Sixth Canadian Edition

OPERATIONS MANAGEMENT

STEVENSON HOJATI CAO

6th
Canadian
Edition

OPERATIONS MANAGEMENT

William J. Stevenson
Rochester Institute of Technology

Mehran Hojati
University of Saskatchewan

James Cao
University of Saskatchewan

Mc Graw Hill Education

OPERATIONS MANAGEMENT, SIXTH CANADIAN EDITION

ISBN-13: 978-1-25-927015-4
ISBN-10: 1-25-927015-7

1 2 3 4 5 6 7 8 9 10 TCP 22 21 20 19 18

Printed and bound in Canada.

Portfolio Director, Business & Economics, International: *Nicole Meehan*
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Manufacturing Production Coordinator: *Sheryl MacAdam*
Interior and Cover Design: *Lightbox Visual Communications, Inc.*
Cover Image: © *D-BASE / Getty Images*
Page Layout: *MPS Limited*
Printer: *Transcontinental Printing Group*

About the Authors

William Stevenson

Saunders College of Business
Rochester Institute of Technology

This book is dedicated to you.

Dr. William Stevenson is an associate professor of decision sciences in the Saunders College of Business at Rochester Institute of Technology. He teaches graduate and undergraduate courses in operations management, management science, quality concepts, and quality applications.

He is the author of textbooks/eBooks in management science and statistics, as well as operations management. His articles have appeared in *Management Science, Decision Sciences, Quality Progress*, and other journals.

Dr. Stevenson received a bachelor's degree in industrial engineering, an M.B.A., and a Ph.D. in production/operations management from Syracuse University.

Mehran Hojati

Edwards School of Business
University of Saskatchewan

I dedicate this book to my mother, Mahvash Hojati.

Dr. Hojati is an associate professor of operations management in the Edwards School of Business at the University of Saskatchewan. He teaches operations management, and purchasing and supply management. He has taught and prepared teaching materials for the Purchasing Management Association of Canada (now Supply Chain Management Association). His articles have appeared in *International Journal of Production Economics, Production & Inventory Management Journal*, and others. His research interests are in the applications of operations research techniques in operations.

Dr. Hojati received a bachelor's degree in economics and a master's degree in operational research from London School of Economics, and a Ph.D. in management science from the University of British Columbia. He is certified in Production and Inventory Management (CPIM), awarded by APICS (the Association for Supply Chain Management).

James Cao

Edwards School of Business
University of Saskatchewan

I dedicate this book to my dearest wife, Vivian, whose love and support has given my life both meaning and direction.

Dr. Cao is an assistant professor at the Edwards School of Business, University of Saskatchewan. He received bachelor's degrees in mathematics, economics, and psychology from the University of California at Irvine. He also has a Ph.D. in management, with a specialization in operations management, from the same school. Dr. Cao has taught undergraduate and graduate classes in operations management, statistics, management science, and quality management. His research interests lie in the field of supply chain management, which deals with both matching supply with demand and the coordination of multi-party decision making.

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Preface

This textbook/eBook is intended as an introduction to operations management in Canada, and demonstrates its applications to service and manufacturing operations. We've included eight chapter supplements which offer a comprehensive and flexible amount of content that can be selected as appropriate for different courses and formats, including undergraduate, graduate, and executive education. This allows instructors to select the chapters that are most relevant for their purposes. That flexibility also extends to the choice of relative weighting of the qualitative or quantitative aspects of the material and the order in which chapters are covered, because chapters do not depend on sequence. For example, some instructors cover project management early, while others cover quality or JIT/lean early.

The topics covered include both strategic issues and planning/control decisions. Activities such as capacity, designing production process and work methods, inventory management and control, and assuring and improving quality are core issues in organizations. Whether operations is your field of study or not, knowledge of operations management will certainly benefit you and the organization you work for.

The advantages of using a Canadian textbook for your operations management learning are numerous, including:

- Canadian locations and companies are showcased
- Examples of Canadian organizations and their decisions are highlighted
- Issues important for Canadian instructors and reviewers are addressed
- International examples are framed and reflected from a Canadian perspective
- There is a focus on Canadian data for context

What's New in the Sixth Canadian Edition?

The new Canadian edition features 12 new Canadian and four other new chapter openers. There are two new Canadian and one other new Operations Tours. There are 22 new Canadian and 16 new other OM in Actions. There are eight new Canadian and 12 new photos with captions. There are five new mini-cases and over 16 new problems. Also, many new discussion and review questions as well as critical thinking, experiential learning, and Internet exercises have been added. These updates provide students with a realistic understanding of Canadian manufacturing and service organizations and the problems they face today.

The table on the next page notes some important chapter-by-chapter changes.

Features Retained From Previous Edition

Balanced Content. The textbook/eBook strives to achieve a careful balance in the presentation of operations management. Care has been taken to balance definitions and concepts with quantitative, hands-on problems; to balance theoretical material with real-life applications; and to balance classical topics in operations management with new developments that particularly interest students.

Problem-Solving Approach. To further students' hands-on experience of OM, the textbook/eBook contains examples with solutions throughout. At the end of most chapters is a group of solved problems to illustrate concepts and techniques. Some of the end-of-chapter problems have answers at the end of the book.

Easy to Read. The writing style is clear, concise, and student friendly, while maintaining the technical rigour necessary for the subject matter. From step-by-step problem solving, to theoretical exposition, to in-depth mini-cases and readings, the book is designed to promote student understanding of the role of operations management in successful organizations—which, in turn, promotes student success in class.

Chapter	Title	Important Changes/Additions
1	Introduction to Operations Management	Expanded coverage of business analytics
2	Competitiveness, Strategic Planning, and Productivity	Clarified key purchasing criteria
3	Demand Forecasting	Added the annual average method for forecasting in the presence of seasonality
4	Product Design	Added material selection and service blueprinting sub-sections; added sections on Kano model and failure modes and effects analysis
5	Strategic Capacity Planning	Expanded coverage of overall equipment effectiveness including an example
6	Process Design and Facility Layout	Added business processes, new service blueprinting and swim lane diagram examples
7	Work/Job Design	Added Human Performance System factors, role of information and communication technologies, mental health at work; deleted MOST
8	Location Planning and Analysis	Added microfactory and clustering to factors that affect location decisions
9	Management of Quality	Added Taguchi loss function, ISO 9001 requirements, Canada Awards of Excellence drivers, affinity diagram, 5 Whys
10	Statistical Quality Control	Added run tests
11	Supply Chain Management	Expanded coverage of RFID including more examples; added risk management and resiliency
12	Inventory Management	Replaced the warehouse operations tour
13	Aggregate Operations Planning and Master Scheduling	Added an example for calculating full-time equivalent
14	Material Requirements Planning and Enterprise Resource Planning	Clarified description of regenerative and net change MRPs
15	Just-in-Time and Lean Production	Added section on world class manufacturing
16	Job and Staff Scheduling	Added subsections on sequencing jobs through one work centre/machine in order to minimize number of late jobs and sequencing jobs through three or more work centres/machines in order to minimize make-span
17	Project Management	Added an example for earned value analysis; updated Microsoft Project tutorial
18	Waiting-Line Analysis	Added border crossing mini-case

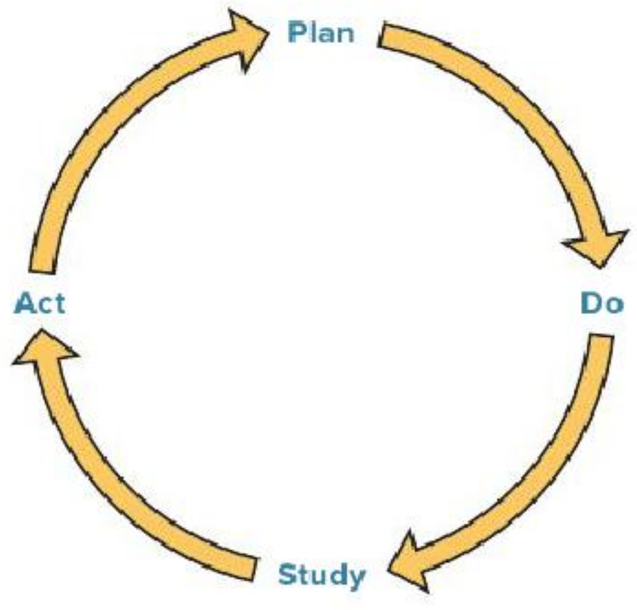
Pedagogy and Learning Tools

A number of key features in this textbook/eBook have been specifically designed to help introductory students learn, understand, and apply operations concepts and problem-solving techniques. All of these have been carefully developed over six Canadian editions and thirteen U.S. editions and have proven successful.

Learning Objectives. Every chapter lists the learning objectives as a short guide to studying the chapter. These objectives are linked to each section and to the questions and problems at the end of the chapter.

Opening Vignettes. Every chapter has an opening vignette (chapter opener) that illustrates the importance of the topic, usually highlighting a company.

Figures and Photos. The sixth Canadian edition includes extensive photographs and graphic illustrations to support student study and provide interest and motivation for all types of learners.



OM In Action. Throughout the new edition are readings about applications of OM. These OM in Action boxes highlight important real-world applications, provide examples of operations issues, and/or offer further elaboration of the content. They also provide a basis for classroom discussion and generate interest in the subject matter.

OM in Action

British Petroleum

In the evening of April 20, 2010, British Petroleum's Deepwater Horizon offshore oil platform was drilling an exploratory well at a record depth of more than 4,000 metres below the ocean surface in the Gulf of Mexico off of Louisiana. At approximately 9:50 p.m., the protective cement barrier around the well suddenly failed, allowing high-pressure methane gas to rise up onto the oil platform. The escaped gas ignited and began a chain reaction that culminated in a series of catastrophic explosions. Eleven men lost their lives that evening, and an unprecedented amount of oil began to

In addition, they attempted to work faster and more cheaply by cancelling an independent diagnostic test used to test the strength of the cement. The test would have detected the problems with the cement seal at a cost of only $140,000. In sharp contrast to this modest sum, BP ultimately had to pay out more than $46 billion in fines to restore the damaged shoreline and compensate the millions of people who lived and worked in the region. The tragic loss of life and the subsequent pollution of the Gulf of Mexico were the results of poor management decisions, based on a lack of understanding of the costs of quality.

Examples With Solutions. Throughout the new edition, wherever a quantitative technique is introduced, an example is included to illustrate the application of that technique. These are designed to be easy to follow.

EXAMPLE 3-14

Compute 2s control limits for forecast errors when the MSE is 9.0.

SOLUTION

$$s = \sqrt{\text{MSE}} = \sqrt{9} = 3$$
$$\text{UCL} = 0 + 2(3.0) = +6.0$$
$$\text{LCL} = 0 - 2(3.0) = -6.0$$

Service Icons. Where **operations management service** topics are addressed in the new edition, a service icon appears in the corresponding margin to flag the attention of both students and instructors.

Web Links. Web addresses of relevant websites are highlighted in the margin with a web icon.

Globe Icons. Where a concept or example has international effect, it is flagged with a globe icon.

End-of-Chapter Resources

For student study and review, the following items are provided at the end of each chapter.

Summary. An overview of the material covered is given in point form.

Key Terms. Key terms are highlighted in the text.

Solved Problems. At the end of most chapters, solved problems illustrate problem solving and the core concepts of the chapter. These have been carefully prepared to enhance student understanding, as well as to provide additional examples of problem solving.

Solved Problems

Problem 1

The tasks shown in the following precedence network are to be assigned to workstations with the intent of minimizing percentage idle time. Management desires an output rate of 275 units per day. Assume 440 minutes are available per day.

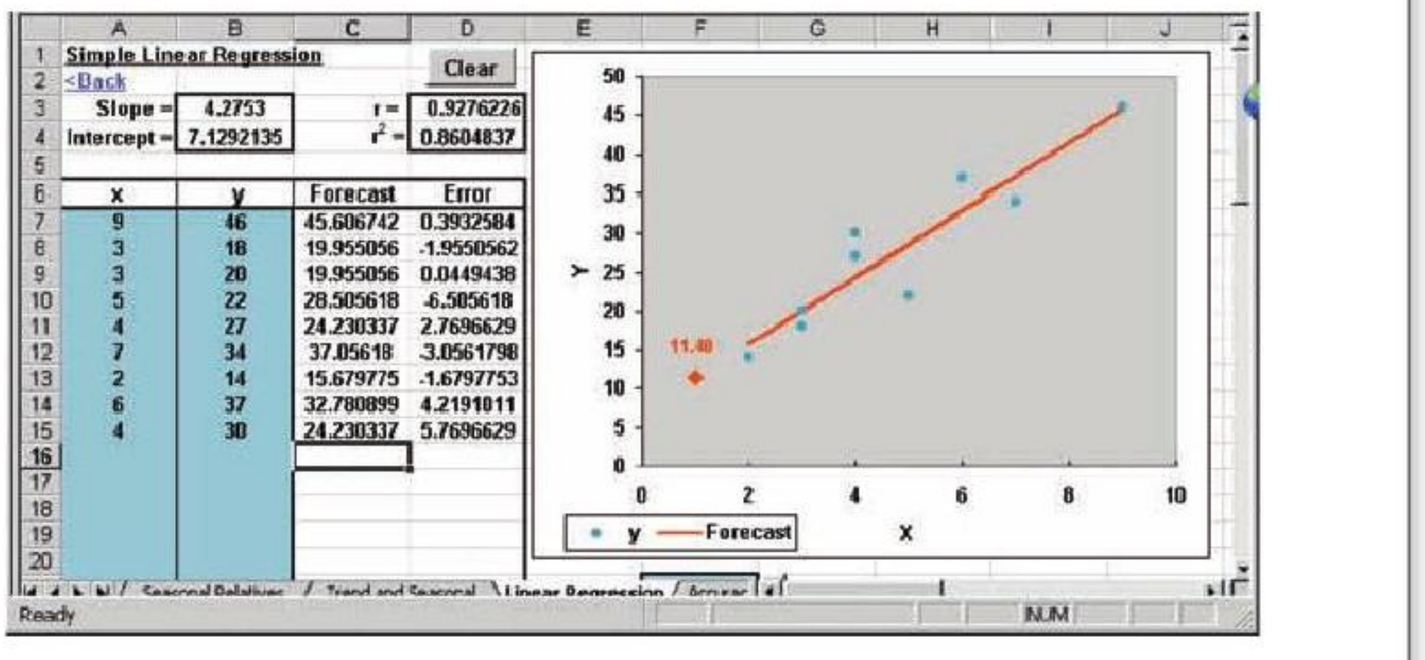
a. Determine the appropriate cycle time.

b. What is the minimum number of workstations possible?

c. Assign the tasks using the "Assign the task with the largest positional weight" heuristic rule.

d. Calculate efficiency.

Excel Spreadsheet Solutions. Where applicable, the solved problems include screen shots of a spreadsheet solution. These are taken from the Excel templates, which can be found on *Connect2*.



Discussion and Review Questions. These are intended to serve as a student self-review or as class discussion starters.

Taking Stock, Critical Thinking Exercises, Experiential Learning Exercises, and Internet Exercises. These activities encourage analytical thinking and help broaden conceptual understanding.

Critical Thinking Exercises

LO3 **1.** Think of a new or revised good or service that you would like to see on the market. Discuss the implications of designing and producing that product relative to legal, profitability, competitiveness, design, and production issues.

LO3 **2.** The speed of product development has continued to increase because of technological advances such as CAD. Do you expect this trend to continue?

LO1–3 **3.** In wintry conditions, highway safety is improved by treating road surfaces with substances that will provide traction and/or melt snow and ice. Sand and rock salt are two widely used substances. Recently, a combination of beet juice and rock salt started being used in some parts of the country to treat road surfaces. Suppose you have been asked to provide a list of factors to consider for a switch from rock salt alone to using a combination of beet juice and rock salt. Name the major considerations you would take into account in making a decision in the following categories: cost considerations; environmental considerations, both positive and negative; and other considerations.

Problems. Most chapters have numerous problems, ranging from simple practice problems that apply techniques to more difficult conceptual problems that provide a challenge and require students to integrate concepts (these are marked with an asterisk).

Operations Tours. These readings give students a descriptive look at operations in action at manufacturing or service organizations. These real-life illustrations show direct application to reinforce the importance of the concepts described in the textbook/eBook.

Mini-Cases. Many chapters include short cases, selected to provide a broader, more integrated thinking opportunity for students.

MINI-CASE www.harveys.ca

Open Wide and Say "Ultra"

In fourth place behind McDonald's, A&W, and Burger King, Harvey's, the Canadian quick-service hamburger chain with more than 340 restaurants, needed a new idea in the mid-1990s. Harvey's is part of Cara Operations Ltd., the airline food services company that also owns the Swiss Chalet chain of restaurants, approximately 100 Air Terminal Restaurants, and Summit Food Services Distributors. Harvey's had had new ideas before (open grill and fresh vegetables, for one), but these had become old hat by 1995. Gabe Tsampalieros, Cara's new president, who was a major franchisee with 60 Harvey's and Swiss Chalet restaurants, started working on the idea in October 1995, and by the following month the mission was clear: "Create Canada's best-selling hamburger." Tsampalieros and Harvey's vice-president planned the launch of the new burger for May 1996.

Harvey's began polling burger lovers across Canada in January 1996, first by telephone and later in focus groups of 8 to shipped around the country). Bonacini produced 12 "taste profiles"—from the bland to the bizarre—and introduced them to the Harvey's executives at a suburban Harvey's training centre. This would be the first in a long series of tasting exercises. (Bonacini thinks he ate 275 bite-sized burgers in a four-month period.)

Each of Harvey's executives tasted a portion of the 12 unlabelled patties and ranked it for "mouth feel," taste, linger, fill factor, and bite. Exotic offerings (Cajun, Oriental, Falafel, and so forth) were rejected, leaving three simply seasoned burgers on the short list.

McCormick Canada Inc., Harvey's spice supplier, was employed to determine the final proportions of seasonings and secret ingredients to replicate the taste of Bonacini's samples in a way that could survive the fast-food process. "They [the meat packagers] would give us a 500-pound batch—that's 2,000 burgers—and we would taste them a couple of days after they had been mixed. Then we would also taste them at one-, two-,

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Acknowledgments

We gratefully acknowledge the input of contributors to the sixth Canadian edition, including:

Kent Kostuk
Federated Cooperatives Ltd

Bryan McCrea
3Twenty Modular

Samantha Dearing
ERCO Worldwide

Dave Ostertag
PotashCorp

Keith WilloughbyUniversity of Saskatchewan

Gwen Miller
Global Institute for Food Security

Luke Jamaat, Progressive Turf Equipment

Amanda H. Butler, Director-Investor Relations, Lincoln Electric Holdings

Shelley Darling, Michael Garron Hospital (formerly Toronto East General Hospital)

We would like to thank the McGraw-Hill Ryerson staff, including Portfolio Managers, Alwynn Pinard and Keara Emmett; Content Developer, Brianna McIlwain; Supervising Editors, Janie Deneau and Jessica Barnoski; Permissions Editor, Karen Hunter; and Copy Editor, Laurel Sparrow, for their excellent work.

Mehran Hojati
James Cao

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We listened to educators from around the world, learned about their challenges, and created a whole new way to deliver a course.

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- Teach at a higher level in class by helping students retain core concepts.
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For more information, please visit www.mheconnect2.com

Chapter 1
Introduction to Operations Management

Courtesy of Case IH Agriculture

LEARNING OBJECTIVES

After completing this chapter, you should be able to:

- **LO1** Define the term *operations management* and identify operations management jobs.
- **LO2** Identify the three major functions of organizations and describe how they interact.
- **LO3** Describe the scope of operations management and provide an overview of this textbook, including differentiating between design and planning/control decisions.
- **LO4** Compare production of goods and services.
- **LO5** Discuss the operations manager's job.
- **LO6** Describe the key aspects of operations management decision making.
- **LO7** Briefly describe the historical evolution of operations management.
- **LO8** Identify the major trends that affect operations management.

World class manufacturing (WCM) is an advanced version of just-in-time/lean manufacturing. Fiat Group started using it in 2005 and brought it to Case New Holland (now CNH Industrial) in 2008 and to Chrysler Group soon after becoming the majority shareholder in 2009.[1] Many other companies have adopted WCM, including Lucerne Foods, Unilever, Magna International, Otis Elevator, Michelin, Celestica, and ArcelorMittal.

CNH Industrial Saskatoon is the only CNH Industrial plant in Canada. It produces planters, headers, air carts, and other equipment for the agriculture division of CNH Industrial, Case IH, and New Holland Agriculture. Over 70 percent of its products are sold in the United States. In order to remain competitive, including with other CNH Industrial plants in the United States, the Saskatoon plant started to implement WCM in 2009. Since then, there has been constant improvement in its WCM score. In five years, its productivity is up approximately 30 percent; it has had no lost-time injury for 3 million hours; warranty claims are down 90 percent; and it hasn't missed a delivery shipment in three years. The Saskatoon plant's score ranks it number seven in the CNH Industrial family, which comprises 54 plants worldwide practising WCM. It recently achieved the Silver status in implementing WCM, the first among the North American CNH Industrial plants.

[1] https://www.fcagroup.com/en-US/group/brand_stories/Pages/wcm_global_quality.aspx

LO1

Introduction

operations management The management of processes (i.e., sequence of activities and resources) that create goods and/or provide services.

process A sequence of activities, usually performed by more than one person, which uses resources and achieves a desired result.

good A tangible item.

service An act or work for someone.

Operations management is the management of processes that create goods and/or provide services. A **process** is a sequence of activities, usually performed by more than one person, which uses resources and achieves a desired result. A **good** is a tangible item, whereas a **service** is an act or work for someone (a customer or client).

Let's use an airline to illustrate the processes involved in its operations. The resources include staff, aircraft, airports, and maintenance facilities. The processes can be classified as core, support, and managerial:

- *Core processes* include taking customer reservations, communicating with customers, checking and boarding, in-flight service, and baggage handling.
- *Support processes* include employee recruitment and training, buying and maintaining aircraft, and buying fuel and spare parts.
- *Managerial processes* include forecasting travel demand, capacity and flight planning, locating maintenance facilities, scheduling planes/pilots/crew and counter staff/baggage handlers, managing inventories, and ensuring that quality standards are met. Most of the managerial processes fall into the realm of operations management.

Now let's consider a bicycle factory:

- *Core processes* include buying raw materials (tubes, etc.) and parts (gears, chains, tires, etc.), fabrication (forming and welding the frame, etc.), and assembly process.
- *Support processes* include recruiting and training workers, and purchasing and maintaining equipment.
- *Managerial processes* include deciding on the style of bicycle (product design), deciding which components to make and which to buy, forecasting demand, scheduling production, and ensuring that quality standards are met.

Obviously, an airline and a bicycle factory are completely different. One is a service provider, the other a producer of goods. Nonetheless, these two companies have many support and managerial processes in common. Both involve buying and managing equipment and supplies, recruiting and training employees, forecasting demand, scheduling activities, and satisfying quality standards.

Cycles Devinci is a Canadian manufacturer of bicycles, founded in Chicoutimi, Quebec, in 1987. In addition to a full line of road, mountain, and hybrid bicycles, Devinci also manufactures the Bixi brand of bicycles used in bike sharing programs in cities such as Montreal and Toronto. See http://www.vitalmtb.com/photos/features/Inside-the-Industry-Devinci-Cycles-Factory-Tour,10452/Slideshow,0/FredLikesTrikes,18548 for a tour of the Devinci factory.

Peter Macdiarmid /Getty Staff

Many companies use operations management strategies, tactics, and actions in order to improve their efficiency and effectiveness. **Efficiency** is operating at minimum cost and time. **Effectiveness** is achieving the intended goals (quality and timeliness).

efficiency Operating at minimum cost and time.

effectiveness Achieving quality and timeliness.

This textbook contains many practical and real-life examples of operations management in the form of chapter openers, photos with captions, readings in the form of OM in Action boxes, mini-cases, problems, and operations tours. For example, the chapter openers are: IKEA's strategy (Chapter 2), Bombardier Business Aircraft forecasting (Chapter 3), 3D printing (Chapter 4), Ford's capacity planning (Chapter 5), Ford's factory changeover (Chapter 6), GE Aviation's participative management (Chapter 7), Feihe's new plant in Kingston (Chapter 8), Lac-Megantic rail disaster (Chapter 9), Trek Bikes quality control (Chapter 10), online-to-store channel (Chapter 11), Federated Cooperatives' inventory management (Chapter 12), Canada Post's holiday planning (Chapter 13), Progressive Turf Equipment's material requirements planning (Chapter 14), lean production in healthcare (Chapter 15), Pier 1 Imports' staff scheduling (Chapter 16), ExxonMobil's project management (Chapter 17), and border crossing waiting line management (Chapter 18).

Why Study Operations Management?

There are a number of reasons to study operations management. First, because a large percentage of a company's expenses occur in the operations area (e.g., purchasing materials, paying workforce salaries), more efficient operations can result in large increases in profit.

Second, a number of management jobs are in operations management—including jobs in purchasing, quality assurance, production planning and control, scheduling, logistics, inventory management, and many more (see the "**Two Operations Management Job Ads**" OM in Action).

OM in Action

Two Operations Management Job Ads

Manufacturing Operations Manager

Location: London, Ontario
Salary: Yearly: min. $80,000; max. $100,000 for 40.0 hours per week
Education: Completion of college/CEGEP/vocational or technical training
Experience: 5 years or more
Staff Responsibility: 21–50
Budgetary Responsibility: $500,001–$1,500,000
Type of Industry: Chemical
Specific Skills: Plan, organize, direct, and control daily operations; Evaluate efficiency of production; Determine adequacy of personnel, equipment, and technologies used for operations; Maintain inventory; Prepare work schedules; Schedule and oversee the maintenance of plant equipment; Plan and manage budgets; Direct quality control inspections; Develop production reporting procedures; Oversee the analysis of data and information; Analyze cost and quality data
Additional Skills: Train staff; Arrange training for staff; Conduct performance reviews; Establish and implement safe work practices and procedures
Work Conditions and Physical Capabilities: Fast-paced environment; Work under pressure; Tight deadlines; Attention to detail; Large workload
Other Information: 5+ yrs exp. as Operations Manager for large-scale Silicon products manufacturer.

Inventory Team Lead

Location: Calgary, Alberta
JOB OVERVIEW: As the Inventory Team Lead, you will lead a team of Inventory Analysts while managing and optimizing composition and replenishment of a portion of inventory held at all operating locations using standard SAP based processes and tools.

KEY ACCOUNTABILITIES

- Manage staff and participate in setting Inventory Management function objectives
- Apply advanced SAP knowledge to execute complex tasks in daily work and make professional judgment based on industry standards, internal guidelines, and best practices
- Analyze business plans and utilize inventory forecasting and modelling techniques to set inventory targets and control levels, develop short-term supply plans, and determine the impact of inventory control issues on service levels

(Cont'd)

- Lead the analysis of inventory status reports and develop inventory performance plan and strategies utilizing total cost of ownership analysis including, but not limited to, inventory levels, inventory turns, Critical Spare Parts Management (CSPM), and fill rates
- Assess risk, identify trends and opportunities, and make recommendations to develop contingency plans and improve CSPM processes, policies, and procedures
- Communicate with internal and external stakeholders on day-to-day inventory management and CSPM issues to initiate stock purchase and disposal processes, and to align inventory management strategies with other company initiatives
- Consult with senior specialists on complex issues and resolve or escalate Inventory Management issues
- Proactively recommend ways to improve Inventory Management activities
- Identify issues in standards, methods, and tools for analysis and control of inventory
- Participate in regular Inventory Management, Material Management and Logistics meetings to evaluate business unit requirements and expectations, and evaluate process and performance optimization opportunities

REQUIRED QUALIFICATIONS

Education and Experience:

- 5+ years of experience in Supply Chain Management with increasing levels of responsibility
- Post-secondary business or Supply Chain and Operations Management degree/accreditation
- SAP Inventory Management experience required
- Inventory modelling and forecasting experience required
- Oil & Gas, Mining or Utilities industry experience preferred
- Supervisory experience preferred

Skills and Knowledge:

- Strong analytical skills required
- Ability to be adaptable and build trust and confidence in colleagues and customers preferred
- Solid experience around Inventory Management including Critical Spare Parts Management, Supply/Demand Planning and Inventory Modelling and forecasting is required
- Possess a strong knowledge in ERP (SAP preferred), Spend Analysis, Business Performance Management (KPIs), as well as Critical Spare Parts Management
- Good understanding of SCM Development, Sourcing Strategy, Supplier Integration, Category Management, Total Cost of Ownership (TCO) and Reverse Logistics is preferred

Working Conditions: Office environment and infrequent business travel will be required to operating locations and third parties.

Third, activities in all the other areas of organizations—such as finance, accounting, human resources, management information systems, and marketing—are all interrelated with operations management activities. So, it is essential for people who work in these areas to have a basic understanding of operations management.

Fourth, operations innovations lead to marketplace and strategic benefits. Examples include Toyota Production System, Dell's direct shipping of personal computers, Zara's fast and responsive supply chain, and Walmart's cross-docking (goods received from suppliers at a distribution centre are transferred to outbound trucks to retail stores without being stored).[2] For an example of operational innovation, see the "**Progressive Insurance**" OM in Action.

OM in Action www.progressive.com

Progressive Insurance

Progressive Insurance (PI) has introduced several operational innovations:

- 1990: Immediate response claims service (serving customers at the accident scene). In 1994, specially marked PI vehicles were used by adjusters to drive to the scene of accidents.
- 1996: Customers could obtain comparison rates online. In 1997, customers could buy auto insurance policies online.
- 2003: Concierge level of claims service (PI takes care of vehicle repair).

Source: https://www.progressive.com/progressive-insurance/history.

[2] https://hbr.org/2004/04/deep-change-how-operational-innovation-can-transform-your-company.

Careers in Operations Management

If you are thinking of a career in operations management, you can obtain relevant information from one or more of the following associations:

- Supply Chain Management Association (SCMA)
- Canadian Institute of Traffic and Transportation (CITT)
- Canadian Supply Chain Sector Council (CSCSC)
- American Production and Inventory Control Society (APICS), now known as the Association for Supply Chain Management
- American Society for Quality (ASQ)
- Project Management Institute (PMI)

Most of these associations offer certification programs and a job bank.

http://scma.com/en/
http://www.citt.ca
http://www.supplychaincanada.org
http://www.apics.org
http://www.asq.org
http://www.pmi.org

Functions Within Organizations

LO2

Organizations are formed to pursue goals that are achieved more efficiently and effectively by the concerted efforts of a group of people rather than by individuals working alone. Organizations are usually structured into departments or functions. Each department is given resources and managed independently, however, they have to collaborate on multi-functional processes.

Organizations are devoted to producing goods and/or providing services. They may be for-profit (i.e., businesses) or non-profit (e.g., hospitals). Their goals, design, management, and outputs (goods/services) may be similar or quite different. Nonetheless, their functions and their processes are similar.

A typical organization has three basic functions: operations (representing manufacturing/service), finance, and marketing (including sales) (see Figure 1-1).

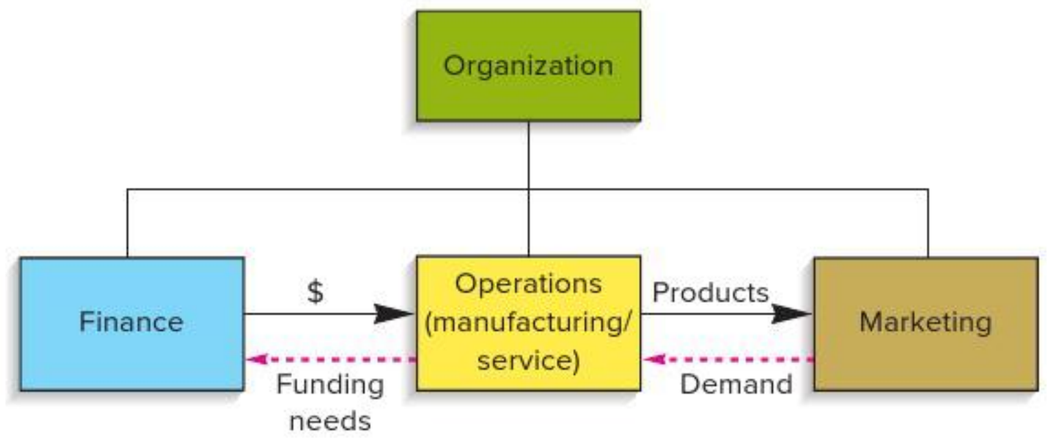


FIGURE 1-1

The three basic functions of an organization and flows between them.

These three functions and other supporting functions (e.g., research and development) perform different but related processes necessary for the organization. The functions must interact to achieve the goals and objectives of the organization, and each makes an important contribution. For instance, unless operations and marketing work together, marketing may promote goods or services that operations cannot profitably deliver, or operations may turn out goods or services for which there is no demand. Similarly, unless finance and operations work closely, funds for materials, building expansion, and new equipment may not be available when needed. Let's take a closer look at these functions.

Operations

The operations function, representing manufacturing/service processes, manages all the activities *directly* related to producing goods or providing services. Hence, it exists both in manufacturing industries which are *goods producing* and in service industries which provide services (see Table 1-1).

TABLE 1-1

Examples of industries.

Industries	Examples
Goods producing	Farming, mining, construction, manufacturing
Services	Healthcare, transportation, food, warehousing, retailing, wholesaling, banking, film production, broadcasting, phone

The production of goods or services involves *transforming/converting* inputs into finished goods or services. For example, a car body manufacturing process converts sheets of steel into a car body by cutting, forming, and welding operations.

The production process must be an adaptive system. To ensure that the desired outputs are obtained, measurements should be taken at various points (*feedback*), and then compared with previously established standards to determine whether corrective action is needed (*control*). Figure 1-2 shows the conversion process. Table 1-2 provides two examples of inputs, transformation processes, and outputs.

FIGURE 1-2

The operations function involves the conversion of inputs into outputs.

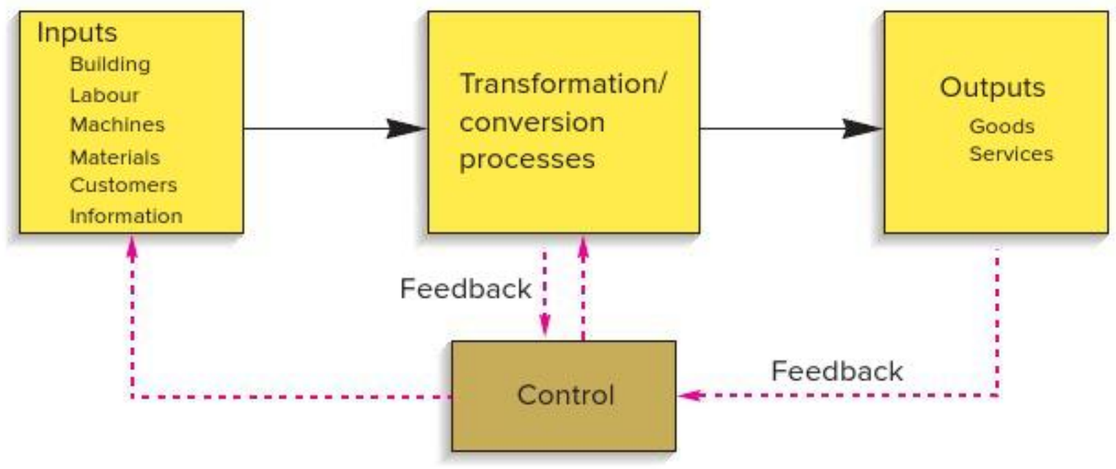


TABLE 1-2

Illustrations of the transformation process.

Food Processor	Inputs	Process	Output
	Raw vegetables	Cleaning	Canned vegetables
	Metal sheets	Making cans	
	Water	Cutting	
	Energy	Cooking	
	Labour	Packing	
	Building	Labelling	
	Equipment		
Hospital	**Inputs**	**Process**	**Output**
	Sick patients, doctors, nurses	Examination	Healthy patients
	Building	Surgery	
	Medical supplies and drugs	Monitoring	
	Equipment	Medication	
	Laboratories	Therapy	

Service

It is important to note that goods and services often occur jointly. For example, having the oil changed in your car is a service, but the new oil is a good. Similarly, house painting is a service, but the paint is a good. The goods–service package is a continuum. It can range from primarily goods with little service to primarily service with few goods (see Figure 1-3).

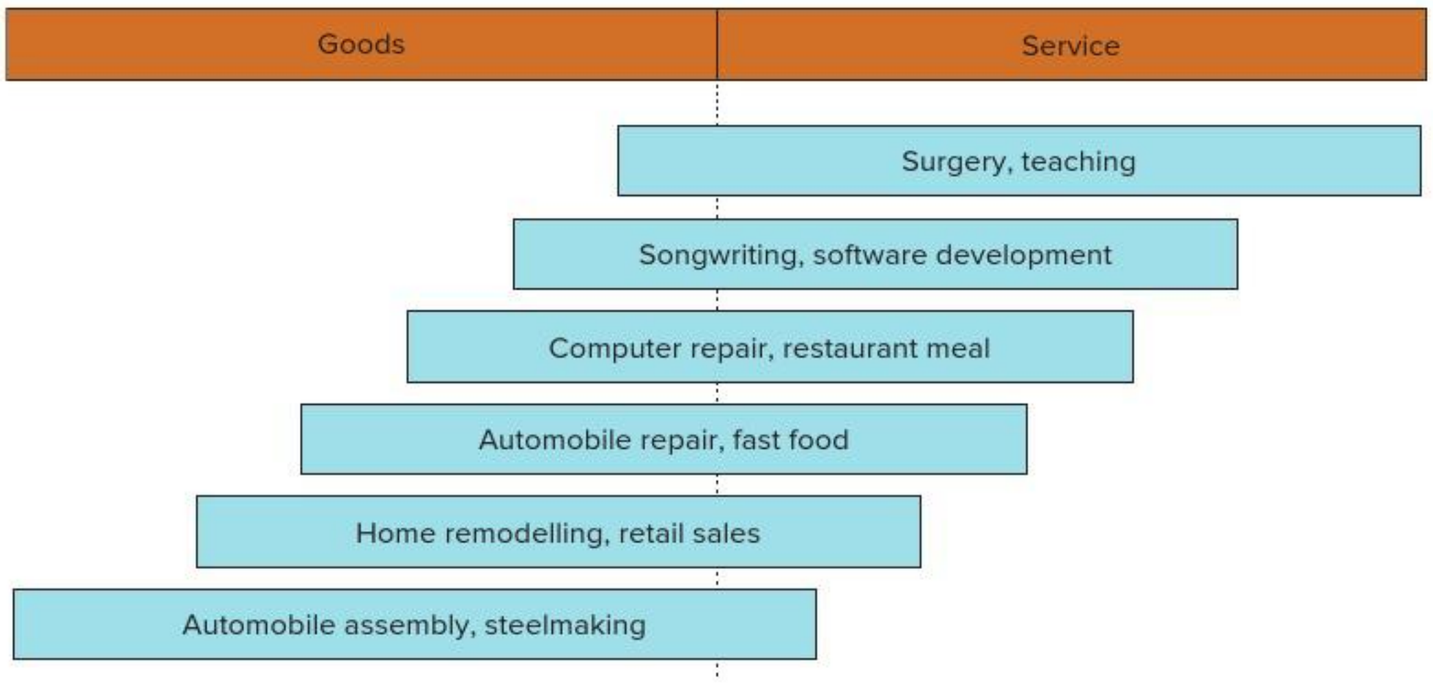


FIGURE 1-3

The goods–service continuum.

The essence of the operations function is to *add value* during the transformation process: **Value added** is the term used to describe the difference between the cost of inputs and the value or price of outputs. In non-profit organizations, the value of outputs (e.g., highway construction, police and fire protection) is their value to society; the greater the value added, the greater the efficiency of these operations. In for-profit organizations, the value of outputs is measured by the prices that customers are willing to pay for those goods or services. Companies use the money generated by value added for research and development, investment in new facilities and equipment, workers' salaries, and owners' *profits*. Consequently, the greater the value added, the greater the amount of funds available for these purposes.

value added The difference between the cost of inputs and the value or price of outputs.

One way that organizations attempt to become more productive (i.e., make more output with the same or fewer inputs) is to critically examine whether any of their activities adds value. Those that do not add value are wasteful. Eliminating or improving such wastes decreases the cost of inputs or transformation, thereby increasing the value added. For instance, a company may discover that it is producing an item much earlier than the scheduled delivery date to a customer, thus requiring the storage of the item in a warehouse until delivery. In effect, additional costs are incurred by storing the item without adding to the value of the item. Reducing storage time would reduce the transformation cost and, hence, increase the value added. A similar comment applies for receiving raw material/parts too early. This is the concept called *just-in-time* (more in Chapter 15). Obviously, working with suppliers and customers can lead to increased productivity for all sides. This is called *supply chain management* (more in Chapter 11).

Finance

The finance function secures funds at favourable terms and allocates those funds throughout the organization. Finance and operations management personnel cooperate by exchanging information and expertise in activities such as:

- *Provision of funds.* The necessary funding of operations and the amount and timing of funding can be important and even critical when funds are tight. Careful planning can help avoid cash flow problems. Most businesses obtain the majority of their funds through the revenues generated by sales of their goods and services.
- *Economic analysis of capital investment proposals.* Evaluation of alternative investments in plant and equipment requires inputs from both operations and finance people.

Marketing

Marketing, including sales, is responsible for receiving customer wants/needs and feedback, and for communicating them to operations and to product design (usually engineers). Operations uses

forecast demand/sales to purchase materials and schedule production, while product design people use that information to improve the quality of current goods and services, and to design new ones. Marketing/sales, product design, and operations (representing manufacturing/service) must work closely together to successfully implement product design changes and to develop and produce new products. One important piece of information sales needs from operations is the manufacturing **lead time** in order to give customers realistic estimates of how long it will take to fill their orders.

lead time The time between the placement of an order and the shipment of the completed order to the customer.

Other Functions

There are many supporting functions that interface with operations (see Figure 1-4).

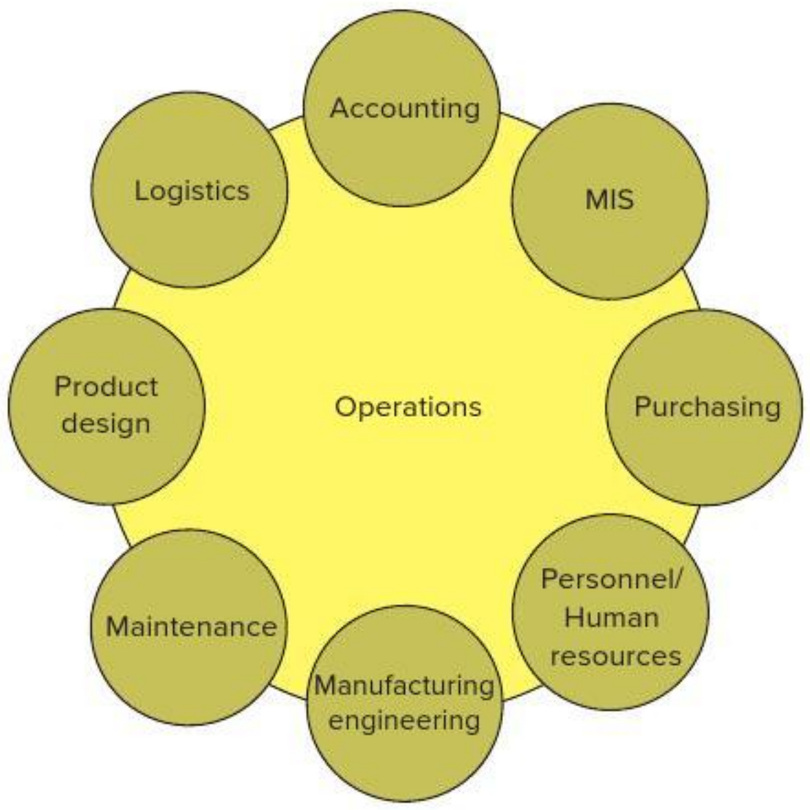
Management accounting supplies management with information on costs of labour, materials, and overhead, and provides reports on items such as scrap, downtime, and inventories. *Financial accounting* deals with accounts payable and receivable, and gathers the information needed for financial statements.

Management information systems (MIS) is concerned with providing management with the information it needs to manage effectively. This occurs through computer and communication systems (hardware and software) that capture relevant information and prepare reports.

Purchasing has responsibility for procurement of materials, supplies, equipment, and services. Close contact with operations is necessary to ensure items are ordered when needed. The purchasing staff identifies appropriate suppliers and facilitates close supplier relationships. Purchasing may also be involved in arranging incoming transportation.

FIGURE 1-4 ▼

Operations interfaces with a number of supporting functions.



The *personnel* or *human resources* department is concerned with recruitment and training of personnel, labour relations, contract negotiations, wage and salary administration, and ensuring the health and safety of employees.

Manufacturing engineering is responsible for the machines and equipment needed in the production process. Also called process engineers, they are mainly trained as mechanical engineers, but other fields such as electrical and chemical engineering may also be needed.

Maintenance and facility management is responsible for the upkeep and repair of equipment, buildings and grounds, heating and air conditioning, removing wastes, parking, and security.

Product design in manufacturing companies is done by design engineers, but in other companies it could be done by people such as architects, scientists, chemists, and chefs. This function is also called research and development. Designers create goods and services from information given to them by marketing people and provide product specifications to operations to make the products.

Logistics involves the transportation of raw material to the plant; storage and warehousing; and transportation of goods to warehouses, retail outlets, or final customers.

Some of these interfaces are elaborated on in later chapters.

LO3 The Scope of Operations Management

We have already noted that operations management is responsible for the creation of goods and services. This encompasses acquisition of resources and the conversion of raw material into outputs using one or more transformation processes. This involves designing, planning, scheduling, executing, and controlling the activities/operations that make up the processes.

A primary function of operations management is decision making. Certain decisions affect the *design* of the system, and others are *planning/control*. Design decisions are usually strategic and long-term (1–5 years ahead), whereas planning decisions are tactical and medium-term

(1–12 months ahead), and control decisions (including scheduling and execution) are short-term (1–12 weeks ahead).

Design involves product, production process, capacity, facility location, layout (arrangement of departments and equipment within a building), buying equipment, and work/job. Planning/control involves quality, inventory, production, scheduling, and project. Operations management is more involved in day-to-day operating decisions and planning than design. However, it has a vital stake in design because *design determines limitations of operations,* which affects price, timeliness, and quality of products. Even though operations management is not solely responsible for design, it can provide information that will have a bearing on design. Table 1-3 provides additional details on the design and planning/control decisions, and indicates in which chapter each topic is discussed.

◀ **TABLE 1-3**
Design and planning/control decisions.

Decision Area	Basic Question(s)	Chapter
Forecasting	What will the demand be?	3
Design		
Product design	What do customers want? How can products be designed?	4
Capacity (long term)	How much capacity will be needed? How can the organization best meet capacity requirements?	5
Process design	What production process should the organization use?	6
Layout	What is the best arrangement for departments, machines, and equipment, in terms of work flow?	6
Work/job design	How to improve work methods? How to measure work?	7
Location	What is a satisfactory location for a facility (factory, warehouse, etc.)?	8
Planning/control		
Quality	How is quality defined? How is quality achieved and improved?	9
Quality control	Are processes performing adequately (i.e., are they in control and capable)?	10
Supply chain management	How can supplier–customer pairs collaborate? Which supplier to choose? How to transport goods?	11
Inventory management	How much to order? When to reorder?	12
Aggregate planning	How to plan production in the medium term?	13
Material requirements planning	How many parts and sub-assemblies will be needed, and when?	14
Just-in-time	How to manage production so that it is fast and lean?	15
Scheduling	How can jobs best be scheduled? How can staff be scheduled?	16
Project management	How to plan, schedule, execute, and control a project?	17
Waiting lines	How to model waiting lines? What service capacity is appropriate?	18