is when work is assigned to workcenters based simply on when it is needed. Resources required to complete the work are not considered.
3. This is when detailed schedules are constructed that consider setup and run times required for each order.
4. This is when work is scheduled from a point in time and out into the future, in essence telling the earliest the work can be completed.
5. This is when work is scheduled in reverse from a future due date, to tell the time original work must be started.
6. If we were to coin the phrase "dual constrained" relative to the resources being scheduled, we would probably be referring to what two resources?
7. For a single machine scheduling problem, what priority rule guarantees that the average (mean) flow time is minimized?
8. Consider the following three jobs that need to be run on two machines in sequence: A(3 1), B(2 2), and C(1 3), where the run times on the first and second machine are given in parenthesis. In what order should the jobs be run to minimize the total time to complete all three jobs?
9. According to APICS, this is a system for utilizing data from the shop as well as data processing files to maintain and communicate status information on shop orders and workcenters.
10. A resource that limits the output of a process by limiting capacity is called this.

1. Manufacturing Execution System 2. Infinite scheduling 3. Finite scheduling 4. Forward scheduling 5. Backward scheduling 6. Labor and equipment (machines) 7. Shortest operating time 8. C B A 9. Shop-floor (or production activity) control 10. Bottleneck

Text Website

The text website, our Online Learning Center (OLC), can be found at **www.mhhe.com/jacobs14e.** It includes a variety of material to help students succeed in the course. These assets include:

- Excel templates
- Online quizzes
- PowerPoint presentations
- Step-by-step solutions to examples
- ScreenCam tutorials
- Chapter outlines
- Updates to the text
- Interactive Operations Management
- Web links



Student Website

Online quizzes
Excel templates
ScreenCam tutorials
Chapter outlines
Step-by-step solutions to text examples
Updates to the text
Interactive Operations Management

Instructor Site

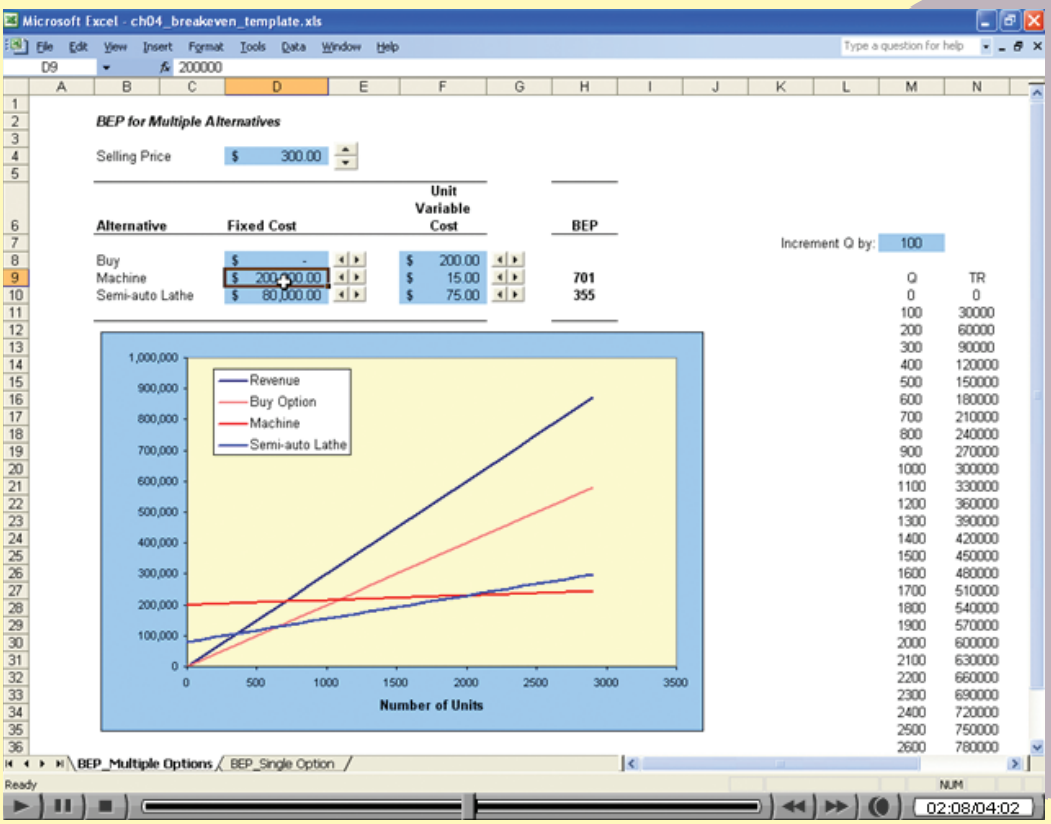
Instructor's Resource Manual
Test Bank
Instructor PowerPoint Slides
Instructor Solutions Manual
Map to Harvard Cases
OSCM Framework PowerPoints

OMC

The Operations Management Center at **www.mhhe.com/pom** offers a wealth of edited and organized OM resources including links to Operations Management *BusinessWeek* articles, OM Organizations, and virtual tours of operations in real companies.

ScreenCam Tutorials

These screen "movies" and voice-over tutorials demonstrate chapter content using Excel and other software platforms.



To view a tutorial on break-even analysis, visit www.mhhe.com/jacobs14e_tutorial_ch07.

For a step-by-step walkthrough of this example, visit www.mhhe.com/jacobs14e_sbs_ch07.

EXAMPLE 7.1: Break-Even Analysis

Suppose a manufacturer has identified the following options for obtaining a machined part: It can buy the part at $200 per unit (including materials); it can make the part on a numerically controlled semiautomatic lathe at $75 per unit (including materials); or it can make the part on a machining center at $15 per unit (including materials). There is negligible fixed cost if the item is purchased; a semiautomatic lathe costs $80,000; and a machining center costs $200,000.

The total cost for each option is

$$\text{Purchase cost} = \$200 \times \text{Demand}$$
$$\text{Produce-using-lathe cost} = \$80{,}000 + \$75 \times \text{Demand}$$
$$\text{Produce-using-machining-center cost} = \$200{,}000 + \$15 \times \text{Demand}$$

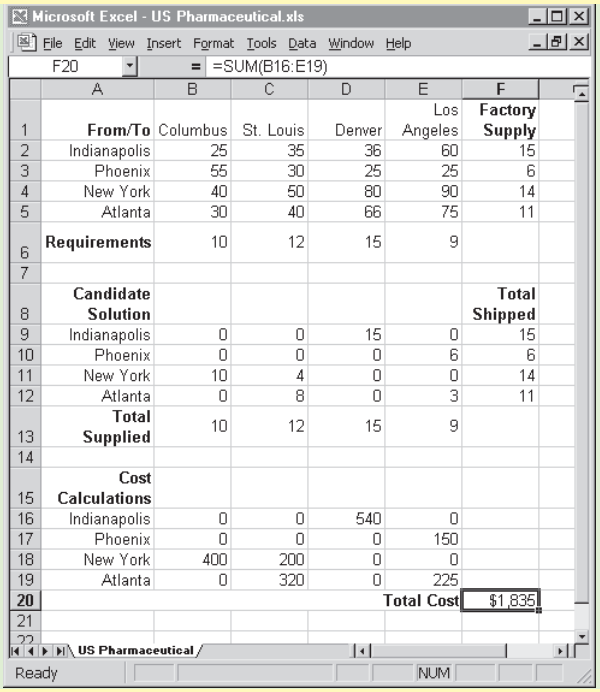
SOLUTION

Whether we approach the solution to this problem as cost minimization or profit maximization really makes no difference as long as the revenue function is the same for all alternatives. Exhibit 7.3 shows the break-even point for each process. If demand is expected to be more than 2,000 units (point A), the machine center is the best choice because this would result in the lowest total cost. If demand is between 640 (point B) and 2,000 units, the semiautomatic lathe is the cheapest. If demand is less than 640 (between 0 and point B), the most economical course is to buy the product.

Excel

An icon in the margin indicates there is a spreadsheet available on the text website.

For the Excel template, visit www.mhhe.com/jacobs14e.



	A	B	C	D	E	F
1	**From/To**	Columbus	St. Louis	Denver	Los Angeles	**Factory Supply**
2	Indianapolis	25	35	36	60	15
3	Phoenix	55	30	25	25	6
4	New York	40	50	80	90	14
5	Atlanta	30	40	66	75	11
6	**Requirements**	10	12	15	9	
7						
8	**Candidate Solution**					**Total Shipped**
9	Indianapolis	0	0	15	0	15
10	Phoenix	0	0	0	6	6
11	New York	10	4	0	0	14
12	Atlanta	0	8	0	3	11
13	**Total Supplied**	10	12	15	9	
14						
15	**Cost Calculations**					
16	Indianapolis	0	0	540	0	
17	Phoenix	0	0	0	150	
18	New York	400	200	0	0	
19	Atlanta	0	320	0	225	
20					**Total Cost**	$1,835
21						
22						