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Operations and Supply Chain Management

David A. Collier • James R. Evans

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Cover Image Source: derrrek/Getty Images

Library of Congress Control Number: 2022918875

ISBN: 978-0-357-90164-9

Cengage
200 Pier 4 Boulevard
Boston, MA 02210
USA

Printed in the United States of America
Print Number: 01 Print Year: 2023

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David A. Collier was the Eminent Scholar, Alico Chair in Operations Management, at the Lutgert College of Business, Florida Gulf Coast University, Fort Myers, Florida. He retired in 2017. Dr. Collier holds a Bachelor of Science of Mechanical Engineering and a Masters of Business Administration from the University of Kentucky and Ph.D. in Production and Operations Management from The Ohio State University. Dr. Collier previously taught at the Fuqua School of Business at Duke University, the Colgate Darden Graduate School of Business at the University of Virginia, the Fisher College of Business at The Ohio State University, and at the University of Warwick in England.

Dr. Collier is the recipient of five awards for outstanding journal articles, has written and published eight invited book chapters, seven of his cases have been reprinted in major marketing and operations management textbooks, several of his articles have been reprinted in the *Harvard Business Review* 10 Must Reads series, and has over 80 refereed journal publications. He has published in journals such as *Management Sciences, Decision Sciences, Journal of Operations Management, Production & Operations Management, International Journal of Operations and Production Management, Business Horizons, Journal of Service Science,* and *International Journal of Service Industry Management.* Dr. Collier has over 34,000 reads and 4,000 citations according to ResearchGate.

He is the author of six books on service, quality, and operations management: *Service Management: The Automation of Services* (1985), *Service Management: Operating Decisions* (1987), *The Service/Quality Solution: Using Service Management to Gain Competitive Advantage* (1994), *Operations Management: Goods, Services and Value Chains* (2005), *Operations and Supply Chain Management* (2018 to current), and *OM6* (current).

After decades of authoring academic articles and textbooks, he wanted a new challenge: writing novels that make a difference.

David (www.theentity.us) is the author of the five-star rated science fiction series, *Earth's Ecocide*, as well as *Romance in My Rambler* using the pen name David A. Bourbon. He dedicates the *Earth's Ecocide* book series to those who love this tiny speck of wonder called Earth.

James R. Evans

James R. Evans is Professor Emeritus of Operations, Business Analytics, and Information Systems in the Lindner College of Business at the University of Cincinnati, having retired after over 43 years on the faculty. He holds BSIE and MSIE degrees from Purdue University and a Ph.D. in Industrial and Systems Engineering from Georgia Tech.

He has been involved in numerous professional societies throughout his career, and served as president of the Decision Sciences Institute in 1997–1998. He also served 11 years on the Board of Examiners and Panel of Judges for the Malcolm Baldrige National Quality Award, and was active in the Partnership for Excellence, the Ohio-based Baldrige initiative. He has been the editor of the *Quality Management Journal*, published by the American Society for Quality and served on editorial boards of numerous other journals.

Dr. Evans has published 100 refereed papers in major academic journals and more than 50 editions of 20 textbooks in diverse areas of business including quality management, Six Sigma, simulation and risk analysis, and business analytics. During the annual Quality Congress in May 2004, the American Society for Quality presented Dr. Evans and coauthor Dr. William Lindsay with the Philip B. Crosby Medal for writing *The Management and Control of Quality, 5th edition*. The Crosby medal was presented "for authoring a distinguished book contributing significantly to the extension of the philosophy and application of the principles, methods, and techniques of quality management." He also received the 2018 Lindner Research Excellence Award from the College of Business at the University of Cincinnati and the 2019 Baldrige Foundation Leadership Award for Excellence in Education.

Preface

Operations and supply chain management (OSCM) has evolved into one of today's most important business disciplines. OSCM is an outgrowth of the disciplines of industrial engineering, strategic management, quality control, and management science. Although OSCM began with a strong focus in production and manufacturing, one cannot deny the fact that over 80 percent of U.S. jobs are now in the service sector and more than half of goods-producing industry jobs involve service processes. Consequently, most business graduates will work in the service sector, or in service-related aspects of manufacturing firms. Thus, it is vital that any book in this area has a strong service orientation.

Operations and Supply Chain Management, 3E is written to help students understand the role of operations in both goods-producing and service-providing organizations. It has evolved from a series of books written by us, beginning with *Operations Management: Goods, Services, and Value Chains*, which was the first text to integrate goods and services from the perspective of the value chain, six editions of a shorter and more student-friendly text, *OM*, a 4LTR Press book published by Cengage Learning, and a subsequent re-branding of that title as *Operations and Supply Chain Management*, which provided a more extensive integration of supply chain management and Cengage digital technology.

In this revision, we have strengthened the focus on supply chains and quantitative applications. New features in this edition are:

- A new concluding chapter 20, *Building Resilience and Continuity in Operations and Supply Chains*, covering such topics as disruptions, resilience and recovery strategies, disaster management, and community lifelines.
- Expanded coverage of supply chains, particularly in view of the recent COVID-19 pandemic and global supply chain challenges.
- Many new opening chapter scenarios are based on current events that provide relevance to the concepts introduced in the chapter.
- A third case study in each chapter in addition to the revised integrative case study that spans all chapters, Diamond Global Supply Chain—Hudson Jewelers, for a total of 80 cases.
- New feature boxes that highlight current events such as the impact of the COVID-19 pandemic on global supply chains, computer chip shortages, and operational and supply chain disruptions that support key concepts and illustrate practical applications.
- Modern concepts of agility, flexibility, and resilience in operations and supply chains.
- New and expanded discussions of technology, including Industry 4.0, Service 4.0, and Quality 4.0; robotics; and smart factories.
- Additional coverage of maintenance concepts, including reactive, preventive, and predictive maintenance.
- Addition of SIPOC (Supplier-Inputs-Process-Outputs-Customers) diagrams and the Deming Cycle (PDSA).
- Expanded illustrations of using Excel tools for simple and multiple linear regression in Supplement A: Probability and Statistics, and a new section on decision trees in Supplement B: Decision Analysis.
- Visual icons that now direct students to Excel templates, data files, and model files used in solved problems and required in the problem and case sections.
- Improvements in style and logical flow of the text, as well as the resolution and readability of all Excel screen shots.

Organization of the Book

This book is divided into three major parts and a set of supplements. Part 1 introduces the basic concepts, terminology, and models of operations and supply chain management. Part 2 focuses on the design of goods and services to support business strategy and the global value chains and processes that create and deliver them to customers. Part 3 addresses more tactical and day-to-day management issues of operating systems and supply chains. Part 4 contains recommended supplements that are intended to provide a basic introduction or review of key quantitative and analytics topics that are used throughout this book. A brief description of each chapter and supplement, including key changes in this edition, follows.

Part 1: Basic Concepts of OM and Value Chains

Chapter 1: Operations Management and Value Chains

This chapter introduces operations management (OM), explains what operations managers do, and provides brief tours of manufacturing and service companies; describes the differences between goods and services, the concepts of a customer benefit package, process, value, and value chains; and discusses the importance of sustainability, the role of business analytics in OM, the history of OM, and current and future challenges of OM. We have also introduced concepts of the 4th Industrial Revolution (Industry 4.0 and Service 4.0).

Chapter 2: Analytics and Performance Measurement in Operations and Value Chains

The chapter provides an in-depth discussion of performance measurement in value chains and the way in which they support operations from a strategic perspective. This includes key categories of organizational performance measures, new measures of agility and resilience, and how internal and external measures are related, the use of analytics in OM with an application to the value of a loyal customer, and four models of organizational performance: the Baldrige Performance Excellence framework, the balanced scorecard, the value chain model, and the Service-Profit Chain model.

Chapter 3: Operations Strategy

The chapter focuses on the importance of operations strategy for gaining competitive advantage. We address approaches for understanding customer wants and needs, ways to evaluate goods and services, key competitive priorities, sustainability and operations strategy, and Professor Terry Hill's strategy development framework with an application to McDonald's Corporation.

Chapter 4: Technology and Operations Management

The chapter focuses on the role of technology in goods-producing and service-providing organizations. Key manufacturing technologies such as Computer-Integrated Manufacturing Systems (CIMs), Computer-Aided Design and Engineering (CAD/CAE), and Flexible Manufacturing Systems (FMSs) are described. Technology in service industries and value chains, such as e-service and customer relationship management (CRM) are also addressed. Finally, benefits and challenges of technology, key decisions such as scalability, and applications of decision analysis are discussed.

Part 2: Designing Operations and Supply Chains

Chapter 5: Goods and Service Design

The chapter focuses on the design of goods and services and the processes that create and deliver them to customers. Topics include an integrated framework for goods and service design, quality function deployment (QFD), Taguchi loss functions, reliability, design for manufacturability and sustainability, service-delivery system design areas, and service encounter design. A case study of LensCrafters provides a broad view of how these ideas are implemented in practice.

Chapter 6: Supply Chain Design

The chapter addresses global supply chains, key decisions in supply chain design and the impact of blockchain technology, efficient and responsive supply chains, push and pull systems, vertical integration and outsourcing with break-even analysis, offshoring and reshoring, location decisions using the center of gravity method and optimization using the transportation model, and a case study of a global supply chain firm using these concepts.

Chapter 7: Process Selection, Design, and Improvement

The chapter addresses process choice decisions and types of processes used to produce goods and services (projects, job shops, flow shops, and continuous flow). It also discusses the product-process matrix, the service-positioning matrix, process design using hierarchical levels of work and process/value stream mapping, mistake-proofing concepts, SIPOC diagrams, and approaches to process improvement, including reengineering.

Chapter 8: Facility and Work Design

The chapter deals with facility layout and work design issues. It includes discussions of broad facility design issues, the four common types of facility layout patterns, assembly line balancing, and basic concepts of work measurement. It also addresses workplace safety, ergonomics, and workforce ethics in global supply chains. We have also included new discussions of today's changing work environments and their implications in OM.

Part 3: Managing Operations and Supply Chains

Chapter 9: Forecasting and Demand Planning

This chapter describes the importance of forecasting in operating systems and supply chains and presents basic quantitative methods for forecasting, including simple moving average, exponential smoothing models, and linear regression. Other topics include understanding the nature of time series, computing, forecast errors and measuring forecast accuracy, using tracking signals, and judgmental forecasting.

Chapter 10: Capacity Management

The chapter focuses on understanding, measuring, and making both long- and short-term capacity decisions. Topics covered include capacity decisions and economies of scale, the focused factory, measuring theoretical and effective capacity, safety capacity, computing capacity requirements for job shops with setup/changeover times, managing capacity by shifting and stimulating demand, revenue management, and learning curves.

Chapter 11: Process Analysis and Resource Utilization

The chapter provides an in-depth discussion of how to analyze processes, compute resource utilization and identify resource levels needed to achieve target utilizations, calculate process throughput, identify bottlenecks, and apply Little's law. In addition, this chapter discusses waiting line management and applications of single and multiple server queueing models and spreadsheet simulation and explains the logic and principles of the Theory of Constraints.

Chapter 12: Managing Inventories in Supply Chains

The chapter focuses on the principles of inventory management systems and quantitative approaches for managing inventories. These include ABC analysis, fixed-order-quantity and fixed-period inventory systems for deterministic and stochastic demand, economic order quantity, quantity discount, and single-period inventory models. Spreadsheet simulation is also illustrated for analyzing fixed-order-quantity inventory systems.

Chapter 13: Supply Chain Management and Logistics

The chapter focuses on the management of supply chains. It introduces the Supply Chain Operations Reference (SCOR) model, concepts of sourcing and purchasing, supplier relationships and value chain integration, logistics and transportation, vendor-managed inventory, and risk management in global supply chains. Emphasis is placed on measuring supply chain performance, and it discusses metrics such as inventory turnover, total supply chain costs, and the cash-to-cash conversion cycle. Other topics include supplier certification, sustainability in supply chains, manufactured goods recovery, reverse logistics, and last mile delivery.

Chapter 14: Resource Management

The chapter describes generic frameworks for resource management in both goods-producing and service-providing organizations. Major topics include aggregate planning decisions and strategies, disaggregation of aggregate plans, applications of linear optimization for resource planning, master production planning, material requirements planning, multiple-level lot sizing, and capacity requirements planning.

Chapter 15: Operations Scheduling and Sequencing

The chapter introduces concepts of operations scheduling and sequencing with applications in both manufacturing and services. Included are heuristic approaches and optimization models for staff scheduling, appointment systems, single processor sequencing criteria and rules, S.M. Johnson's two-resource sequencing algorithm, Gantt charts, dispatching, and the Clarke-Wright vehicle routing and scheduling heuristic.

Chapter 16: Quality Management

The chapter explains basic concepts quality, the philosophies of Deming, Juran, and Crosby, the GAP model, ISO 9000, Six Sigma and the DMAIC process, the cost of quality, the Seven Quality Control tools, root cause analysis, Kaizen, and breakthrough improvement. Numerical examples illustrating metrics used in Six Sigma such as defects per million opportunities and sigma levels are included. We have also included new discussions of quality management systems and the Deming Cycle.

Chapter 17: Quality Control and SPC

This chapter addresses quality control systems and the role of statistical process control (SPC), emphasizing the construction and analysis of control charts for continuous and discrete data. Other topics discussed include common and special cause variation, quality at the source, quality control in services, practical issues in implementing SPC, and process capability indexes and analysis.

Chapter 18: Lean Operating Systems

The concepts of lean operating systems are introduced in goods-producing and service-providing organizations. This includes a discussion of the key principles of lean thinking, waste in organizations, and lean tools such as the 5Ss, batching and single-piece flow, and total productive maintenance, which we have enhanced by clarifying concepts of reactive, preventative, and predictive maintenance. Also included are a discussion of Lean Six Sigma, lean "tours" of a manufacturing and a service organization, just-in-time and Kanban systems, and a comparison of the philosophies of lean thinking, quality management, and the Theory of Constraints.

Chapter 19: Project Management

The chapter addresses project management from both an organizational and a technical viewpoint. Tools and techniques for planning, scheduling, and controlling projects are illustrated. Topics include the project life cycle, the role of project managers, project networks, the Critical Path Method and PERT, contributors to project success or impediments, project control and Gantt charts, time and cost trade-offs, and project crashing decisions.

Chapter 20: Building Resilience and Continuity in Operations and Supply Chains

This new chapter focuses on the challenges that operations and supply chains face today that have resulted from the global pandemic and global supply chain pressures. We address concepts of disruption, business continuity, resilience in operations and supply chains, planning for business continuity, and dealing with disasters and emergencies. We also take a look back on key topics in this book and how they can be used in addressing these issues.

Part 4: Supplements

Supplement A: Probability and Statistics

The supplement provides a review of key concepts of probability and statistics used in the text. Topics include descriptive statistics, frequency distributions and histograms, author-supplied Excel templates, the Excel Data Analysis Regression tool, and sample size determination. The chapter also describes basic discrete and continuous probability distributions including the uniform, normal, Poisson, and exponential distributions, and computing expected values. In this edition, we have added additional examples and Excel techniques for implementing simple linear and multiple linear regression.

Supplement B: Decision Analysis

The supplement reviews concepts of decision analysis that are used in product selection, facility capacity expansion and location, inventory analysis, technology and process selection, and other areas of operations management. Topics include structuring decision problems, making

decisions with and without event probabilities, and the expected value of perfect information. An Excel template is illustrated for performing these computations. We have also added a new section on decision trees.

Supplement C: Break-Even Analysis

This supplement describes the use of break-even analysis with applications in profitability analysis, outsourcing decisions, and technology choice decisions that are discussed in the text. Both analytical equations and an Excel template are used. The Excel Goal Seek tool is illustrated for finding break-even points.

Supplement D: Linear Optimization

This supplement reviews the process of formulating linear optimization models and solving them with Excel Solver, which are used in several chapters in the text. It also describes how to interpret the Solver Answer and Sensitivity reports.

Supplement E: The Transportation and Assignment Problems

This supplement extends from Supplement D and explains the transportation and assignment problems, which are used in supply chain management and scheduling applications. It illustrates the formulation of the optimization models, how to implement them on spreadsheets, and how to solve them using Excel Solver.

Supplement F: Queuing Models

This supplement introduces basic concepts of queuing systems that have wide applicability in manufacturing and service organizations. The focus is on defining queuing terms and structures, probability distributions of arrival and service processes, performance metrics, and analytical models for single server and multiple server queues. Excel templates for these models are illustrated.

Supplement G: Simulation

This supplement reviews basic concepts of simulation modeling, generating random samples from probability distributions (drawing upon concepts in Supplement A) and implementing them in spreadsheets. A simple example of simulating a production-inventory system using Excel is described in detail, including the use of Excel data tables to perform multiple replications of the simulation model.

Features and Pedagogy to Enhance Learning

Each chapter begins with

1. a practical discussion or scenario to which students can easily relate, and which provides motivation for the practical importance of the chapter material, and
2. a set of Learning Objectives for the chapter.

Throughout each chapter are numerous feature boxes that highlight real organizations and provide practical insight into the concepts and applications of OSCM. Chapters with quantitative material have detailed solved problems that carefully illustrate the use of formulas, equations, calculations, Excel templates, and insights obtained from the results. These features assist student understanding and their ability to successfully answer end-of-chapter and and exercises.

At the end of each chapter can be found a summary of the chapter Learning Objectives and a list of Key Terms that were defined in the chapter, which students should know and understand. Questions and problems are provided in four categories:

- ***Review questions*** to check student's basic understanding of key concepts (all chapters),
- ***Discussion questions and experiential activities*** that require thoughtful discussion or hands-on experiences (all chapters),
- ***Computational problems and exercises*** that are intended to be solved manually in order to master the formulas and equations (chapters with quantitative content), and
- ***Excel-based problems*** that may be solved using spreadsheets or the supplied spreadsheet templates to perform more complex calculations or what-if analyses (chapters with quantitative content).

The number and scope of the questions and problems have been greatly expanded from the previous editions of our books. A set of 37 unique Excel templates created by one of the authors is available. These templates allow students to enter data and easily calculate results. Student template worksheets are protected to avoid any corruption of formulas; unprotected templates are available to instructors. In addition, Excel worksheets with data sets for problems and cases are also available.

Icons are used throughout the book to designate Excel templates, data files, or model files used in solved problems and cases. There are three types of icons:

- An ***Excel template*** is a worksheet that allows you to enter data and automatically performs calculations to obtain an answer or conduct an analysis. The templates are protected so that you may only enter data and not corrupt any Excel formulas.

- An ***Excel data file*** is an Excel worksheet that contains data used to solve a problem or perform an analysis. Some data may be copied to the appropriate template.

- An ***Excel model file*** is one that contains both data and formulas to perform calculations. Model files differ from templates in that they are developed for unique problem scenarios and are often displayed in Solved Problems. You can inspect the formulas to help you develop models for some of the problems in the book.

Each chapter also has four cases, which require students to thoughtfully apply the concepts and techniques in a broader context. The cases are drawn from a variety of industries such as manufacturing, banking, sports, health care, and professional engineering services. Three cases in each chapter are stand-alone, while the third, *Diamond Global Supply Chain—Hudson Jewelers*, is an integrative case that spans all chapters, focusing on the mining, production, cutting, distribution, and marketing of diamonds in global supply chains.

MindTap

OUTCOME-DRIVEN DIGITAL RESOURCES PROPEL STUDENTS FROM MEMORIZATION TO MASTERY. MindTap's learning and teaching resources equip you with complete ownership of your course. You can use these digital tools to challenge every student, build their confidence and empower them with the knowledge and skills to succeed in business today. MindTap includes all the resources that come with the textbook including all Excel templates used for Solved Problem examples and associated end-of-chapter Excel problems.

MindTap includes a variety of learning tools such as quizzes to check fundamental understanding, algorithmic problems with full solutions, feedback for practice, chapter overview

videos, problem walk-through videos that show step-by-step how to solve quantitative problems, and Excel-based problems that ask students to perform what-if analyses. MindTap showcases Excel Online integration powered by Microsoft, which helps students learn to be become better problem solvers using spreadsheets, while minimizing instructor grading time. For more information about the MindTap online learning platform that accompanies this text, please contact your Cengage learning consultant.

Instructor & Student Resources

Additional instructor and student resources for this product are available online. Instructor assets include an Instructor's Manual, Solutions and Answers Guide, Educator's Guide, PowerPoint® slides, and a test bank powered by Cognero®. Students will find a download for data files and Excel models. Sign up or sign in at www.cengage.com to search for and access this product and its online resources.

Acknowledgments

We are indebted to our retired senior acquisitions editor Charles McCormick, Jr., whose vision of integrating goods and services into an operations management book brought us together. In addition, we thank our current Sr. Product Portfolio Manager, Aaron Arnsparger, and his colleagues, especially Sr. Content Manager, Conor Allen; Sr. Learning Designer, Brandon Foltz; Product Marketing Manager, Colin Kramer; and Digital Project Manager, Dan Swanson and Andrew Southwell.

We hope you enjoy this book about an important body of knowledge that we both sincerely care about. As one unknown source once said, "Do not follow where the path may lead. Go instead where there is no path and leave a trail." We worked hard at trying to integrate and balance our focus on goods and services and provide innovative ways of thinking about operations and supply chain management concepts, models, and techniques. If any students or instructors have any positive feedback, suggestions for improvement, or discover any errors, please contact one of us.

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Operations Management and Value Chains

1

Apple's significant profit margins are in large part due to a focus on its global supply chain and operational excellence.

MANDEL NGAN/AFP/Getty Images

Learning Objectives

After studying this chapter, you should be able to:

- **1-1** Explain the concept and importance of operations management.
- **1-2** Describe what operations managers do.
- **1-3** Explain the differences between goods and services.
- **1-4** Define the concept of value and explain how the value of goods and services can be enhanced.
- **1-5** Describe a customer benefit package.
- **1-6** Explain the difference between value chains and supply chains, and identify three general types of processes in a business.
- **1-7** Contrast the three different frameworks for describing value chains.
- **1-8** Summarize the historical development of OM.
- **1-9** State the current and future key challenges facing OM.

Apple has mastered the art of blending physical goods with services to create value for its customers. Think iPod + Apple Music, iPhone/iPad + apps, Apple stores + Genius Bar; well, you get the picture. Managing all operations involved—from the design of innovative goods and services through their delivery to the customer and postsale services—is one of Apple's core competencies.

"Operations expertise is as big an asset for Apple as product innovation or marketing," says Mike Fawkes, the former supply chain chief at Hewlett-Packard. "They've taken operational excellence to a level never seen before."

Managers and engineers often work at global supplier and manufacturer sites to refine their operations, and designers work with suppliers to create new tooling equipment. When the iPad 2 debuted, Apple employees monitored every handoff point—suppliers, production, loading dock, airport, truck depot, and distribution center—to make sure each unit was accounted for and of the highest quality.

Apple developed a robot called Daisy as an efficient and effective way to disassemble goods collected from Apple's trade-in program. For example, it can disassemble many different iPhone models, at a rate of 200 per hour. This recycling effort reclaims 14 minerals, such as lithium, that can be reused while protecting the environment.

In managing its global supply chain, Apple purchases components and materials from suppliers, then ships them to an assembly plant in China. From there, products bought at Apple's online store are shipped directly to consumers (via UPS/Fedex). Apple also maintains inventory at a central warehouse in California and ships products to retail stores.

Apple's retail stores give it a final operational advantage. The company can track demand by the store and by the hour, and adjust production forecasts daily. If it becomes clear that a given part will run out, teams are deployed and given approval to spend millions of dollars on extra equipment to undo the bottleneck. Apple's significant profit margins are in large part due to this focus on its global supply chain and operational excellence.[1]

However, recent supply chain problems have hurt Apple's profits. Tim Cook, CEO of Apple, said, "If you look at Q4, 2021 for a moment, we had about $6 billion in supply constraints and it affected the iPhone, the iPad, and the Mac. … One was the chip shortages that you've heard a lot about from many different companies throughout the industry. And the second was COVID-related manufacturing disruptions in Southeast Asia." Clearly, Apple, and nearly all other global companies, face significant supply chain challenges.

What Do You Think?

Cite some other examples in which digital content has been combined with physical goods. How does this change the way companies must manage their operations?

Creating and delivering goods and services to customers depends on an effective system of linked facilities and processes, and the ability to manage them effectively around the world. Apple, for example, manages a large, global network of suppliers in countries, such as Malaysia and Indonesia, and factories in the United States, China, and other countries to produce its physical goods, which must be coordinated with the development and production of software and other digital content, retail sales, and service and support. As the opening anecdote suggests, coordinating these goods-producing and service-providing processes and dealing with supply chain woes can be extremely challenging.

Operations management (OM) *is the science and art of ensuring that goods and services are created and delivered successfully to customers.* OM includes the design of goods, services, and the processes that create them; the day-to-day management of those processes; and the continual improvement of these goods, services, and processes. A vital component of OM is *supply chain management*—managing the flow and distribution of goods and services, information, and finances from their points of origin to their points of consumption. The way in which goods and services, and the processes that create and support them, are designed and managed can make the difference between a delightful or an unhappy customer experience. That is what Operations and Supply Chain Management are all about!

1-1 The Importance and Scope of Operations Management

Why is OM important? To answer this, we might first ask the question: What makes a company successful? In 1887, William Cooper Procter, grandson of the founder of Procter & Gamble (P&G), told his employees, "The first job we have is to turn out quality

What Do Operations Managers Do?

Some key activities that operations managers perform include the following:

- Forecasting: predict the future demand for raw materials, finished goods, and services.
- Supply chain management: manage the flow of materials, information, people, and money from suppliers to customers.
- Facility layout and design: determine the best configuration of machines, storage, offices, and departments to provide the highest levels of efficiency and customer satisfaction.
- Technology selection: use technology to improve productivity and respond faster to customers.
- Quality management: ensure that goods, services, and processes will meet customer expectations and requirements.
- Purchasing: coordinate the acquisition of materials, supplies, and services.
- Resource and capacity management: ensure that the right amount of resources (labor, equipment, materials, and information) is available when needed.
- Process design: select the right equipment, information, and work methods to produce high-quality goods and services efficiently.
- Job design: decide the best way to assign people to work tasks and job responsibilities.
- Service encounter design: determine the best types of interactions between service providers and customers, and how to recover from service upsets.
- Scheduling: determine when resources such as employees and equipment should be assigned to work.
- Sustainability: decide the best way to manage the risks associated with products and operations to preserve resources for future generations.

merchandise that consumers will buy and keep on buying. If we produce it efficiently and economically, we will earn a profit, in which you will share." Procter's statement—which is still as relevant today as it was over 130 years ago—addresses three issues that are at the core of operations management: *efficiency*, *cost*, and *quality*. Efficiency (a measure of how well resources are used in creating outputs), the cost of operations, and the quality of the goods and services that create customer satisfaction all contribute to profitability and ultimately the long-run success of a company. A company cannot be successful without people who understand how these concepts relate to each other, which is the essence of OM, and who can apply OM principles effectively in making decisions. OM is the only function by which managers can directly affect the value provided to all stakeholders—customers, employees, investors, and society (See the box, "What Do Operations Managers Do?").

OM is taking on a greater importance in today's business and social environment as technological innovation is happening at a rapid pace. We are in the midst of what many call the 4th Industrial Revolution.[2] The 1st Industrial Revolution, which occurred between the middle of the eighteenth and nineteenth centuries, was a result of the invention of steam machines, mining and iron production, the use of water and steam power, and the development of new machine tools, led to the transformation of society with trains and the mechanization of manufacturing. The 2nd Industrial Revolution (from the 1830s to the early twentieth century) is typically seen as the period where electricity and new manufacturing inventions that it enabled, such as the assembly line, led to mass production. The 3rd Industrial Revolution began around 1969 and extended into the second decade of this century and was associated with the development of computers, the Internet, robotics, digital manufacturing, information technology, and automation. The 4th Industrial Revolution, in which we are living today, is the information-intensive transformation of manufacturing and service industries characterized by cloud computing, enterprise software, big data analytics, artificial intelligence, and augmented reality, and has led

to the development of powerful semiconductors, autonomous machines, smart factories, and connected environments of people, processes, services, and systems, aided by the Internet of things (IoT).

The term **Industry 4.0** is used interchangeably with the 4th Industrial Revolution, and is described as *the information-intensive transformation of manufacturing in a connected environment of big data, people, processes, services, systems, and IoT-enabled industrial assets*. Industry 4.0 offers the opportunity for manufacturers to improve operations in a way that could never be done before to save costs, increase profitability, reduce waste, prevent errors and delays, speed up production, and create a more resilient work environment. For example, a supply chain can use real-time information adjust and optimize its performance; if a weather delay ties up a shipment, the supply chain can quickly change and adjust manufacturing schedules and priorities. Autonomous robots can quickly pick products at a warehouse to reduce costs also and optimize floor space.

While Industry 4.0 is prominent in manufacturing, we should recognize that services dominate our economy, and that many of the elements of the 4th Industrial Revolution apply to services as well. IBM defines **Service 4.0** as *applying digitization to services that create higher productivity, innovation, and value chain advantages in service industries*.[3] For example, the health care industry is using Internet-connected devices by which patients can monitor their health and send data electronically to their doctors. Artificial intelligence has also been used to monitor and predict the spread of COVID-19. (The health care industry has coined the term Healthcare 4.0.) Throughout this book, we will balance our discussions of manufacturing and services.

1-2 OM in the Workplace

Many people who are considered "operations managers" have titles such as chief operating officer, hotel or restaurant manager, vice president of manufacturing, customer service manager, plant manager, field service manager, or supply chain manager. The concepts and methods of OM can be used in any job, regardless of the functional area of business or industry, to better create value for internal customers (within the organization) and for external customers (outside the organization). OM principles are used in accounting, human resources management, legal work, financial activities, marketing, environmental management, and every type of service activity. Thus, everyone should understand OM and be able to apply its tools and concepts. Following are some examples of how the authors' former students (who were not OM majors!) are using OM in their jobs.

After graduating from college, Shelly Decker and her sister embarked on an entrepreneurial venture to manufacture and sell natural soaps and body products. Shelly was an accounting and information systems major in college, but she was using OM skills every day:

- *Process design*: When a new product was to be introduced, the best way to produce it had to be determined. This involved charting the detailed steps needed to make the product.
- *Inventory management*: Inventory was tightly controlled to keep cost down and to avoid production that wasn't needed. Inventory was taken every four weeks and adjusted in the inventory management system accordingly.
- *Scheduling*: Production schedules were created to ensure that enough product was available for both retail and wholesale customers, taking into account such factors as current inventory and soap production capacity.

- *Quality management*: Each product was inspected and had to conform to the highest quality standards. If a product did not conform to standards (e.g., wrong color; improper packaging; improper labeling; improper weight, size, or shape), it was removed from inventory to determine where the process broke down and to initiate corrective action.

Without an understanding of OM, the company would never have gotten off the ground!

Tom James started as a senior software developer for a small software development company that creates sales proposal automation software. Tom uses OM skills in dealing with quality and customer service issues related to the software products, and he is also extensively involved in project management activities related to the development process, including identifying tasks, assigning developers to tasks, estimating the time and cost to complete projects, and studying the variance between the estimated and actual time it took to complete the project. He is also involved in continuous improvement projects. For example, he seeks to reduce development time and increase the efficiency of the development team. Tom was an information technology and management major in college.

Brooke Wilson began as a process manager for JPMorgan Chase in the credit card division. After several years of working as an operations analyst, he was promoted to a production supervisor position overseeing "plastic card production." Among his OM-related activities are:

- *Planning and budgeting*: Representing the plastic card production area in all meetings, developing annual budgets and staffing plans, and watching technology that might affect the production of plastic credit cards.

United Performance Metals: The Life of an Operations Manager

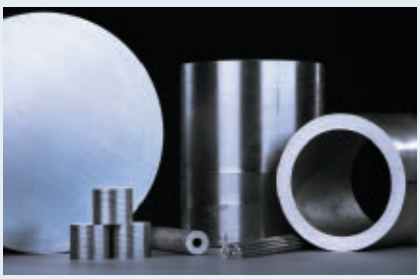
United Performance Metals, formerly known as Ferguson Metals, located in Hamilton, Ohio, is a supplier of stainless steel and high-temperature alloys for the specialty metal market. The company's primary production operations include slitting coil stock and cutting sheet steel to customer specifications with rapid turnaround times from order to delivery. With only 78 employees, about half of whom are in operations, the director of operations and quality is involved in a variety of daily activities that draw upon knowledge of not only OM and engineering, but also finance, accounting, organizational behavior, and other subjects. He typically spends about 50 percent of his time working with foremen, supervisors, salespeople, and other staff discussing such issues as whether or not the company has the capability to accomplish a specific customer request, as well as routine production, quality, and shipping issues. The remainder of his time is spent investigating such issues as the technical feasibility and cost implications of new capital equipment or changes to existing processes, trying to reduce costs, seeking and facilitating design improvements on the shop floor, and motivating the workforce. The ability to understand customer needs, motivate employees, work with other departments, and integrate processes and technology are skills that all operations managers need.

AP Images/Mark Duncan

Coiled steel awaiting processing.

Maskalin/Alamy Stock Photo

Slitting coils into finished strips.



Olaf Doering/Alamy Stock Photo

Some of Ferguson's finished products.

- *Inventory management*: Overseeing the management of inventory for items such as plastic blank cards; inserts such as advertisements; envelopes, postage, and credit card rules and disclosure inserts.
- *Scheduling and capacity*: Daily to annual scheduling of all resources (equipment, people, and inventory) necessary to issue new credit cards and reissue cards that are up for renewal, replace old or damaged cards, as well as cards that are stolen.
- *Quality*: Embossing the card with accurate customer information and quickly getting the card in the hands of the customer.

Brooke was an accounting major in college.

1-3 Understanding Goods and Services

Companies design, produce, and deliver a wide variety of goods and services that consumers purchase. *A* **good** *is a physical product that you can see, touch, or possibly consume*. Examples of goods include cell phones, appliances, food, flowers, soap, airplanes, furniture, coal, lumber, personal computers, paper, and industrial machines. *A* **durable good** *is one that does not quickly wear out and typically lasts at least three years*. Vehicles, dishwashers, and furniture are some examples. *A* **nondurable good** *is one that is no longer useful once it's used, or lasts for less than three years*. Examples are toothpaste, software, clothing and shoes, and food. Goods-producing firms are found in industries such as manufacturing, farming, forestry, mining, construction, and fishing.

A **service** *is any primary or complementary activity that does not directly produce a physical product*. Services represent the nongoods part of a transaction between a buyer (customer) and a seller (supplier).[4] Service-providing firms are found in industries such as banking, lodging, education, health care, and government. The services they provide might be a mortgage loan, a comfortable and safe place to sleep, a college degree, a medical procedure, or police and fire protection.

Designing and managing operations in a goods-producing firm is quite different from that in a service organization. Thus, it is important to understand the nature of goods and services, and particularly the differences between them.

Goods and services share many similarities. They are driven by customers and provide value and satisfaction to customers who purchase and use them. They can be standardized for the mass market or customized to individual needs. They are created and provided to customers by some type of process involving people and technology. Services that do not involve significant interaction with customers (e.g., credit card processing) can be managed much the same as goods in a factory, using proven principles of OM that have been refined over the years. Nevertheless, some very significant differences exist between goods and services that make the management of service-providing organizations different from goods-producing organizations and create different demands on the operations function.[5]

1. **Goods are tangible, whereas services are intangible.** Goods are consumed, but services are experienced. Goods-producing industries rely on machines and "hard technology" to perform work. Goods can be moved, stored, and repaired, and generally require physical skills and expertise during production. Customers can often try them before buying. Services, on the other hand, make more use of information systems and other "soft technology," require strong behavioral skills, and are often difficult to describe and demonstrate. A senior executive of the Hilton Corporation stated, "We sell time. You can't put a hotel room on the shelf."[6]

2. **Customers participate in many service processes, activities, and transactions.** Many services require that the customer be present either physically, on a telephone, or online for service to commence. In addition, the customer and service provider often coproduce a service, meaning that they work together to create and simultaneously consume the service, as would be the case between a bank teller and a customer to complete a financial transaction. The higher the customer participation, the more uncertainty the firm has with respect to service time, capacity, scheduling, quality performance, and operating cost.

   A **service encounter** *is an interaction between the customer and the service provider.* Some examples of service encounters are making a hotel reservation, asking a grocery store employee where to find the pickles, or making a purchase on a website. Service encounters consist of one or more **moments of truth**—*any episodes, transactions, or experiences in which a customer comes into contact with any aspect of the delivery system, however remote, and thereby has an opportunity to form an impression.*[7] A moment of truth might be a gracious welcome by an employee at the hotel check-in counter, a grocery store employee who seems too impatient to help, or trying to navigate a confusing website. Customers judge the value of a service and form perceptions through service encounters. Therefore, employees who interact directly with customers or design service processes need to understand the importance of service encounters.

Customers judge the value of a service and form perceptions through service encounters.

3. **The demand for services is more difficult to predict than the demand for goods.** Customer arrival rates and demand patterns for such service delivery systems as banks, airlines, supermarkets, call centers, and courts are very difficult to forecast. The demand for services is time-dependent, especially over the short term (by hour or day). This places many pressures on service firm managers to adequately plan staffing levels and capacity.
4. **Services cannot be stored as physical inventory.** In goods-producing firms, inventory can be used to decouple customer demand from the production process or between stages of the production process and ensure constant availability despite fluctuations in demand. Service firms do not have physical inventory to absorb such fluctuations in demand. For service delivery systems, availability depends on the system's capacity. For example, a hospital must have an adequate supply of beds for the purpose of meeting unanticipated patient demand, and a float pool of nurses when things get very busy. Once an airline seat, a hotel room, or an hour of a lawyer's day are gone, there is no way to recapture the lost revenue.
5. **Service management skills are paramount to a successful service encounter.** Employees who interact with customers require service management skills such as knowledge and technical expertise (operations), cross-selling other products and services (marketing), and good human interaction skills (human resources). **Service management** *integrates marketing, human resources, and operations functions to plan, create, and deliver goods and services, and their associated service encounters*. OM principles are useful in designing service encounters and supporting marketing objectives.
6. **Service facilities typically need to be in close proximity to the customer.** When customers must physically interact with a service facility—for example, post offices,

hotels, and branch banks—they must be in a location convenient to customers. A manufacturing facility, on the other hand, can be located on the other side of the globe, as long as goods are delivered to customers in a timely fashion. In today's Internet age, many services are only a few mouse clicks away.

7. **Patents do not protect services.** A patent on a physical good or software code can provide protection from competitors. The intangible nature of a service makes it more difficult to keep a competitor from copying a business concept, facility layout, or service encounter design. For example, restaurant chains are quick to copy new menu items or drive-through concepts.

These differences between goods and services have important implications to all areas of an organization, and especially to operations. These are summarized in Exhibit 1.1. Some are obvious, whereas others are more subtle. By understanding them, organizations can better select the appropriate mix of goods and services to meet customer needs and create the most effective operating systems to produce and deliver those goods and services.

EXHIBIT 1.1 How Goods and Services Affect Operations Management Activities

OM Activity	Goods	Services
Forecasting	Forecasts involve longer-term time horizons. Goods-producing firms can use physical inventory as a buffer to mitigate forecast errors. Forecasts can be aggregated over larger time frames (e.g., months or weeks).	Forecast horizons generally are shorter, and forecasts are more variable and time-dependent. Forecasting must often be done on a daily or hourly basis, or sometimes even more frequently.
Facility Location	Goods-producing facilities can be located close to raw materials, suppliers, labor, or customers/markets.	Service facilities must be located close to customers/markets for convenience and speed of service.
Facility Layout and Design	Factories and warehouses can be designed for efficiency because few, if any, customers are present.	The facility must be designed for good customer interaction and movement through the facility and its processes.
Technology	Goods-producing facilities use various types of automation to produce, package, and ship physical goods.	Service facilities tend to rely more on information-based hardware and software.
Quality	Goods-producing firms can define clear, physical, and measurable quality standards and capture measurements using various physical devices.	Quality measurements must account for customer's perception of service quality and often must be gathered through surveys or personal contact.
Inventory/Capacity	Goods-producing firms use physical inventory such as raw materials and finished goods as a buffer for fluctuations in demand.	Service capacity such as equipment or employees is the substitute for physical inventory.
Process Design	Because customers have no participation or involvement in goods-producing processes, the processes can be more mechanistic and controllable.	Customers usually participate extensively in service creation and delivery (sometimes called coproduction), requiring more flexibility and adaptation to special circumstances.
Job/Service Encounter Design	Goods-producing employees require strong technical and production skills.	Service employees need more behavioral and service management skills.
Scheduling	Scheduling revolves around the movement and location of materials, parts, and subassemblies and when to assign resources (i.e., employees, equipment) to accomplish the work most efficiently.	Scheduling focuses on when to assign employees and equipment (i.e., service capacity) to accomplish the work most efficiently without the benefit of physical inventory.
Supply Chain Management	Goods-producing firms focus mainly on the physical flow of goods, often in a global network, with the goal of maximizing customer satisfaction and profit, and minimizing delivery time, costs, and environmental impact.	Service-providing firms focus mainly on the flow of people, information, and services, often in a global network, with the goal of maximizing customer satisfaction and profit, and minimizing delivery time, costs, and environmental impact.

A similar classification of OM activities in terms of high/low customer contact was first proposed in the classic article by R. B. Chase, "Where Does the Customer Fit in a Service Operation?" (*Harvard Business Review*, November–December 1978, p. 139).

1-4 The Concept of Value

Today's consumers demand innovative products, high quality, quick response, impeccable service, and low prices; in short, they want value in every purchase or experience. One of the most important points that we emphasize in this book is that the underlying purpose of every organization is to provide value to its customers and stakeholders.

Value *is the perception of the benefits associated with a good, service, or bundle of goods and services in relation to what buyers are willing to pay for them*. The decision to purchase a good or service or a customer benefit package is based on an assessment by the customer of the perceived benefits in relation to its price. The customer's cumulative judgment of the perceived benefits leads to either satisfaction or dissatisfaction. One of the simplest functional forms of value is:

$$\text{Value} = \frac{\text{perceived benefits}}{\text{price (cost) to the customer}}$$

If the value ratio is high, the good or service is perceived favorably by customers, and the organization providing it is more likely to be successful.

The focus on value has forced many traditional goods-producing companies to add services and, increasingly, digital content to complement their physical goods. A goods-producing company can no longer be viewed as simply a factory that churns out physical goods because customer perceptions of goods are influenced highly by such facilitating services as financing and leasing, shipping and installation, maintenance and repair, and technical support and consulting. Today we see digital content such as apps, streaming videos, and social networks becoming vital to create customer value. Coordinating the operational capability to design and deliver an integrated package of physical and digital goods and services is the essence of operations management.

How to Increase Value?

To increase value, an organization must

(a) increase perceived benefits while holding price or cost constant;

(b) increase perceived benefits while reducing price or cost; or

(c) decrease price or cost while holding perceived benefits constant.

In addition, proportional increases or decreases in perceived benefits as well as price result in no net change in value. Management must determine how to maximize value by designing processes and systems that create and deliver the appropriate goods and services customers want to use, pay for, and experience.

1-5 Customer Benefit Packages

"Bundling" goods, services, and digital content in a certain way to provide value to customers not only enhances what customers receive, but can also differentiate the product from competitors. Such a bundle is often called a customer benefit package. *A* **customer benefit package (CBP)** *is a clearly defined set of tangible (goods-content) and intangible (service-content) features that the customer recognizes, pays for, uses, or experiences*. The CBP is a way to conceptualize and visualize goods and services by thinking broadly about how goods and services are bundled and configured together.

A CBP consists of a primary good or service coupled with peripheral goods and/or services, and sometimes variants. *A* **primary good or service** *is the "core" offering that attracts customers and responds to their basic needs*. For example, the primary service of a personal checking account is convenient financial transactions. **Peripheral goods or services** *are those that are not essential to the primary good or service, but enhance it*.