Operations and Productivity

CHAPTER 1

CHAPTER OUTLINE

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Alaska Airlines

10 OM STRATEGY DECISIONS

- Design of Goods and Services
- Managing Quality
- Process Strategy
- Location Strategies
- Layout Strategies
- Human Resources
- Supply-Chain Management
- Inventory Management
- Scheduling
- Maintenance

GLOBAL COMPANY PROFILE
Hard Rock Cafe

Operations Management at Hard Rock Cafe

Operations managers throughout the world are producing products every day to provide for the well-being of society. These products take on a multitude of forms. They may be washing machines at Whirlpool, motion pictures at DreamWorks, rides at Disney World, or food at Hard Rock Cafe. These firms produce thousands of complex products every day—to be delivered as the customer ordered them, when the customer wants them, and where the customer wants them. Hard Rock does this for over 35 million guests worldwide every year. This is a challenging task, and the operations manager's job, whether at Whirlpool, DreamWorks, Disney, or Hard Rock, is demanding.

Andre Jenny/Alamy

Hard Rock Cafe in Orlando, Florida, prepares over 3,500 meals each day. Seating more than 1,500 people, it is one of the largest restaurants in the world. But Hard Rock's operations managers serve the hot food hot and the cold food cold.

Demetrio Carrasco/Rough Guides/Dorling Kindersley, Ltd.

Operations managers are interested in the attractiveness of the layout, but they must be sure that the facility contributes to the efficient movement of people and material with the necessary controls to ensure that proper portions are served.

Presselect/Alamy

Lots of work goes into designing, testing, and costing meals. Then suppliers deliver quality products on time, every time, for well-trained cooks to prepare quality meals. But none of that matters unless an enthusiastic waitstaff, such as the one shown here, holding guitars previously owned by members of U2, is doing its job.

Efficient kitchen layouts, motivated personnel, tight schedules, and the right ingredients at the right place at the right time are required to delight the customer.

Jack Picone/Alamy

Orlando-based Hard Rock Cafe opened its first restaurant in London in 1971, making it over 45 years old and the granddaddy of theme restaurants. Although other theme restaurants have come and gone, Hard Rock is still going strong, with 150 restaurants in more than 53 countries—and new restaurants opening each year. Hard Rock made its name with rock music memorabilia, having started when Eric Clapton, a regular customer, marked his favorite bar stool by hanging his guitar on the wall in the London cafe. Now Hard Rock has 70,000 items and millions of dollars invested in memorabilia. To keep customers coming back time and again, Hard Rock creates value in the form of good food and entertainment.

The operations managers at Hard Rock Cafe at Universal Studios in Orlando provide more than 3,500 custom products—in this case meals—every day. These products are designed, tested, and then analyzed for cost of ingredients, labor requirements, and customer satisfaction. On approval, menu items are put into production—and then only if the ingredients are available from qualified suppliers. The production process, from receiving, to cold storage, to grilling or baking or frying, and a dozen other steps, is designed and maintained to yield a quality meal. Operations managers, using the best people they can recruit and train, also prepare effective employee schedules and design efficient layouts.

Managers who successfully design and deliver goods and services throughout the world understand operations. In this text, we look not only at how Hard Rock's managers create value but also how operations managers in other services, as well as in manufacturing, do so. Operations management is demanding, challenging, and exciting. It affects our lives every day. Ultimately, operations managers determine how well we live.

LEARNING OBJECTIVES

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LO 1.2 ***Explain*** the distinction between goods and services 11
LO 1.3 ***Explain*** the difference between production and productivity 13
LO 1.4 ***Compute*** single-factor productivity 14
LO 1.5 ***Compute*** multifactor productivity 15
LO 1.6 ***Identify*** the critical variables in enhancing productivity 16

STUDENT TIP Let's begin by defining what this course is about.

What Is Operations Management?

LO 1.1 *Define* operations management

Operations management (OM) is a discipline that applies to restaurants like Hard Rock Cafe as well as to factories like Ford and Whirlpool. The techniques of OM apply throughout the world to virtually all productive enterprises. It doesn't matter if the application is in an office, a hospital, a restaurant, a department store, or a factory—the production of goods and services requires operations management. And the *efficient* production of goods and services requires effective applications of the concepts, tools, and techniques of OM that we introduce in this book.

VIDEO 1.1 Operations Management at Hard Rock

VIDEO 1.2 Operations Management at Frito-Lay

As we progress through this text, we will discover how to manage operations in an economy in which both customers and suppliers are located throughout the world. An array of informative examples, charts, text discussions, and pictures illustrates concepts and provides information. We will see how operations managers create the goods and services that enrich our lives.

In this chapter, we first define *operations management*, explaining its heritage and exploring the exciting role operations managers play in a huge variety of organizations. Then we discuss production and productivity in both goods- and service-producing firms. This is followed by a discussion of operations in the service sector and the challenge of managing an effective and efficient production system.

Production The creation of goods and services.

Operations management (OM) Activities that relate to the creation of goods and services through the transformation of inputs to outputs.

Production is the creation of goods and services. **Operations management (OM)** is the set of activities that creates value in the form of goods and services by transforming inputs into outputs. Activities creating goods and services take place in all organizations. In manufacturing firms, the production activities that create goods are usually quite obvious. In them, we can see the creation of a tangible product such as a Sony TV or a Harley-Davidson motorcycle.

In an organization that does not create a tangible good or product, the production function may be less obvious. We often call these activities *services*. The services may be "hidden" from the public and even from the customer. The product may take such forms as the transfer of funds from a savings account to a checking account, the transplant of a liver, the filling of an empty seat on an airplane, or the education of a student. Regardless of whether the end product is a good or service, the production activities that go on in the organization are often referred to as operations, or *operations management*.

STUDENT TIP Operations is one of the three functions that every organization performs.

Organizing to Produce Goods and Services

To create goods and services, all organizations perform three functions (see Figure 1.1). These functions are the necessary ingredients not only for production but also for an organization's survival. They are:

1. *Marketing*, which generates the demand, or at least takes the order for a product or service (nothing happens until there is a sale).
2. *Production/operations*, which creates, produces, and delivers the product.
3. *Finance/accounting*, which tracks how well the organization is doing, pays the bills, and collects the money.

Universities, churches or synagogues, and businesses all perform these functions. Even a volunteer group such as the Boy Scouts of America is organized to perform these three basic

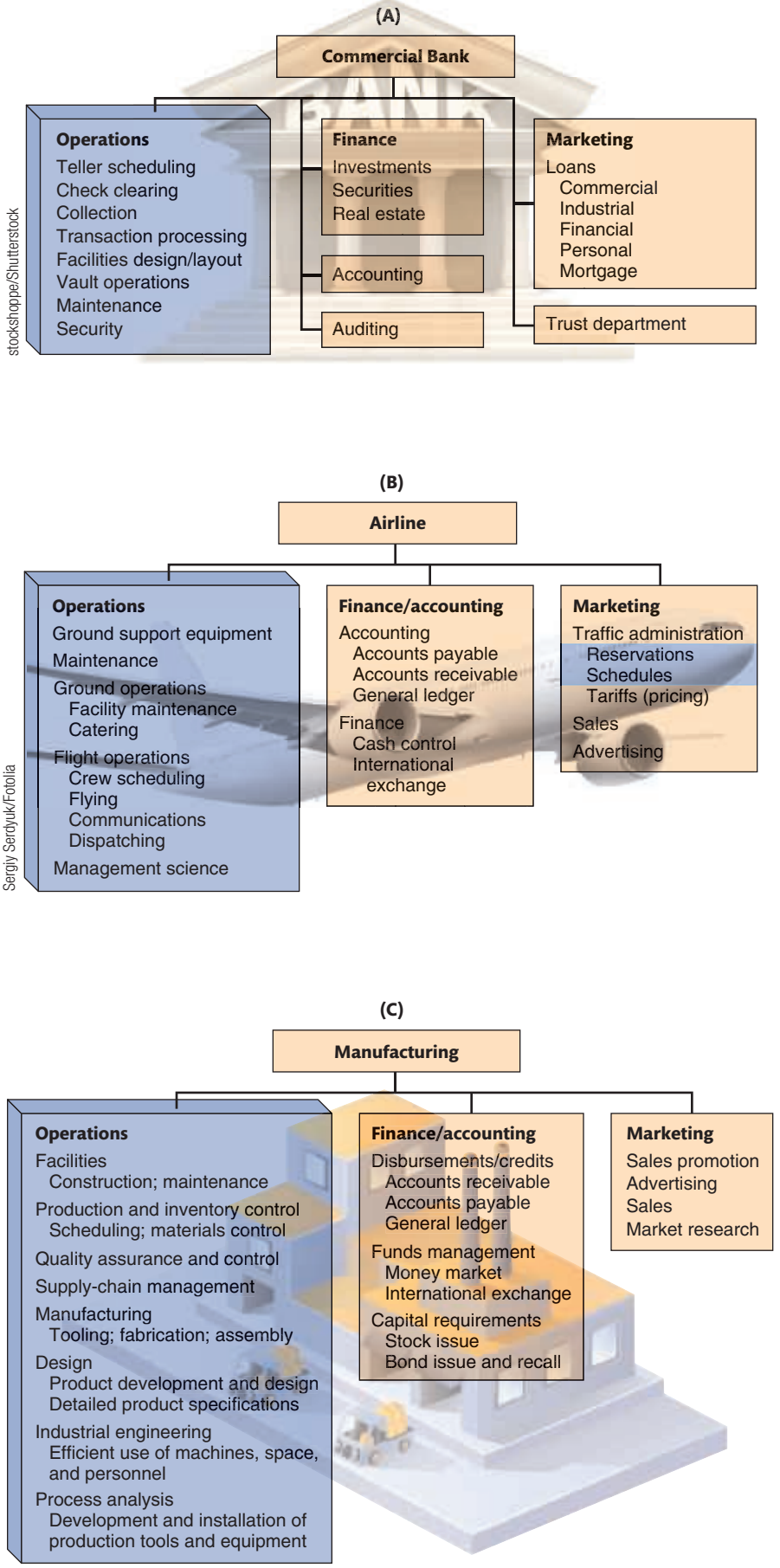


Figure **1.1**

Organization Charts for Two Service Organizations and One Manufacturing Organization

(A) a bank, (B) an airline, and (C) a manufacturing organization. The blue areas are OM activities.

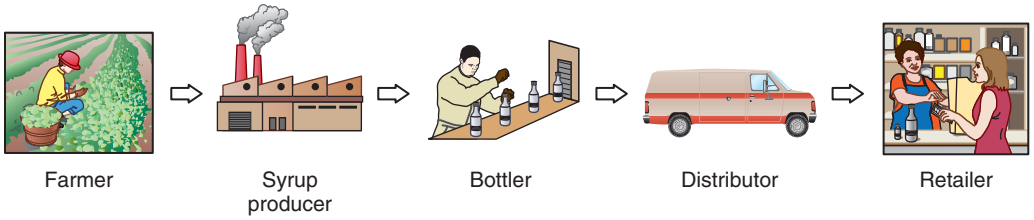
STUDENT TIP

The areas in blue indicate the significant role that OM plays in both manufacturing and service firms.

Figure 1.2

Soft Drink Supply Chain

A supply chain for a bottle of Coke requires a beet or sugar cane farmer, a syrup producer, a bottler, a distributor, and a retailer, each adding value to satisfy a customer. Only with collaborations between all members of the supply chain can efficiency and customer satisfaction be maximized. The supply chain, in general, starts with the provider of basic raw materials and continues all the way to the final customer at the retail store.



functions. Figure 1.1 shows how a bank, an airline, and a manufacturing firm organize themselves to perform these functions. The blue-shaded areas show the operations functions in these firms.

The Supply Chain

Supply chain

A global network of organizations and activities that supplies a firm with goods and services.

Through the three functions—marketing, operations, and finance—value for the customer is created. However, firms seldom create this value by themselves. Instead, they rely on a variety of suppliers who provide everything from raw materials to accounting services. These suppliers, when taken together, can be thought of as a *supply chain.* A **supply chain** (see Figure 1.2) is a global network of organizations and activities that supply a firm with goods and services.

As our society becomes more technologically oriented, we see increasing specialization. Specialized expert knowledge, instant communication, and cheaper transportation also foster specialization and worldwide supply chains. It just does not pay for a firm to try to do everything itself. The expertise that comes with specialization exists up and down the supply chain, adding value at each step. When members of the supply chain collaborate to achieve high levels of customer satisfaction, we have a tremendous force for efficiency and competitive advantage. Competition in the 21st century is not between companies; it is between *supply chains.*

STUDENT TIP

Good OM managers are scarce and, as a result, career opportunities and pay are excellent.

Why Study OM?

We study OM for four reasons:

1. OM is one of the three major functions of any organization, and it is integrally related to all the other business functions. All organizations market (sell), finance (account), and produce (operate), and it is important to know how the OM activity functions. Therefore, we study *how people organize themselves for productive enterprise*.
2. We study OM because we want to know *how goods and services are produced*. The production function is the segment of our society that creates the products and services we use.
3. We study OM to *understand what operations managers do*. Regardless of your job in an organization, you can perform better if you understand what operations managers do. In addition, understanding OM will help you explore the numerous and lucrative career opportunities in the field.
4. We study OM *because it is such a costly part of an organization*. A large percentage of the revenue of most firms is spent in the OM function. Indeed, OM provides a major opportunity for an organization to improve its profitability and enhance its service to society. Example 1 considers how a firm might increase its profitability via the production function.

Example 1

EXAMINING THE OPTIONS FOR INCREASING CONTRIBUTION

Fisher Technologies is a small firm that must double its dollar contribution to fixed cost and profit in order to be profitable enough to purchase the next generation of production equipment. Management has determined that if the firm fails to increase contribution, its bank will not make the loan and the equipment cannot be purchased. If the firm cannot purchase the equipment, the limitations of the old equipment will force Fisher to go out of business and, in doing so, put its employees out of work and discontinue producing goods and services for its customers.

APPROACH ▶ Table 1.1 shows a simple profit-and-loss statement and three strategic options (marketing, finance/accounting, and operations) for the firm. The first option is a *marketing option*, where excellent marketing management may increase sales by 50%. By increasing sales by 50%, contribution will in turn increase 71%. But increasing sales 50% may be difficult; it may even be impossible.

TABLE 1.1 Options for Increasing Contribution

		MARKETING OPTION[a]	FINANCE/ ACCOUNTING OPTION[b]	OM OPTION[c]
	CURRENT	INCREASE SALES REVENUE 50%	REDUCE FINANCE COSTS 50%	REDUCE PRODUCTION COSTS 20%
Sales	$100,000	$150,000	$100,000	$100,000
Costs of goods	–80,000	–120,000	–80,000	–64,000
Gross margin	20,000	30,000	20,000	36,000
Finance costs	–6,000	–6,000	–3,000	–6,000
Subtotal	14,000	24,000	17,000	30,000
Taxes at 25%	–3,500	–6,000	–4,250	–7,500
Contribution[d]	$ 10,500	$ 18,000	$ 12,750	$ 22,500

[a]Increasing sales 50% increases contribution by $7,500, or 71% (7,500/10,500).
[b]Reducing finance costs 50% increases contribution by $2,250, or 21% (2,250/10,500).
[c]Reducing production costs 20% increases contribution by $12,000, or 114% (12,000/10,500).
[d]Contribution to fixed cost (excluding finance costs) and profit.

The second option is a *finance/accounting option*, where finance costs are cut in half through good financial management. But even a reduction of 50% is still inadequate for generating the necessary increase in contribution. Contribution is increased by only 21%.

The third option is an *OM option*, where management reduces production costs by 20% and increases contribution by 114%.

SOLUTION ▶ Given the conditions of our brief example, Fisher Technologies has increased contribution from $10,500 to $22,500. It may now have a bank willing to lend it additional funds.

INSIGHT ▶ The OM option not only yields the greatest improvement in contribution but also may be the only feasible option. Increasing sales by 50% and decreasing finance cost by 50% may both be virtually impossible. Reducing operations cost by 20% may be difficult but feasible.

LEARNING EXERCISE ▶ What is the impact of only a 15% decrease in costs in the OM option? [Answer: A $19,500 contribution; an 86% increase.]

Example 1 underscores the importance of the effective operations activity of a firm. Development of increasingly effective operations is the approach taken by many companies as they face growing global competition.

What Operations Managers Do

All good managers perform the basic functions of the management process. The management process consists of *planning*, *organizing*, *staffing*, *leading*, and *controlling*. Operations managers apply this management process to the decisions they make in the OM function. The **10 strategic OM decisions** are introduced in Table 1.2. Successfully addressing each of these decisions requires planning, organizing, staffing, leading, and controlling.

10 Strategic OM Decisions
- Design of goods and services
- Managing quality
- Process strategy
- Location strategies
- Layout strategies
- Human resources
- Supply-chain management
- Inventory management
- Scheduling
- Maintenance

Where Are the OM Jobs? How does one get started on a career in operations? The 10 strategic OM decisions identified in Table 1.2 are made by individuals who work in the disciplines shown in the blue areas of Figure 1.1. Business students who know their accounting,

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An operations manager must successfully address the 10 decisions around which this text is organized.

TABLE 1.2 Ten Strategic Operations Management Decisions

DECISION	CHAPTER(S)
1. *Design of goods and services:* Defines much of what is required of operations in each of the other OM decisions. For instance, product design usually determines the lower limits of cost and the upper limits of quality, as well as major implications for sustainability and the human resources required.	5, Supplement 5
2. *Managing quality:* Determines the customer's quality expectations and establishes policies and procedures to identify and achieve that quality.	6, Supplement 6
3. *Process and capacity strategy:* Determines how a good or service is produced (i.e., the process for production) and commits management to specific technology, quality, human resources, and capital investments that determine much of the firm's basic cost structure.	7, Supplement 7
4. *Location strategy:* Requires judgments regarding nearness to customers, suppliers, and talent, while considering costs, infrastructure, logistics, and government.	8
5. *Layout strategy:* Requires integrating capacity needs, personnel levels, technology, and inventory requirements to determine the efficient flow of materials, people, and information.	9
6. *Human resources and job design:* Determines how to recruit, motivate, and retain personnel with the required talent and skills. People are an integral and expensive part of the total system design.	10
7. *Supply chain management:* Decides how to integrate the supply chain into the firm's strategy, including decisions that determine what is to be purchased, from whom, and under what conditions.	11, Supplement 11
8. *Inventory management:* Considers inventory ordering and holding decisions and how to optimize them as customer satisfaction, supplier capability, and production schedules are considered.	12, 14, 16
9. *Scheduling:* Determines and implements intermediate- and short-term schedules that effectively and efficiently utilize both personnel and facilities while meeting customer demands.	13, 15
10. *Maintenance:* Requires decisions that consider facility capacity, production demands, and personnel necessary to maintain a reliable and stable process.	17

statistics, finance, and OM have an opportunity to assume entry-level positions in all of these areas. As you read this text, identify disciplines that can assist you in making these decisions. Then take courses in those areas. The more background an OM student has in accounting, statistics, information systems, and mathematics, the more job opportunities will be available. About 40% of *all* jobs are in OM.

The following professional organizations provide various certifications that may enhance your education and be of help in your career:

- APICS, the Association for Operations Management (www.apics.org)
- American Society for Quality (ASQ) (www.asq.org)
- Institute for Supply Management (ISM) (www.ism.ws)
- Project Management Institute (PMI) (www.pmi.org)
- Council of Supply Chain Management Professionals (www.cscmp.org)

Figure 1.3 shows some recent job opportunities.

The Heritage of Operations Management

The field of OM is relatively young, but its history is rich and interesting. Our lives and the OM discipline have been enhanced by the innovations and contributions of numerous individuals. We now introduce a few of these people, and we provide a summary of significant events in operations management in Figure 1.4.

Operations Management Positions

SEARCH JOBS

Date Job Title

1/15 **Plant Manager**
Division of Fortune 1000 company seeks plant manager for plant located in the upper Hudson Valley area. This plant manufactures loading dock equipment for commercial markets. The candidate must be experienced in plant management including expertise in production planning, purchasing, and inventory management. Good written and oral communication skills are a must, along with excellent application of skills in managing people.

2/23 **Operations Analyst**
Expanding national coffee shop: top 10 "Best Places to Work" wants junior level systems analyst to join our excellent store improvement team. Business or I.E. degree, work methods, labor standards, ergonomics, cost accounting knowledge a plus. This is a hands-on job and excellent opportunity for a team player with good people skills. West Coast location. Some travel required.

3/18 **Quality Manager**
Several openings exist in our small package processing facilities in the Northeast, Florida, and Southern California for quality managers. These highly visible positions require extensive use of statistical tools to monitor all aspects of service, timeliness, and workload measurement. The work involves (1) a combination of hands-on applications and detailed analysis using databases and spreadsheets, (2) processing of audits to identify areas for improvement, and (3) management of implementation of changes. Positions involve night hours and weekends.

4/6 **Supply-Chain Manager and Planner**
Responsibilities entail negotiating contracts and establishing long-term relationships with suppliers. We will rely on the selected candidate to maintain accuracy in the purchasing system, invoices, and product returns. A bachelor's degree and up to 2 years related experience are required. Working knowledge of MRP, ability to use feedback to master scheduling and suppliers and consolidate orders for best price and delivery are necessary. Proficiency in all PC Windows applications, particularly Excel and Word, is essential. Effective verbal and written communication skills are essential.

5/14 **Process Improvement Consultants**
An expanding consulting firm is seeking consultants to design and implement lean production and cycle time reduction plans in both service and manufacturing processes. Our firm is currently working with an international bank to improve its back office operations, as well as with several manufacturing firms. A business degree required; APICS certification a plus.

Figure **1.3**

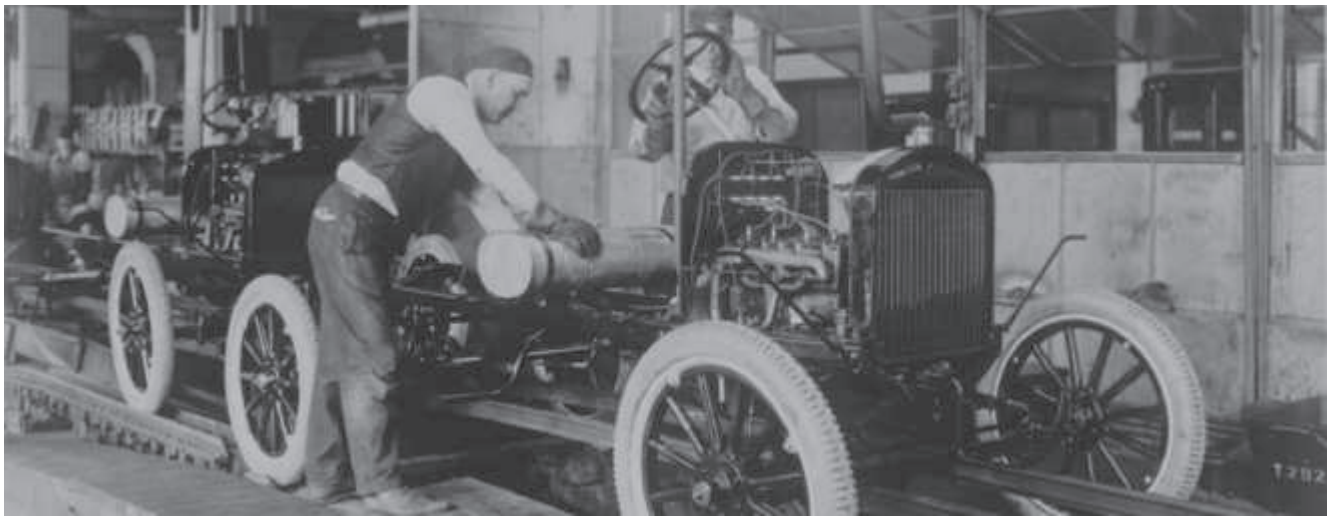
Many Opportunities Exist for Operations Managers

Eli Whitney (1800) is credited for the early popularization of interchangeable parts, which was achieved through standardization and quality control. Through a contract he signed with the U.S. government for 10,000 muskets, he was able to command a premium price because of their interchangeable parts.

Frederick W. Taylor (1881), known as the father of scientific management, contributed to personnel selection, planning and scheduling, motion study, and the now popular field of ergonomics. One of his major contributions was his belief that management should be much more resourceful and aggressive in the improvement of work methods. Taylor and his colleagues, Henry L. Gantt and Frank and Lillian Gilbreth, were among the first to systematically seek the best way to produce.

Another of Taylor's contributions was the belief that management should assume more responsibility for:

1. Matching employees to the right job.
2. Providing the proper training.
3. Providing proper work methods and tools.
4. Establishing legitimate incentives for work to be accomplished.



Everett Collection/Newscom

Cost Focus		Quality Focus	Customization Focus	Globalization Focus
Early Concepts 1776–1880 Labor Specialization (Smith, Babbage) Standardized Parts (Whitney) **Scientific Management Era 1880–1910** Gantt Charts (Gantt) Motion & Time Studies (Gilbreth) Process Analysis (Taylor) Queuing Theory (Erlang)	**Mass Production Era 1910–1980** Moving Assembly Line (Ford/Sorensen) Statistical Sampling (Shewhart) Economic Order Quantity (Harris) Linear Programming PERT/CPM (DuPont) Material Requirements Planning (MRP)	**Lean Production Era 1980–1995** Just-in-Time (JIT) Computer-Aided Design (CAD) Electronic Data Interchange (EDI) Total Quality Management (TQM) Baldrige Award Empowerment Kanbans	**Mass Customization Era 1995–2005** Internet/E-Commerce Enterprise Resource Planning International Quality Standards (ISO) Finite Scheduling Supply Chain Management Mass Customization Build-to-Order Radio Frequency Identification (RFID)	**Globalization Era 2005–2020** Global Supply Chains Growth of Transnational Organizations Instant Communications Sustainability Ethics in a Global Workforce Logistics

Figure **1.4**

Significant Events in Operations Management

By 1913, Henry Ford and Charles Sorensen combined what they knew about standardized parts with the quasi-assembly lines of the meatpacking and mail-order industries and added the revolutionary concept of the assembly line, where men stood still and material moved.

Quality control is another historically significant contribution to the field of OM. Walter Shewhart (1924) combined his knowledge of statistics with the need for quality control and provided the foundations for statistical sampling in quality control. W. Edwards Deming (1950) believed, as did Frederick Taylor, that management must do more to improve the work environment and processes so that quality can be improved.

Operations management will continue to progress as contributions from other disciplines, including *industrial engineering, statistics, management,* and *economics*, improve decision making.

Innovations from the *physical sciences* (biology, anatomy, chemistry, physics) have also contributed to advances in OM. These innovations include new adhesives, faster integrated circuits, gamma rays to sanitize food products, and specialized glass for iPhones and plasma TVs. Innovation in products and processes often depends on advances in the physical sciences.

Especially important contributions to OM have come from *information technology*, which we define as the systematic processing of data to yield information. Information technology—with wireless links, Internet, and e-commerce—is reducing costs and accelerating communication.

Decisions in operations management require individuals who are well versed in analytical tools, in information technology, and often in one of the biological or physical sciences. In this textbook, we look at the diverse ways a student can prepare for a career in operations management.

Operations for Goods and Services

STUDENT TIP
Services are especially important because almost 80% of all jobs are in service firms.

Manufacturers produce a tangible product, while service products are often intangible. But many products are a combination of a good and a service, which complicates the definition of a service. Even the U.S. government has trouble generating a consistent definition. Because definitions vary, much of the data and statistics generated about the service sector are inconsistent. However, we define **services** as including repair and maintenance, government, food and lodging, transportation, insurance, trade, financial, real estate, education, legal, medical, entertainment, and other professional occupations.

Services
Economic activities that typically produce an intangible product (such as education, entertainment, lodging, government, financial, and health services).

The operation activities for both goods and services are often very similar. For instance, both have quality standards, are designed and produced on a schedule that meets customer demand, and are made in a facility where people are employed. However, some major differences *do* exist between goods and services. These are presented in Table 1.3.

LO 1.2 *Explain* the distinction between goods and services

We should point out that in many cases, the distinction between goods and services is not clear-cut. In reality, almost all services and almost all goods are a mixture of a service and a tangible product. Even services such as consulting may require a tangible report. Similarly, the sale of most goods includes a service. For instance, many products have the service components of financing and delivery (e.g., automobile sales). Many also require after-sale training and maintenance (e.g., office copiers and machinery). "Service" activities may also be an integral part of production. Human resource activities, logistics, accounting, training, field service, and repair are all service activities, but they take place within a manufacturing organization. Very few services are "pure," meaning they have no tangible component. Counseling may be one of the exceptions.

Growth of Services

Services constitute the largest economic sector in postindustrial societies. Until about 1900, most Americans were employed in agriculture. Increased agricultural productivity allowed people to leave the farm and seek employment in the city. Similarly, manufacturing employment has decreased for the past 60 years. The changes in agriculture, manufacturing, and service employment as a percentage of the workforce are shown in Figure 1.5. Although the *number* of people employed in manufacturing has decreased since 1950, each person is now producing almost 20 times more than in 1950. Services became the dominant

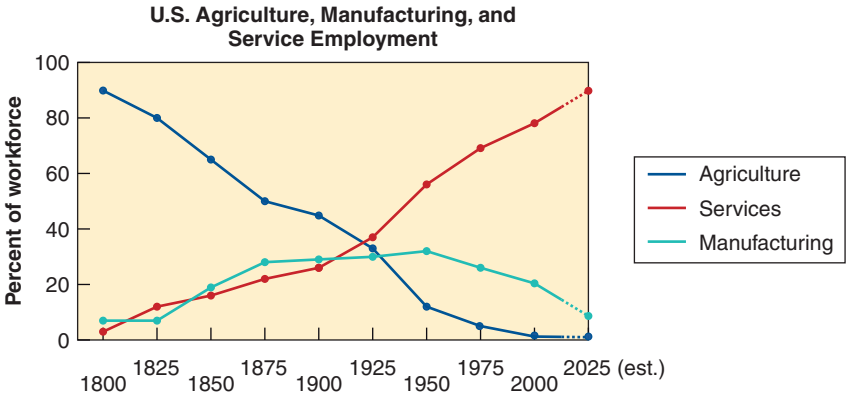
TABLE 1.3 Differences Between Goods and Services

CHARACTERISTICS OF SERVICES	CHARACTERISTICS OF GOODS
Intangible: Ride in an airline seat	Tangible: The seat itself
Produced and consumed simultaneously: Beauty salon produces a haircut that is consumed as it is produced	Product can usually be kept in inventory (beauty care products)
Unique: Your investments and medical care are unique	Similar products produced (iPods)
High customer interaction: Often what the customer is paying for (consulting, education)	Limited customer involvement in production
Inconsistent product definition: Auto insurance changes with age and type of car	Product standardized (iPhone)
Often knowledge based: Legal, education, and medical services are hard to automate	Standard tangible product tends to make automation feasible
Services dispersed: Service may occur at retail store, local office, house call, or via Internet.	Product typically produced at a fixed facility
Quality may be hard to evaluate: Consulting, education, and medical services	Many aspects of quality for tangible products are easy to evaluate (strength of a bolt)
Reselling is unusual: Musical concert or medical care	Product often has some residual value

Figure 1.5

U.S. Agriculture, Manufacturing, and Service Employment

Source: U.S. Bureau of Labor Statistics.



employer in the early 1920s, with manufacturing employment peaking at about 32% in 1950. The huge productivity increases in agriculture and manufacturing have allowed more of our economic resources to be devoted to services. Consequently, much of the world can now enjoy the pleasures of education, health services, entertainment, and myriad other things that we call services. Examples of firms and percentage of employment in the U.S. **service sector** are shown in Table 1.4. Table 1.4 also provides employment percentages for the nonservice sectors of manufacturing, construction, agriculture, and mining on the bottom four lines.

Service sector

The segment of the economy that includes trade, financial, lodging, education, legal, medical, and other professional occupations.

Service Pay

Although there is a common perception that service industries are low paying, in fact, many service jobs pay very well. Operations managers in the maintenance facility of an airline are very well paid, as are the operations managers who supervise computer services to the financial community. About 42% of all service workers receive wages above the national average. However, the service-sector average is driven down because 14 of the U.S. Department of

TABLE 1.4 Examples of Organizations in Each Sector

SECTOR	EXAMPLE	PERCENT OF ALL JOBS	
Service Sector			
Education, Medical, Other	San Diego State University, Arnold Palmer Hospital	15.3	
Trade (retail, wholesale), Transportation	Walgreen's, Walmart, Nordstrom, Alaska Airlines	15.8	
Information, Publishers, Broadcast	IBM, Bloomberg, Pearson, ESPN	1.9	
Professional, Legal, Business Services, Associations	Snelling and Snelling, Waste Management, American Medical Association, Ernst & Young	13.6	85.2
Finance, Insurance, Real Estate	Citicorp, American Express, Prudential, Aetna	9.6	
Leisure, Lodging, Entertainment	Olive Garden, Motel 6, Walt Disney	10.4	
Government (Fed, State, Local)	U.S., State of Alabama, Cook County	15.6	
Manufacturing Sector	General Electric, Ford, U.S. Steel, Intel		8.6
Construction Sector	Bechtel, McDermott		4.3
Agriculture	King Ranch		1.4
Mining Sector	Homestake Mining		.5
Grand Total			100.0

Source: Bureau of Labor Statistics, 2015.

Commerce categories of the 33 service industries do indeed pay below the all-private industry average. Of these, retail trade, which pays only 61% of the national private industry average, is large. But even considering the retail sector, the average wage of all service workers is about 96% of the average of all private industries.

The Productivity Challenge

STUDENT TIP

Why is productivity important? Because it determines our standard of living.

Productivity

The ratio of outputs (goods and services) divided by one or more inputs (such as labor, capital, or management).

The creation of goods and services requires changing resources into goods and services. The more efficiently we make this change, the more productive we are and the more value is added to the good or service provided. **Productivity** is the ratio of outputs (goods and services) divided by the inputs (resources, such as labor and capital) (see Figure 1.6). The operations manager's job is to enhance (improve) this ratio of outputs to inputs. Improving productivity means improving efficiency.[1]

This improvement can be achieved in two ways: reducing inputs while keeping output constant or increasing output while keeping inputs constant. Both represent an improvement in productivity. In an economic sense, inputs are labor, capital, and management, which are integrated into a production system. Management creates this production system, which provides the conversion of inputs to outputs. Outputs are goods and services, including such diverse items as guns, butter, education, improved judicial systems, and ski resorts. *Production* is the making of goods and services. High production may imply only that more people are working and that employment levels are high (low unemployment), but it does not imply high *productivity*.

LO 1.3 *Explain* the difference between production and productivity

Measurement of productivity is an excellent way to evaluate a country's ability to provide an improving standard of living for its people. *Only through increases in productivity can the standard of living improve.* Moreover, only through increases in productivity can labor, capital, and management receive additional payments. If returns to labor, capital, or management are increased without increased productivity, prices rise. On the other hand, downward pressure is placed on prices when productivity increases because more is being produced with the same resources.

The benefits of increased productivity are illustrated in the *OM in Action* box "Improving Productivity at Starbucks."

For well over a century (from about 1869), the U.S. has been able to increase productivity at an average rate of almost 2.5% per year. Such growth has doubled U.S. wealth every 30 years. The manufacturing sector, although a decreasing portion of the U.S. economy, has on occasion seen annual productivity increases exceeding 4%, and service sector increases of almost 1%. However, U.S. annual productivity growth in the early part of the 21st century is slightly below the 2.5% range for the economy as a whole and in recent years has been trending down.[2]

In this text, we examine how to improve productivity through operations management. Productivity is a significant issue for the world and one that the operations manager is uniquely qualified to address.

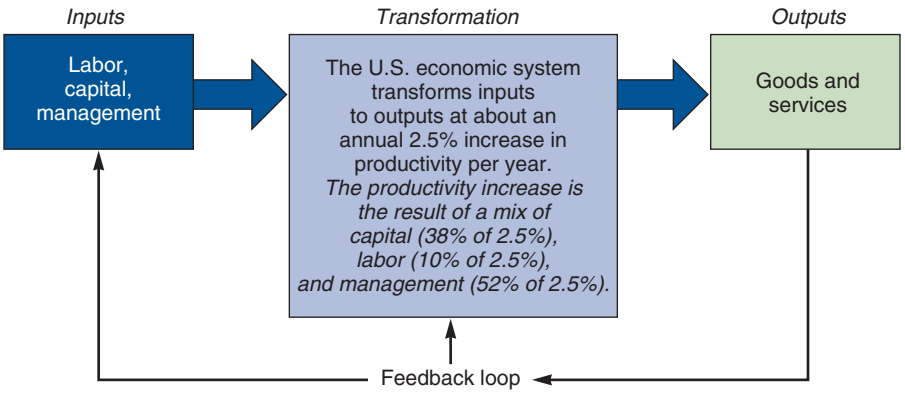


Figure 1.6

The Economic System Adds Value by Transforming Inputs to Outputs

An effective feedback loop evaluates performance against a strategy or standard. It also evaluates customer satisfaction and sends signals to managers controlling the inputs and transformation process.

OM in Action Improving Productivity at Starbucks

"This is a game of seconds …" says Silva Peterson, whom Starbucks has put in charge of saving seconds. Her team of 10 analysts is constantly asking themselves: "How can we shave time off this?"

Peterson's analysis suggested that there were some obvious opportunities. First, stop requiring signatures on credit-card purchases under $25. This sliced 8 seconds off the transaction time at the cash register.

Then analysts noticed that Starbucks' largest cold beverage, the Venti size, required two bending and digging motions to scoop up enough ice. The scoop was too small. Redesign of the scoop provided the proper amount in one motion and cut 14 seconds off the average time of 1 minute.

Third were new espresso machines; with the push of a button, the machines grind coffee beans and brew. This allowed the server, called a "barista" in Starbucks's vocabulary, to do other things. The savings: about 12 seconds per espresso shot.

As a result, operations improvements at Starbucks outlets have increased the average transactions per hour to 11.7—a 46% increase—and yearly volume by $250,000, to about $1 million. The result: a 27% improvement in overall productivity—about 4.5% per year. In the service industry, a 4.5% per year increase is very tasty.

Sources: BusinessWeek (August 23–30, 2012) and *The Wall Street Journal* (October 13, 2010 and August 4, 2009).

Kondor83/Shutterstock

Productivity Measurement

LO 1.4 *Compute* single-factor productivity

The measurement of productivity can be quite direct. Such is the case when productivity is measured by labor-hours per ton of a specific type of steel. Although labor-hours is a common measure of input, other measures such as capital (dollars invested), materials (tons of ore), or energy (kilowatts of electricity) can be used.[3] An example of this can be summarized in the following equation:

$$\text{Productivity} = \frac{\text{Units produced}}{\text{Input used}} \tag{1-1}$$

For example, if units produced = 1,000 and labor-hours used is 250, then:

$$\text{Single-factor productivity} = \frac{\text{Units produced}}{\text{Labor-hours used}} = \frac{1{,}000}{250} = 4 \text{ units per labor-hour}$$

Single-factor productivity
Indicates the ratio of goods and services produced (outputs) to one resource (input).

Multifactor productivity
Indicates the ratio of goods and services produced (outputs) to many or all resources (inputs).

The use of just one resource input to measure productivity, as shown in Equation (1-1), is known as **single-factor productivity**. However, a broader view of productivity is **multifactor productivity**, which includes all inputs (e.g., capital, labor, material, energy). Multifactor productivity is also known as *total factor productivity*. Multifactor productivity is calculated by combining the input units as shown here:

$$\text{Multifactor productivity} = \frac{\text{Output}}{\text{Labor} + \text{Material} + \text{Energy} + \text{Capital} + \text{Miscellaneous}} \tag{1-2}$$

To aid in the computation of multifactor productivity, the individual inputs (the denominator) can be expressed in dollars and summed as shown in Example 2.

Example 2

COMPUTING SINGLE-FACTOR AND MULTIFACTOR GAINS IN PRODUCTIVITY

Collins Title Insurance Ltd. wants to evaluate its labor and multifactor productivity with a new computerized title-search system. The company has a staff of four, each working 8 hours per day (for a payroll cost of $640/day) and overhead expenses of $400 per day. Collins processes and closes on 8 titles each day. The new computerized title-search system will allow the processing of 14 titles per day. Although the staff, their work hours, and pay are the same, the overhead expenses are now $800 per day.

APPROACH ► Collins uses Equation (1-1) to compute labor productivity and Equation (1-2) to compute multifactor productivity.

LO 1.5 *Compute* multifactor productivity

SOLUTION ▶

$$\text{Labor productivity with the old system: } \frac{8 \text{ titles per day}}{32 \text{ labor-hours}} = .25 \text{ titles per labor-hour}$$

$$\text{Labor productivity with the new system: } \frac{14 \text{ titles per day}}{32 \text{ labor-hours}} = .4375 \text{ titles per labor-hour}$$

$$\text{Multifactor productivity with the old system: } \frac{8 \text{ titles per day}}{\$640 + 400} = .0077 \text{ titles per dollar}$$

$$\text{Multifactor productivity with the new system: } \frac{14 \text{ titles per day}}{\$640 + 800} = .0097 \text{ titles per dollar}$$

Labor productivity has increased from .25 to .4375. The change is $(.4375 - .25)/.25 = 0.75$, or a 75% increase in labor productivity. Multifactor productivity has increased from .0077 to .0097. This change is $(.0097 - .0077)/.0077 = 0.26$, or a 26% increase in multifactor productivity.

INSIGHT ▶ Both the labor (single-factor) and multifactor productivity measures show an increase in productivity. However, the multifactor measure provides a better picture of the increase because it includes all the costs connected with the increase in output.

LEARNING EXERCISE ▶ If the overhead goes to $960 (rather than $800), what is the multifactor productivity? [Answer: .00875.]

RELATED PROBLEMS ▶ 1.1, 1.2, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 1.10, 1.11, 1.13, 1.14, 1.17

Use of productivity measures aids managers in determining how well they are doing. But results from the two measures can be expected to vary. If labor productivity growth is entirely the result of capital spending, measuring just labor distorts the results. Multifactor productivity is usually better, but more complicated. Labor productivity is the more popular measure. The multifactor-productivity measures provide better information about the trade-offs among factors, but substantial measurement problems remain. Some of these measurement problems are:

1. *Quality* may change while the quantity of inputs and outputs remains constant. Compare an HDTV of this decade with a black-and-white TV of the 1950s. Both are TVs, but few people would deny that the quality has improved. The unit of measure—a TV—is the same, but the quality has changed.
2. *External elements* may cause an increase or a decrease in productivity for which the system under study may not be directly responsible. A more reliable electric power service may greatly improve production, thereby improving the firm's productivity because of this support system rather than because of managerial decisions made within the firm.
3. *Precise units of measure* may be lacking. Not all automobiles require the same inputs: Some cars are subcompacts, others are 911 Turbo Porsches.

Productivity measurement is particularly difficult in the service sector, where the end product can be hard to define. For example, economic statistics ignore the quality of your haircut, the outcome of a court case, or the service at a retail store. In some cases, adjustments are made for the quality of the product sold but *not* the quality of the sales presentation or the advantage of a broader product selection. Productivity measurements require specific inputs and outputs, but a free economy is producing worth—what people want—which includes convenience, speed, and safety. Traditional measures of outputs may be a very poor measure of these other measures of worth. Note the quality-measurement problems in a law office, where each case is different, altering the accuracy of the measure "cases per labor-hour" or "cases per employee."

Productivity Variables

As we saw in Figure 1.6, productivity increases are dependent on three **productivity variables**:

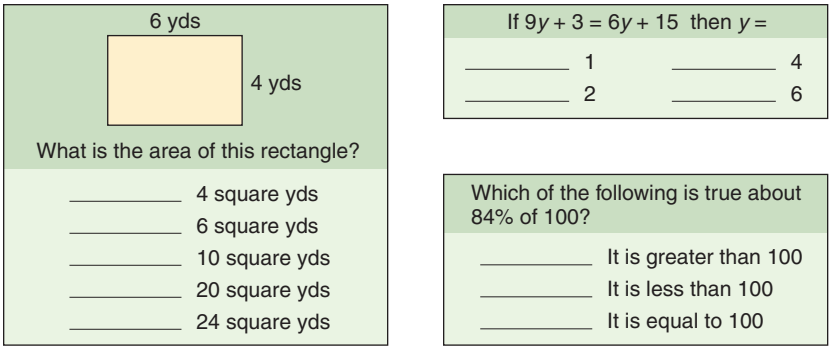
Productivity variables
The three factors critical to productivity improvement—labor, capital, and the art and science of management.

1. *Labor,* which contributes about 10% of the annual increase.
2. *Capital,* which contributes about 38% of the annual increase.
3. *Management,* which contributes about 52% of the annual increase.

These three factors are critical to improved productivity. They represent the broad areas in which managers can take action to improve productivity.

Figure 1.7

About Half of the 17-Year-Olds in the U.S. Cannot Correctly Answer Questions of This Type



LO 1.6 *Identify* the critical variables in enhancing productivity

Labor Improvement in the contribution of labor to productivity is the result of a healthier, better-educated, and better-nourished labor force. Some increase may also be attributed to a shorter workweek. Historically, about 10% of the annual improvement in productivity is attributed to improvement in the quality of labor. Three key variables for improved labor productivity are:

1. Basic education appropriate for an effective labor force.
2. Diet of the labor force.
3. Social overhead that makes labor available, such as transportation and sanitation.

Illiteracy and poor diets are a major impediment to productivity, costing countries up to 20% of their productivity. Infrastructure that yields clean drinking water and sanitation is also an opportunity for improved productivity, as well as an opportunity for better health, in much of the world.

In developed nations, the challenge becomes *maintaining and enhancing the skills of labor* in the midst of rapidly expanding technology and knowledge. Recent data suggest that the average American 17-year-old knows significantly less mathematics than the average Japanese at the same age, and about half cannot answer the questions in Figure 1.7. Moreover, about one-third of American job applicants tested for basic skills were deficient in reading, writing, or math.

Overcoming shortcomings in the quality of labor while other countries have a better labor force is a major challenge. Perhaps improvements can be found not only through increasing competence of labor but also via *better utilized labor with a stronger commitment*. Training, motivation, team building, and the human resource strategies discussed in Chapter 10, as well as improved education, may be among the many techniques that will contribute to increased labor productivity. Improvements in labor productivity are possible; however, they can be expected to be increasingly difficult and expensive.

Capital Human beings are tool-using animals. Capital investment provides those tools. Capital investment has increased in the U.S. every year except during a few very severe recession periods. Annual capital investment in the U.S. has increased at an annual rate of 1.5% after allowances for depreciation.

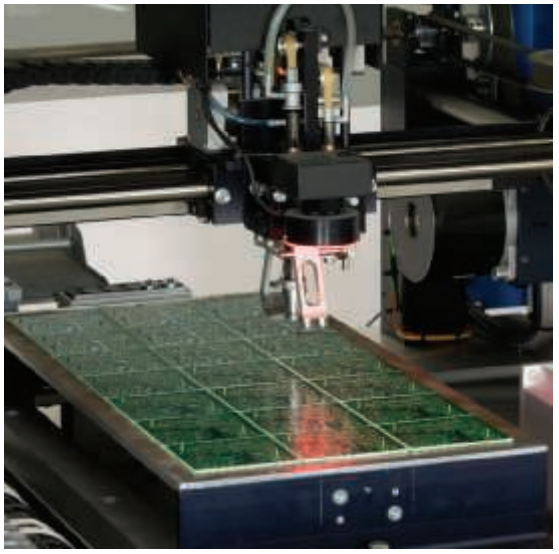
Inflation and taxes increase the cost of capital, making capital investment increasingly expensive. When the capital invested per employee drops, we can expect a drop in productivity. Using labor rather than capital may reduce unemployment in the short run, but it also makes economies less productive and therefore lowers wages in the long run. Capital investment is often a necessary, but seldom a sufficient, ingredient in the battle for increased productivity.

The trade-off between capital and labor is continually in flux. The higher the cost of capital or perceived risk, the more projects requiring capital are "squeezed out": they are not pursued because the potential return on investment for a given risk has been reduced. Managers adjust their investment plans to changes in capital cost and risk.

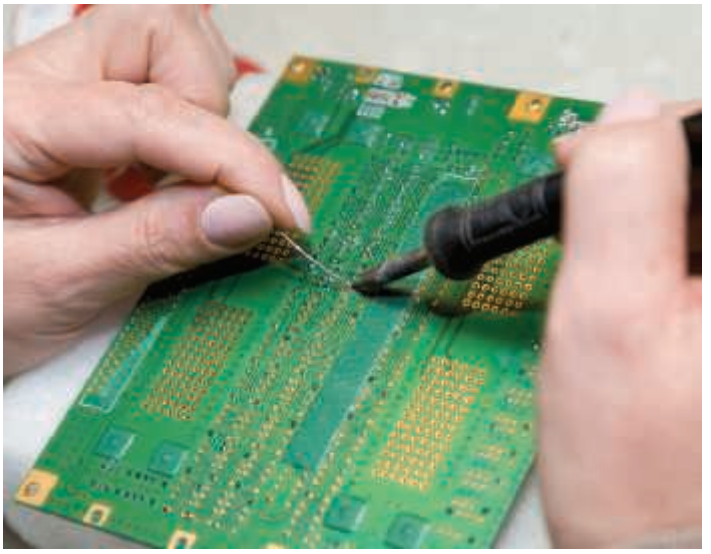
Management Management is a factor of production and an economic resource. Management is responsible for ensuring that labor and capital are effectively used to increase productivity. Management accounts for over half of the annual increase in productivity. This increase includes improvements made through the use of knowledge and the application of technology.

Knowledge society
A society in which much of the labor force has migrated from manual work to work based on knowledge.

Using knowledge and technology is critical in postindustrial societies. Consequently, postindustrial societies are also known as **knowledge societies**. Knowledge societies are those in which much of the labor force has migrated from manual work to technical and information-processing



Andrzej Thiel/Fotolia



Guy Shapira/Shutterstock

The effective use of capital often means finding the proper trade-off between investment in capital assets (automation, left) and human assets (a manual process, right). While there are risks connected with any investment, the cost of capital and physical investments is fairly clear-cut, but the cost of employees has many hidden costs including fringe benefits, social insurance, and legal constraints on hiring, employment, and termination.

tasks requiring ongoing education. The required education and training are important high-cost items that are the responsibility of operations managers as they build organizations and workforces. The expanding knowledge base of contemporary society requires that managers use *technology and knowledge effectively.*

More effective use of capital also contributes to productivity. It falls to the operations manager, as a productivity catalyst, to select the best new capital investments as well as to improve the productivity of existing investments.

The productivity challenge is difficult. A country cannot be a world-class competitor with second-class inputs. Poorly educated labor, inadequate capital, and dated technology are second-class inputs. High productivity and high-quality outputs require high-quality inputs, including good operations managers.

Productivity and the Service Sector

The service sector provides a special challenge to the accurate measurement of productivity and productivity improvement. The traditional analytical framework of economic theory is based primarily on goods-producing activities. Consequently, most published economic data relate to goods production. But the data do indicate that, as our contemporary service economy has increased in size, we have had slower growth in productivity.

Olaf Jandke/Agencja Fotograficzna Caro/Alamy

Siemens, a multi-billion-dollar German conglomerate, has long been known for its apprentice programs in its home country. Because education is often the key to efficient operations in a technological society, Siemens has spread its apprentice-training programs to its U.S. plants. These programs are laying the foundation for the highly skilled workforce that is essential for global competitiveness.

OM in Action Taco Bell Improves Productivity and Goes Green to Lower Costs

Founded in 1962 by Glenn Bell, Taco Bell seeks competitive advantage via low cost. Like many other services, Taco Bell relies on its operations management to improve productivity and reduce cost.

Its menu and meals are designed to be easy to prepare. Taco Bell has shifted a substantial portion of food preparation to suppliers who could perform food processing more efficiently than a stand-alone restaurant. Ground beef is precooked prior to arrival and then reheated, as are many dishes that arrive in plastic boil bags for easy sanitary reheating. Similarly, tortillas arrive already fried and onions prediced. Efficient layout and automation has cut to 8 seconds the time needed to prepare tacos and burritos and has cut time in the drive-through lines by 1 minute. These advances have been combined with training and empowerment to increase the span of management from one supervisor for 5 restaurants to one supervisor for 30 or more.

Operations managers at Taco Bell have cut in-store labor by 15 hours per day and reduced floor space by more than 50%. The result is a store that can average 164 seconds for each customer, from drive-up to pull-out.

In 2010, Taco Bell completed the rollout of its new Grill-to-Order kitchens by installing water- and energy-saving grills that conserve 300 million gallons of water and 200 million kilowatt hours of electricity each year. This "green"-inspired cooking method also saves the company's 5,800 restaurants $17 million per year.

Effective operations management has resulted in productivity increases that support Taco Bell's low-cost strategy. Taco Bell is now the fast-food low-cost leader with a 58% share of the Mexican fast-food market.

Bob Pardue-Signs/Alamy

Sources: Business Week (May 5, 2011); *Harvard Business Review* (July/August 2008); and J. Hueter and W. Swart, *Interfaces* (Vol. 28; issue 1).

Productivity of the service sector has proven difficult to improve because service-sector work is:

1. Typically labor intensive (e.g., counseling, teaching).
2. Frequently focused on unique individual attributes or desires (e.g., investment advice).
3. Often an intellectual task performed by professionals (e.g., medical diagnosis).
4. Often difficult to mechanize and automate (e.g., a haircut).
5. Often difficult to evaluate for quality (e.g., performance of a law firm).

The more intellectual and personal the task, the more difficult it is to achieve increases in productivity. Low-productivity improvement in the service sector is also attributable to the growth of low-productivity activities in the service sector. These include activities not previously a part of the measured economy, such as child care, food preparation, house cleaning, and laundry service. These activities have moved out of the home and into the measured economy as more and more women have joined the workforce. Inclusion of these activities has probably resulted in lower measured productivity for the service sector, although, in fact, actual productivity has probably increased because these activities are now more efficiently produced than previously.

However, despite the difficulty of improving productivity in the service sector, improvements are being made. And this text presents a multitude of ways to make these improvements. Indeed, what can be done when management pays attention to how work actually gets done is astonishing!

Although the evidence indicates that all industrialized countries have the same problem with service productivity, the U.S. remains the world leader in overall productivity *and* service productivity. Retailing is twice as productive in the U.S. as in Japan, where laws protect shopkeepers from discount chains. The U.S. telephone industry is at least twice as productive as Germany's. The U.S. banking system is also 33% more efficient than Germany's banking oligopolies. However, because productivity is central to the operations manager's job and because the service sector is so large, we take special note in this text of how to improve productivity in the service sector. (See, for instance, the *OM in Action* box "Taco Bell Improves Productivity and Goes Green to Lower Costs.")

Current Challenges in Operations Management

Operations managers work in an exciting and dynamic environment. This environment is the result of a variety of challenging forces, from globalization of world trade to the transfer of ideas, products, and money at electronic speeds. Let's look at some of these challenges:

- *Globalization:* The rapid decline in the cost of communication and transportation has made markets global. Similarly, resources in the form of capital, materials, talent, and labor are also now global. As a result, countries throughout the world are contributing to globalization as they vie for economic growth. Operations managers are rapidly seeking creative designs, efficient production, and high-quality goods via international collaboration.
- *Supply-chain partnering:* Shorter product life cycles, demanding customers, and fast changes in technology, materials, and processes require supply-chain partners to be in tune with the needs of end users. And because suppliers may be able to contribute unique expertise, operations managers are outsourcing and building long-term partnerships with critical players in the supply chain.
- *Sustainability:* Operations managers' continuing battle to improve productivity is concerned with designing products and processes that are ecologically sustainable. This means designing green products and packaging that minimize resource use, can be recycled or reused, and are generally environmentally friendly.
- *Rapid product development:* Technology combined with rapid international communication of news, entertainment, and lifestyles is dramatically chopping away at the life span of products. OM is answering with new management structures, enhanced collaboration, digital technology, and creative alliances that are more responsive and effective.
- *Mass customization:* Once managers recognize the *world* as the marketplace, the cultural and individual differences become quite obvious. In a world where consumers are increasingly aware of innovation and options, substantial pressure is placed on firms to respond in a creative way. And OM must rapidly respond with product designs and flexible production processes that cater to the individual whims of consumers. The goal is to produce customized products, whenever and wherever needed.
- *Lean operations:* Lean is the management model sweeping the world and providing the standard against which operations managers must compete. Lean can be thought of as the driving force in a well-run operation, where the customer is satisfied, employees are respected, and waste does not exist. The theme of this text is to build organizations that are more efficient, where management creates enriched jobs that help employees engage in continuous improvement, and where goods and services are produced and delivered when and where the customer desires them. These ideas are also captured in the phrase *Lean*.

These challenges must be successfully addressed by today's operations managers. This text will provide you with the foundations necessary to meet those challenges.

STUDENT TIP

One of the reasons OM is such an exciting discipline is that an operations manager is confronted with ever-changing issues, from technology, to global supply chains, to sustainability.

Ethics, Social Responsibility, and Sustainability

The systems that operations managers build to convert resources into goods and services are complex. And they function in a world where the physical and social environment is evolving, as are laws and values. These dynamics present a variety of challenges that come from the conflicting perspectives of **stakeholders**, such as customers, distributors, suppliers, owners, lenders, employees, and community. Stakeholders, as well as government agencies at various levels, require constant monitoring and thoughtful responses.

Stakeholders

Those with a vested interest in an organization, including customers, distributors, suppliers, owners, lenders, employees, and community members.

Identifying ethical and socially responsible responses while developing sustainable processes that are also effective and efficient productive systems is not easy. Managers are also challenged to:

- Develop and produce safe, high-quality green products
- Train, retain, and motivate employees in a safe workplace
- Honor stakeholder commitments

Managers must do all this while meeting the demands of a very competitive and dynamic world marketplace. If operations managers have a *moral awareness and focus on increasing productivity in this system*, then many of the ethical challenges will be successfully addressed. The organization will use fewer resources, the employees will be committed, the market will be satisfied, and the ethical climate will be enhanced. Throughout this text, we note ways in which operations managers can take ethical and socially responsible actions while successfully addressing these challenges of the market. We also conclude each chapter with an *Ethical Dilemma* exercise.

Summary

Operations, marketing, and finance/accounting are the three functions basic to all organizations. The operations function creates goods and services. Much of the progress of operations management has been made in the twentieth century, but since the beginning of time, humankind has been attempting to improve its material well-being. Operations managers are key players in the battle to improve productivity.

As societies become increasingly affluent, more of their resources are devoted to services. In the U.S., more than 85% of the workforce is employed in the service sector. Productivity improvements and a sustainable environment are difficult to achieve, but operations managers are the primary vehicle for making improvements.

Key Terms

Production (p. 4)
Operations management (OM) (p. 4)
Supply chain (p. 6)
10 strategic OM decisions (p. 7)
Services (p. 11)
Service sector (p. 12)
Productivity (p. 13)
Single-factor productivity (p. 14)
Multifactor productivity (p. 14)
Productivity variables (p. 15)
Knowledge society (p. 16)
Stakeholders (p. 19)

Ethical Dilemma

The American car battery industry boasts that its recycling rate now exceeds 95%, the highest rate for any commodity. However, with changes brought about by specialization and globalization, parts of the recycling system are moving offshore. This is particularly true of automobile batteries, which contain lead. The Environmental Protection Agency (EPA) is contributing to the offshore flow with newly implemented standards that make domestic battery recycling increasingly difficult and expensive. The result is a major increase in used batteries going to Mexico, where environmental standards and control are less demanding than they are in the U.S. One in five batteries is now exported to Mexico. There is seldom difficulty finding buyers because lead is expensive and in worldwide demand. While U.S. recyclers operate in sealed, mechanized plants, with smokestacks equipped with scrubbers and plant surroundings monitored for traces of lead, this is not the case in most Mexican plants. The harm from lead is legendary, with long-run residual effects. Health issues include high blood pressure, kidney damage, detrimental effects on fetuses during pregnancy, neurological problems, and arrested development in children.

Given the two scenarios below, what action do you take?

a) You own an independent auto repair shop and are trying to safely dispose of a few old batteries each week. (Your battery supplier is an auto parts supplier who refuses to take your old batteries.)

b) You are manager of a large retailer responsible for disposal of thousands of used batteries each day.

Discussion Questions

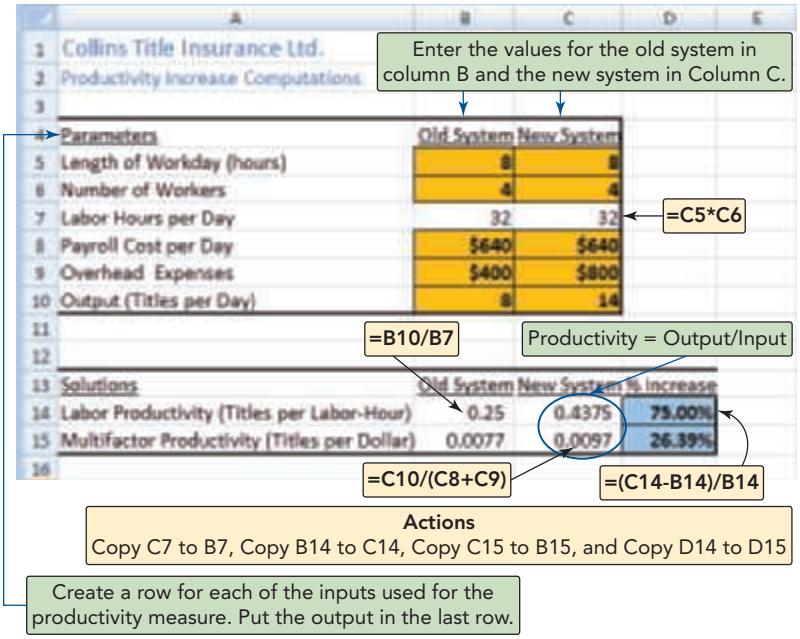
1. Why should one study operations management?
2. Identify four people who have contributed to the theory and techniques of operations management.
3. Briefly describe the contributions of the four individuals identified in the preceding question.
4. Figure 1.1 outlines the operations, finance/accounting, and marketing functions of three organizations. Prepare a chart similar to Figure 1.1 outlining the same functions for one of the following:
   a. a newspaper
   b. a drugstore
   c. a college library
   d. a summer camp
   e. a small costume-jewelry factory
5. Answer Question 4 for some other organization, perhaps an organization where you have worked.
6. What are the three basic functions of a firm?
7. Identify the 10 strategic operations management decisions.
8. Name four areas that are significant to improving labor productivity.
9. The U.S., and indeed much of the rest of the world, has been described as a "knowledge society." How does this affect productivity measurement and the comparison of productivity between the U.S. and other countries?
10. What are the measurement problems that occur when one attempts to measure productivity?
11. Mass customization and rapid product development were identified as challenges to modern manufacturing operations. What is the relationship, if any, between these challenges? Can you cite any examples?
12. What are the five reasons productivity is difficult to improve in the service sector?
13. Describe some of the actions taken by Taco Bell to increase productivity that have resulted in Taco Bell's ability to serve "twice the volume with half the labor."
14. As a library or Internet assignment, find the U.S. productivity rate (increase) last year for the (a) national economy, (b) manufacturing sector, and (c) service sector.

Using Software for Productivity Analysis

This section presents three ways to solve productivity problems with computer software. First, you can create your own Excel spreadsheets to conduct productivity analysis. Second, you can use the Excel OM software that comes with this text. Third, POM for Windows is another program that is available with this text.

CREATING YOUR OWN EXCEL SPREADSHEETS

Program 1.1 illustrates how to build an Excel spreadsheet for the data in Example 2.



Program **1.1**

USING EXCEL OM

Excel OM is an Excel "add-in" with 24 Operations Management decision support "Templates." To access the templates, double-click on the *Excel OM* tab at the top of the page, then in the menu bar choose the appropriate chapter (in this case Chapter 1), from either the "Chapter" or "Alphabetic" tab on the left. Each of Excel OM's 24 modules includes instructions for that particular module. The instructions can be turned on or off via the "instruction" tab in the menu bar.

USING POM FOR WINDOWS

POM for Windows is decision support software that includes 24 Operations Management modules. The modules are accessed by double-clicking on *Module* in the menu bar, and then double-clicking on the appropriate (in this case *Productivity*) item. Instructions are provided for each module just below the menu bar.

Solved Problems

Virtual Office Hours help is available in MyOMLab.

SOLVED PROBLEM 1.1

Productivity can be measured in a variety of ways, such as by labor, capital, energy, material usage, and so on. At Modern Lumber, Inc., Art Binley, president and producer of apple crates sold to growers, has been able, with his current equipment, to produce 240 crates per 100 logs. He currently purchases 100 logs per day, and each log requires 3 labor-hours to process. He believes that he can hire a professional buyer who can buy a better-quality log at the same cost. If this is the case, he can increase his production to 260 crates per 100 logs. His labor-hours will increase by 8 hours per day.

What will be the impact on productivity (measured in crates per labor-hour) if the buyer is hired?

SOLUTION

(a) Current labor productivity $= \dfrac{240 \text{ crates}}{100 \text{ logs} \times 3 \text{ hours/log}}$

$= \dfrac{240}{300}$

$= .8$ crates per labor-hour

(b) Labor productivity with buyer $= \dfrac{260 \text{ crates}}{(100 \text{ logs} \times 3 \text{ hours/log}) + 8 \text{ hours}}$

$= \dfrac{260}{308}$

$= .844$ crates per labor-hour

Using current productivity (.80 from [a]) as a base, the increase will be 5.5% (.844/.8 = 1.055, or a 5.5% increase).

SOLVED PROBLEM 1.2

Art Binley has decided to look at his productivity from a multifactor (total factor productivity) perspective (refer to Solved Problem 1.1). To do so, he has determined his labor, capital, energy, and material usage and decided to use dollars as the common denominator. His total labor-hours are now 300 per day and will increase to 308 per day. His capital and energy costs will remain constant at $350 and $150 per day, respectively. Material costs for the 100 logs per day are $1,000 and will remain the same. Because he pays an average of $10 per hour (with fringes), Binley determines his productivity increase as follows:

SOLUTION

CURRENT SYSTEM	
Labor:	300 hrs. @10 = 3,000
Material:	100 logs/day 1,000
Capital:	350
Energy:	150
Total Cost:	$4,500

Multifactor productivity of current system:
= 240 crates/$4,500 = .0533 crates/dollar

SYSTEM WITH PROFESSIONAL BUYER	
308 hrs. @10 =	$3,080
	1,000
	350
	150
	$4,580

Multifactor productivity of proposed system:
= 260 crates/$4,580 = .0568 crates/dollar

Using current productivity (.0533) as a base, the increase will be .066. That is, .0568/.0533 = 1.066, or a 6.6% increase.

Problems

Note: PX means the problem may be solved with POM for Windows and/or Excel OM.

Problems 1.1 to 1.17 relate to The Productivity Challenge

• **1.1** Chuck Sox makes wooden boxes in which to ship motorcycles. Chuck and his three employees invest a total of 40 hours per day making the 120 boxes.
a) What is their productivity?
b) Chuck and his employees have discussed redesigning the process to improve efficiency. If they can increase the rate to 125 per day, what will be their new productivity?
c) What will be their unit *increase* in productivity per hour?
d) What will be their percentage change in productivity? PX

• **1.2** Carbondale Casting produces cast bronze valves on a 10-person assembly line. On a recent day, 160 valves were produced during an 8-hour shift.
a) Calculate the labor productivity of the line.
b) John Goodale, the manager at Carbondale, changed the layout and was able to increase production to 180 units per 8-hour shift. What is the new labor productivity per labor-hour?
c) What is the percentage of productivity increase? PX

• **1.3** This year, Druehl, Inc., will produce 57,600 hot water heaters at its plant in Delaware, in order to meet expected global demand. To accomplish this, each laborer at the plant will work 160 hours per month. If the labor productivity at the plant is 0.15 hot water heaters per labor-hour, how many laborers are employed at the plant?

• **1.4** Lori Cook produces "Final Exam Care Packages" for resale by her sorority. She is currently working a total of 5 hours per day to produce 100 care packages.
a) What is Lori's productivity?
b) Lori thinks that by redesigning the package, she can increase her total productivity to 133 care packages per day. What will be her new productivity?
c) What will be the percentage increase in productivity if Lori makes the change? PX

•• **1.5** George Kyparisis makes bowling balls in his Miami plant. With recent increases in his costs, he has a newfound interest in efficiency. George is interested in determining the productivity of his organization. He would like to know if his organization is maintaining the manufacturing average of 3% increase in productivity per year? He has the following data representing a month from last year and an equivalent month this year:

	LAST YEAR	NOW
Units produced	1,000	1,000
Labor (hours)	300	275
Resin (pounds)	50	45
Capital invested ($)	10,000	11,000
Energy (BTU)	3,000	2,850

Show the productivity percentage change for each category and then determine the improvement for labor-hours, the typical standard for comparison. PX

•• **1.6** George Kyparisis (using data from Problem 1.5) determines his costs to be as follows:

- *Labor:* $10 per hour
- *Resin:* $5 per pound
- *Capital expense:* 1% per month of investment
- *Energy:* $0.50 per BTU

Show the percent change in productivity for one month last year versus one month this year, on a multifactor basis with dollars as the common denominator. PX

• **1.7** Hokey Min's Kleen Karpet cleaned 65 rugs in October, consuming the following resources:

Labor:	520 hours at $13 per hour
Solvent:	100 gallons at $5 per gallon
Machine rental:	20 days at $50 per day

a) What is the labor productivity per dollar?
b) What is the multifactor productivity? PX

•• **1.8** Lillian Fok is president of Lakefront Manufacturing, a producer of bicycle tires. Fok makes 1,000 tires per day with the following resources:

Labor:	400 hours per day @ $12.50 per hour
Raw material:	20,000 pounds per day @ $1 per pound
Energy:	$5,000 per day
Capital costs:	$10,000 per day

a) What is the labor productivity per labor-hour for these tires at Lakefront Manufacturing?
b) What is the multifactor productivity for these tires at Lakefront Manufacturing?
c) What is the percent change in multifactor productivity if Fok can reduce the energy bill by $1,000 per day without cutting production or changing any other inputs? PX

••• **1.9** Brown's, a local bakery, is worried about increased costs—particularly energy. Last year's records can provide a fairly good estimate of the parameters for this year. Wende Brown, the owner, does not believe things have changed much, but she did invest an additional $3,000 for modifications to the bakery's ovens to make them more energy efficient. The modifications were supposed to make the ovens at least 15% more efficient. Brown has asked you to check the energy savings of the new ovens and also to look over other measures of the bakery's productivity to see if the modifications were beneficial. You have the following data to work with:

	LAST YEAR	NOW
Production (dozen)	1,500	1,500
Labor (hours)	350	325
Capital investment ($)	15,000	18,000
Energy (BTU)	3,000	2,750

PX

Taras Vyshnya/Shutterstock

•• **1.10** Munson Performance Auto, Inc., modifies 375 autos per year. The manager, Adam Munson, is interested in obtaining a measure of overall performance. He has asked you to provide him with a multifactor measure of last year's performance as a benchmark for future comparison. You have assembled the following data. Resource inputs were labor, 10,000 hours; 500 suspension and engine modification kits; and energy, 100,000 kilowatt-hours. Average labor cost last year was $20 per hour, kits cost $1,000 each, and energy costs were $3 per kilowatt-hour. What do you tell Mr. Munson? PX

•• **1.11** Lake Charles Seafood makes 500 wooden packing boxes for fresh seafood per day, working in two 10-hour shifts. Due to increased demand, plant managers have decided to operate three 8-hour shifts instead. The plant is now able to produce 650 boxes per day.
a) Calculate the company's productivity before the change in work rules and after the change.
b) What is the percentage increase in productivity?
c) If production is increased to 700 boxes per day, what is the new productivity? PX

••• **1.12** Charles Lackey operates a bakery in Idaho Falls, Idaho. Because of its excellent product and excellent location, demand has increased by 25% in the last year. On far too many occasions, customers have not been able to purchase the bread of their choice. Because of the size of the store, no new ovens can be added. At a staff meeting, one employee suggested ways to load the ovens differently so that more loaves of bread can be baked at one time. This new process will require that the ovens be loaded by hand, requiring additional manpower. This is the only thing to be changed. If the bakery makes 1,500 loaves per month with a labor productivity of 2.344 loaves per labor-hour, how many workers will Lackey need to *add*? (*Hint:* Each worker works 160 hours per month.)

•• **1.13** Refer to Problem 1.12. The pay will be $8 per hour for employees. Charles Lackey can also improve the yield by purchasing a new blender. The new blender will mean an increase in his investment. This added investment has a cost of $100 per month, but he will achieve the same output (an increase to 1,875) as the change in labor-hours. Which is the better decision?
a) Show the productivity change, in loaves per dollar, with an increase in labor cost (from 640 to 800 hours).
b) Show the new productivity, in loaves per dollar, with only an increase in investment ($100 per month more).
c) Show the percent productivity change for labor and investment.

••• **1.14** Refer to Problems 1.12 and 1.13. If Charles Lackey's utility costs remain constant at $500 per month, labor at $8 per hour, and cost of ingredients at $0.35 per loaf, but Charles does not purchase the blender suggested in Problem 1.13, what will the productivity of the bakery be? What will be the percent increase or decrease?

•• **1.15** In December, General Motors produced 6,600 customized vans at its plant in Detroit. The labor productivity at this plant is known to have been 0.10 vans per labor-hour during that month. 300 laborers were employed at the plant that month.
a) How many hours did the average laborer work that month?
b) If productivity can be increased to 0.11 vans per labor-hour, how many hours would the average laborer work that month?

••**1.16** Susan Williams runs a small Flagstaff job shop where garments are made. The job shop employs eight workers. Each worker is paid $10 per hour. During the first week of March, each worker worked 45 hours. Together, they produced a batch of 132 garments. Of these garments, 52 were "seconds" (meaning that they were flawed). The seconds were sold for $90 each at a factory outlet store. The remaining 80 garments were sold to retail outlets at a price of $198 per garment. What was the labor productivity, in dollars per labor-hour, at this job shop during the first week of March?

•••**1.17** As part of a study for the Department of Labor Statistics, you are assigned the task of evaluating the improvement in productivity of small businesses. Data for one of the small businesses you are to evaluate are shown at right. The data are the monthly average of last year and the monthly average this year. Determine the multifactor productivity with dollars as the common denominator for:

a) Last year.
b) This year.
c) Then determine the percent change in productivity for the monthly average last year versus the monthly average this year on a multifactor basis.

- *Labor:* $8 per hour
- *Capital:* 0.83% per month of investment
- *Energy:* $0.60 per BTU

	LAST YEAR	THIS YEAR
Production (dozen)	1,500	1,500
Labor (hours)	350	325
Capital investment ($)	15,000	18,000
Energy (BTU)	3,000	2,700

CASE STUDIES

Uber Technologies, Inc.

The $41 billion dollar firm Uber Technology, Inc., is unsettling the traditional taxi business. In over 40 countries and 240 markets around the world, Uber and similar companies are challenging the existing taxi business model. Uber and its growing list of competitors, Lyft, Sidecar, and Flywheel in America, and fledging rivals in Europe, Asia, and India, think their smart phone apps can provide a new and improved way to call a taxi. This disruptive business model uses an app to arrange rides between riders and cars, theoretically a nearby car, which is tracked by the app. The Uber system also provides a history of rides, routes, and fees as well as automatic billing. In addition, driver and rider are also allowed to evaluate each other. The services are increasingly popular, worrying established taxi services in cities from New York to Berlin, and from Rio de Janeiro to Bangkok. In many markets, Uber has proven to be the best, fastest, and most reliable way to find a ride. Consumers worldwide are endorsing the system as a replacement for the usual taxi ride. As the most established competitor in the field, Uber is putting more cars on the road, meaning faster pickup times, which should attract even more riders, which in turn attracts even more drivers, and so on. This growth cycle may speed the demise of the existing taxi businesses as well as provide substantial competition for firms with a technology-oriented model similar to Uber's.

The Uber business model initially attempts to bypass a number of regulations and at the same time offer better service and lower fees than traditional taxis. However, the traditional taxi industry is fighting back, and regulations are mounting. The regulations vary by country and city, but increasingly special licensing, testing, and inspections are being imposed. Part of the fee charged to riders does not go to the driver, but to Uber, as there are real overhead costs. Uber's costs, depending on the locale, may include insurance, background checks for drivers, vetting of vehicles, software development and maintenance, and centralized billing. How these overhead costs compare to traditional taxi costs is yet to be determined. Therefore, improved efficiency may not be immediately obvious, and contract provisions are significant (see www.uber.com/legal/usa/terms).

In addition to growing regulations, a complicating factor in the model is finding volunteer drivers at inopportune times. A sober driver and a clean car at 1:00 a.m. New Year's Eve does cost more. Consequently, Uber has introduced "surge" pricing. Surge pricing means a higher price, sometimes much higher, than normal. Surge pricing has proven necessary to ensure that cars and drivers are available at unusual times. These higher surge prices can be a shock to riders, making the "surge price" a contentious issue.

Discussion Questions

1. The market has decided that Uber and its immediate competitors are adding efficiency to our society. How is Uber providing that added efficiency?
2. Do you think the Uber model will work in the trucking industry?
3. In what other areas/industries might the Uber model be used?

Sources: Wall Street Journal (January 2, 2015), B3, and (Dec. 18, 2014), D1; and www.bloombergview.com/articles/2014-12-11/can-uber-rule-the-world.

Frito-Lay: Operations Management in Manufacturing

Video Case

Frito-Lay, the massive Dallas-based subsidiary of PepsiCo, has 38 plants and 48,000 employees in North America. Seven of Frito-Lay's 41 brands exceed $1 billion in sales: Fritos, Lay's, Cheetos, Ruffles, Tostitos, Doritos, and Walker's Potato Chips. Operations is the focus of the firm—from designing products for new markets, to meeting changing consumer preferences, to adjusting to rising commodity costs, to subtle issues involving flavors and preservatives—OM is under constant cost, time, quality, and market pressure. Here is a look at how the 10 decisions of OM are applied at this food processor.

In the food industry, product development kitchens experiment with new products, submit them to focus groups, and perform test marketing. Once the product specifications have been set, processes capable of meeting those specifications and the necessary quality standards are created. At Frito-Lay, quality begins at the farm, with onsite inspection of the potatoes used in Ruffles and the corn used in Fritos. Quality continues throughout the manufacturing process, with visual inspections and with statistical process control of product variables such as oil, moisture, seasoning, salt, thickness, and weight. Additional quality evaluations are conducted throughout shipment, receipt, production, packaging, and delivery.

The production process at Frito-Lay is designed for large volumes and small variety, using expensive special-purpose equipment, and with swift movement of material through the facility. Product-focused facilities, such as Frito-Lay's, typically have high capital costs, tight schedules, and rapid processing. Frito-Lay's facilities are located regionally to aid in the rapid delivery of products because freshness is a critical issue. Sanitary issues and necessarily fast processing of products put a premium on an efficient layout. Production lines are designed for balanced throughput and high utilization. Cross-trained workers, who handle a variety of production lines, have promotion paths identified for their particular skill set. The company rewards employees with medical, retirement, and education plans. Its turnover is very low.

The supply chain is integral to success in the food industry; vendors must be chosen with great care. Moreover, the finished food product is highly dependent on perishable raw materials. Consequently, the supply chain brings raw material (potatoes, corn, etc.) to the plant securely and rapidly to meet tight production schedules. For instance, from the time that potatoes are picked in St. Augustine, Florida, until they are unloaded at the Orlando plant, processed, packaged, and shipped from the plant is under 12 hours. The requirement for fresh product requires on-time, just-in-time deliveries combined with both low raw material and finished goods inventories. The continuous-flow nature of the specialized equipment in the production process permits little work-in-process inventory. The plants usually run 24/7. This means that there are four shifts of employees each week.

Tight scheduling to ensure the proper mix of fresh finished goods on automated equipment requires reliable systems and effective maintenance. Frito-Lay's workforce is trained to recognize problems early, and professional maintenance personnel are available on every shift. Downtime is very costly and can lead to late deliveries, making maintenance a high priority.

Discussion Questions*

1. From your knowledge of production processes and from the case and the video, identify how each of the 10 decisions of OM is applied at Frito-Lay.
2. How would you determine the productivity of the production process at Frito-Lay?
3. How are the 10 decisions of OM different when applied by the operations manager of a production process such as Frito-Lay versus a service organization such as Hard Rock Cafe (see the Hard Rock Cafe video case below)?

*You may wish to view the video that accompanies this case before addressing these questions.

Hard Rock Cafe: Operations Management in Services

Video Case

In its 45 years of existence, Hard Rock has grown from a modest London pub to a global power managing 150 cafes, 13 hotels/casinos, and live music venues. This puts Hard Rock firmly in the service industry—a sector that employs over 75% of the people in the U.S. Hard Rock moved its world headquarters to Orlando, Florida, in 1988 and has expanded to more than 40 locations throughout the U.S., serving over 100,000 meals each day. Hard Rock chefs are modifying the menu from classic American—burgers and chicken wings—to include higher-end items such as stuffed veal chops and lobster tails. Just as taste in music changes over time, so does Hard Rock Cafe, with new menus, layouts, memorabilia, services, and strategies.

At Orlando's Universal Studios, a traditional tourist destination, Hard Rock Cafe serves over 3,500 meals each day. The cafe employs about 400 people. Most are employed in the restaurant, but some work in the retail shop. Retail is now a standard and increasingly prominent feature in Hard Rock Cafes (since close to 48% of revenue comes from this source). Cafe employees include kitchen and waitstaff, hostesses, and bartenders. Hard Rock employees are not only competent in their job skills but are also passionate about music and have engaging personalities. Cafe staff is scheduled down to 15-minute intervals to meet seasonal and daily demand changes in the tourist environment of Orlando. Surveys are done on a regular basis to evaluate quality of food and service at the cafe. Scores are rated on a 1-to-7 scale, and if the score is not a 7, the food or service is a failure.

Hard Rock is adding a new emphasis on live music and is redesigning its restaurants to accommodate the changing tastes. Since Eric Clapton hung his guitar on the wall to mark his favorite bar stool, Hard Rock has become the world's leading collector and exhibitor of rock 'n' roll memorabilia, with changing exhibits at its cafes throughout the world. The collection includes 70,000 pieces, valued at $40 million. In keeping with the times, Hard Rock also maintains a Web site, www.hardrock.com, which receives over 100,000 hits per week, and a weekly cable television

program on VH1. Hard Rock's brand recognition, at 92%, is one of the highest in the world.

Discussion Questions*

1. From your knowledge of restaurants, from the video, from the *Global Company Profile* that opens this chapter, and from the case itself, identify how each of the 10 OM strategy decisions is applied at Hard Rock Cafe.
2. How would you determine the productivity of the kitchen staff and waitstaff at Hard Rock?
3. How are the 10 OM strategy decisions different when applied to the operations manager of a service operation such as Hard Rock versus an automobile company such as Ford Motor Company?

*You may wish to view the video that accompanies this case before addressing these questions.

- **Additional Case Study:** Visit MyOMLab for these case studies:
  National Air Express: Introduces the issue of productivity, productivity improvement, and measuring productivity.
  Zychol Chemicals Corp.: The production manager must prepare a productivity report, which includes multifactor analysis.

Endnotes

1. *Efficiency* means doing the job well—with a minimum of resources and waste. Note the distinction between being *efficient*, which implies doing the job well, and *effective*, which means doing the right thing. A job well done—say, by applying the 10 strategic decisions of operations management—helps us be *efficient*; developing and using the correct strategy helps us be *effective*.
2. U.S. Dept. of Labor, 2015: www.bls.gov/lpc/
3. The quality and time period are assumed to remain constant.

Chapter 1 *Rapid* Review

Main Heading	Review Material	MyOMLab
WHAT IS OPERATIONS MANAGEMENT? (p. 4)	■ **Production**—The creation of goods and services ■ **Operations management (OM)**—Activities that relate to the creation of goods and services through the transformation of inputs to outputs	Concept Questions: 1.1–1.4 **VIDEOS 1.1 and 1.2** OM at Hard Rock OM at Frito-Lay
ORGANIZING TO PRODUCE GOODS AND SERVICES (pp. 4–6)	All organizations perform three functions to create goods and services: **1.** *Marketing*, which generates demand **2.** *Production/operations,* which creates the product **3.** *Finance/accounting,* which tracks how well the organization is doing, pays the bills, and collects the money	Concept Questions: 2.1–2.4
THE SUPPLY CHAIN (p. 6)	■ **Supply chain**—A global network of organizations and activities that supply a firm with goods and services	Concept Questions: 3.1–3.4
WHY STUDY OM? (pp. 6–7)	We study OM for four reasons: **1.** To learn how people organize themselves for productive enterprise **2.** To learn how goods and services are produced **3.** To understand what operations managers do **4.** Because OM is a costly part of an organization	Concept Questions: 4.1–4.2
WHAT OPERATIONS MANAGERS DO (pp. 7–8)	Ten **OM strategic decisions** are required of operations managers: **1.** Design of goods and services **2.** Managing quality **3.** Process strategy **4.** Location strategies **5.** Layout strategies **6.** Human resources **7.** Supply chain management **8.** Inventory management **9.** Scheduling **10.** Maintenance About 40% of *all* jobs are in OM. Operations managers possess job titles such as plant manager, quality manager, process improvement consultant, and operations analyst.	Concept Questions: 5.1–5.4
THE HERITAGE OF OPERATIONS MANAGEMENT (pp. 8–10)	Significant events in modern OM can be classified into six eras: **1.** Early concepts (1776–1880)—Labor specialization (Smith, Babbage), standardized parts (Whitney) **2.** Scientific management (1880–1910)—Gantt charts (Gantt), motion and time studies (Gilbreth), process analysis (Taylor), queuing theory (Erlang) **3.** Mass production (1910–1980)—Assembly line (Ford/Sorensen), statistical sampling (Shewhart), economic order quantity (Harris), linear programming (Dantzig), PERT/CPM (DuPont), material requirements planning **4.** Lean production (1980–1995)—Just-in-time, computer-aided design, electronic data interchange, total quality management, Baldrige Award, empowerment, kanbans **5.** Mass customization (1995–2005)—Internet/e-commerce, enterprise resource planning, international quality standards, finite scheduling, supply-chain management, mass customization, build-to-order, radio frequency identification (RFID) **6.** Globalization era (2005–2020)—Global supply chains, growth of transnational organizations, instant communications, sustainability, ethics in a global work force, logistics and shipping	Concept Questions: 6.1–6.4
OPERATIONS FOR GOODS AND SERVICES (pp. 11–13)	■ **Services**—Economic activities that typically produce an intangible product (such as education, entertainment, lodging, government, financial, and health services). Almost all services and almost all goods are a mixture of a service and a tangible product. ■ **Service sector**—The segment of the economy that includes trade, financial, lodging, education, legal, medical, and other professional occupations. Services now constitute the largest economic sector in postindustrial societies. The huge productivity increases in agriculture and manufacturing have allowed more of our economic resources to be devoted to services. Many service jobs pay very well.	Concept Questions: 7.1–7.4

Main Heading	Review Material	MyOMLab
THE PRODUCTIVITY CHALLENGE (pp. 13–18)	■ **Productivity**—The ratio of outputs (goods and services) divided by one or more inputs (such as labor, capital, or management) High production means producing many units, while high productivity means producing units efficiently. Only through increases in productivity can the standard of living of a country improve. U.S. productivity has averaged a 2.5% increase per year for over a century. $\text{Single-factor productivity} = \frac{\text{Units produced}}{\text{Input used}}$ (1-1) ■ **Single-factor productivity**—Indicates the ratio of goods and services produced (outputs) to one resource (input). ■ **Multifactor productivity**—Indicates the ratio of goods and services produced (outputs) to many or all resources (inputs). Multifactor productivity $= \frac{\text{Output}}{\text{Labor} + \text{Material} + \text{Energy} + \text{Capital} + \text{Miscellaneous}}$ (1-2) Measurement problems with productivity include: (1) the quality may change, (2) external elements may interfere, and (3) precise units of measure may be lacking. ■ **Productivity variables**—The three factors critical to productivity improvement are labor (10%), capital (38%), and management (52%). ■ **Knowledge society**—A society in which much of the labor force has migrated from manual work to work based on knowledge	Concept Questions: 8.1–8.4 Problems: 1.1–1.17 Virtual Office Hours for Solved Problems: 1.1, 1.2
CURRENT CHALLENGES IN OPERATIONS MANAGEMENT (pp. 18–19)	Some of the current challenges for operations managers include: ■ Global focus; international collaboration ■ Supply chain partnering; joint ventures; alliances ■ Sustainability; green products; recycle, reuse ■ Rapid product development; design collaboration ■ Mass customization; customized products ■ Lean operations; continuous improvement and elimination of waste	Concept Questions: 9.1–9.4
ETHICS, SOCIAL RESPONSIBILITY, AND SUSTAINABILITY (p. 19)	Among the many ethical challenges facing operations managers are (1) efficiently developing and producing safe, quality products; (2) maintaining a clean environment; (3) providing a safe workplace; and (4) honoring stakeholder commitments. ■ **Stakeholders**—Those with a vested interest in an organization	Concept Question: 10.1

Self Test

■ **Before taking the self-test,** refer to the learning objectives listed at the beginning of the chapter and the key terms listed at the end of the chapter.

LO 1.1 Productivity increases when:
- **a)** inputs increase while outputs remain the same.
- **b)** inputs decrease while outputs remain the same.
- **c)** outputs decrease while inputs remain the same.
- **d)** inputs and outputs increase proportionately.
- **e)** inputs increase at the same rate as outputs.

LO 1.2 Services often:
- **a)** are tangible.
- **b)** are standardized.
- **c)** are knowledge based.
- **d)** are low in customer interaction.
- **e)** have consistent product definition.

LO 1.3 Productivity:
- **a)** can use many factors as the numerator.
- **b)** is the same thing as production.
- **c)** increases at about 0.5% per year.
- **d)** is dependent upon labor, management, and capital.
- **e)** is the same thing as effectiveness.

LO 1.4 Single-factor productivity:
- **a)** remains constant.
- **b)** is never constant.
- **c)** usually uses labor as a factor.
- **d)** seldom uses labor as a factor.
- **e)** uses management as a factor.

LO 1.5 Multifactor productivity:
- **a)** remains constant.
- **b)** is never constant.
- **c)** usually uses substitutes as common variables for the factors of production.
- **d)** seldom uses labor as a factor.
- **e)** always uses management as a factor.

LO 1.6 Productivity increases each year in the U.S. are a result of three factors:
- **a)** labor, capital, management
- **b)** engineering, labor, capital
- **c)** engineering, capital, quality control
- **d)** engineering, labor, data processing
- **e)** engineering, capital, data processing

Answers: LO 1.1. b; LO 1.2. c; LO 1.3. d; LO 1.4. c; LO 1.5. c; LO 1.6. a.