sinology/Moment/Getty Images

Introduction to Operations and Supply Chain Management

LEARNING OBJECTIVES

After reading this chapter, you will be able to:

1.1 Describe what the operations function is and how it relates to other business functions.

1.2 Discuss the key factors that have contributed to the evolution of operations and supply chain management.

1.3 Discuss how and why businesses operate globally and the importance of globalization in supply chain management.

1.4 Calculate and interpret productivity measures used for measuring competitiveness.

1.5 Discuss the importance of operations and supply chain management to a firm's strategy and the process of developing, aligning, and deploying strategy.

A Global Chip Shortage

It's a tiny thing – a computer chip – with a massive influence on the world economy and our everyday lives. Production of computer chips (i.e., semiconductors) is concentrated in huge factory operations in Asia. When flowing normally, the supply chain for chips is reliable. Orders are arranged long in advance of new product introductions for cellphones, computers,

gaming consoles, and automobiles. Supply of these tiny components continues throughout the life cycle of the product, uninterrupted and invisible to the consumer. But when supply is delayed due to pandemic-related labor shortages, dock closures, natural disasters or global conflict, and coveted products that use these chips are also delayed, consumers begin to notice supply chains and their global reach.

We want you to notice supply chains, too, and to be curious about how products, some with hundreds of components, are designed, made, and delivered. To help examine the operations and supply chain process, we open each chapter with a vignette about a common product, in this case, computer chips, following their production and distribution up and down the supply chain from sand and silicon to the latest consumer and industrial products.

Join us on this journey into the fascinating world of semiconductors, electronics, high-tech industries, clamoring customers, and global supply chains. Learn about the network of companies and countries, financial markets and local markets, makers and shippers, and global trade policies and agreements that bring products to your door.

Operations management is the design, operation, and improvement of processes and systems that produce goods and services. Increasingly, these processes are taking place outside the boundaries of a traditional enterprise. Thus, while today's managers need to understand how to manage operations efficiently within their own firm, they also need to develop skills in coordinating operations across a global supply chain.

In this text, you will learn how to analyze processes, ensure quality, create value, and manage the flow of information, products and services across a network of customers, enterprises, and supply chain partners.

1.1 The Operations Function

LEARNING OBJECTIVE 1.1

Describe what the operations function is and how it relates to other business functions.

operations A function or system that transforms inputs into outputs of greater value.

operations management The design, operation, and improvement of productive systems.

value chain A series of activities from supplier to customer that add value to a product or service.

Operations is often defined as a transformation process. As shown in **Figure 1.1**, inputs (such as material, machines, labor, management, and capital) are transformed into outputs (goods and services). Requirements and feedback from customers are used to adjust factors in the transformation process, which may in turn alter inputs. In **operations management**, we try to ensure that the transformation process is performed efficiently and that the output is of greater *value* than the sum of the inputs. Thus, the role of operations is to create value. The transformation process itself can be viewed as a series of activities along a **value chain** extending from supplier to customer.

The input–transformation–output process is characteristic of a wide variety of operating systems. In an automobile factory, sheet steel is formed into different shapes, painted and finished, and then assembled with thousands of component parts to produce a working

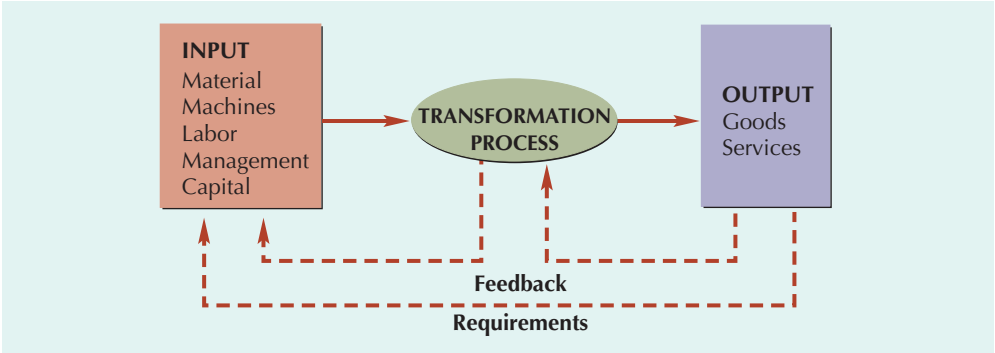

FIGURE 1.1 **Operations as a Transformation Process**

automobile. In an aluminum factory, various grades of bauxite are mixed, heated, and cast into ingots of different sizes. In a hospital, patients are helped to become healthier individuals through special care, meals, medication, lab work, and surgical procedures. Obviously, "operations" can take many different forms. The transformation process can be

physical,	as in manufacturing operations;
locational,	as in transportation or warehouse operations;
exchange,	as in retail operations;
physiological,	as in healthcare;
psychological,	as in entertainment; or
informational,	as in communication.

Activities in operations management (OM) include organizing work, selecting processes, arranging layouts, locating facilities, designing jobs, measuring performance, controlling quality, scheduling work, managing inventory, and planning production. Operations managers deal with people, technology, and deadlines. These managers need good technical, conceptual, and behavioral skills. Their activities are closely intertwined with other functional areas of a firm.

The four primary functional areas of a firm are marketing, finance, operations, and human resources. As shown in **Figure 1.2**, for most firms, operations is the technical core or "hub" of the organization, interacting with the other functional areas and suppliers to produce goods and provide services for customers. For example, to obtain monetary resources for production, operations provides finance and accounting with production and inventory data, capital budgeting requests, and capacity expansion and technology plans. Finance pays workers and suppliers, performs cost analyses, approves capital investments, and communicates requirements of shareholders and financial markets. Marketing provides operations with sales forecasts, customer orders, customer feedback, and information on promotions and product development. Operations, in turn, provides marketing with information on product or service availability, lead-time estimates, order status, and delivery schedules. For personnel needs, operations relies on human resources to recruit, train, evaluate, and compensate workers and to assist with legal issues, job design, and union activities. Outside the organization, operations interacts with suppliers to order materials or services, communicate production and delivery requirements, certify quality, negotiate contracts, and finalize design specifications.

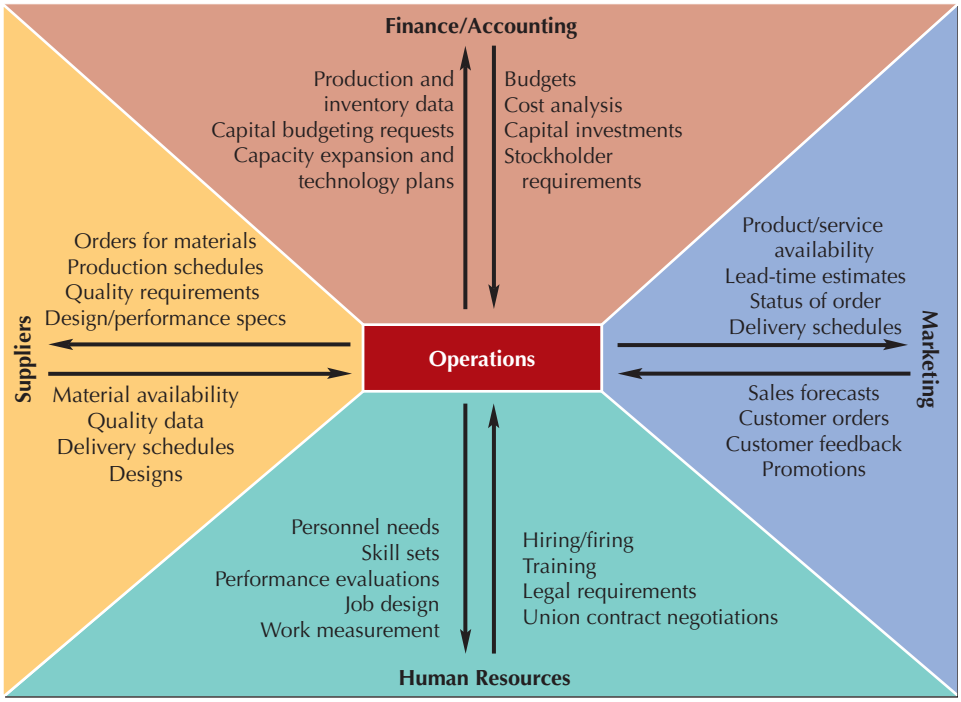

FIGURE 1.2 **Operations as the Technical Core**

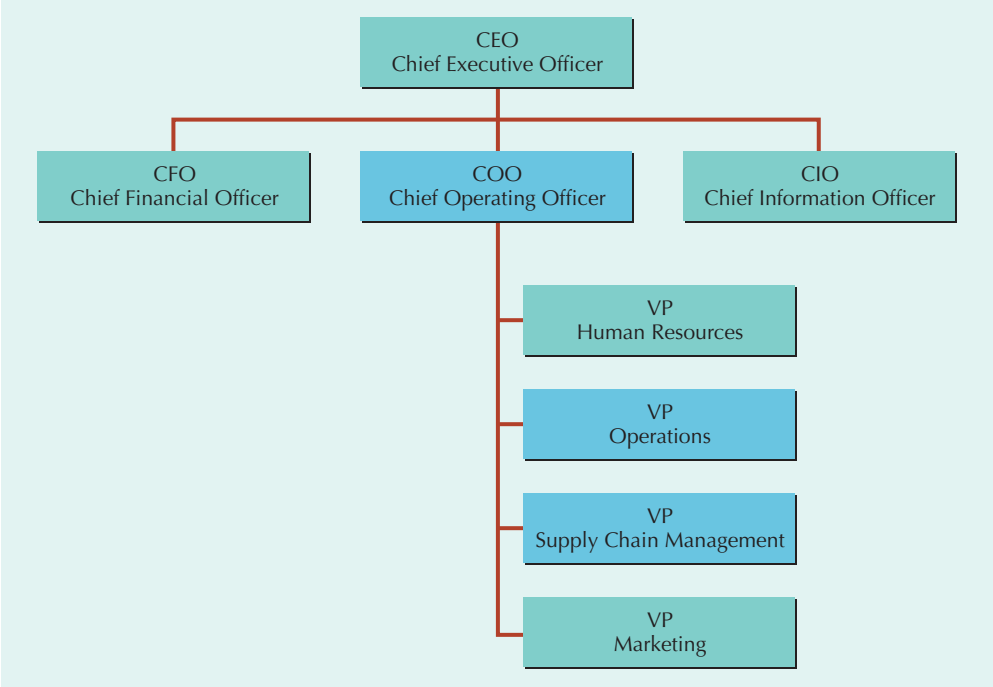

FIGURE 1.3 Sample Organizational Structure

As a field of study, operations brings together many disciplines and provides an integrated view of business organizations. Operations and supply chain managers are in demand in business, industry, and government. Chief operating officers (COOs) run major corporations as shown in **Figure 1.3**, vice-presidents of operations and supply chain management oversee scores of departments, facilities, and employees. Typical jobs for new college graduates include business process analyst, systems analyst, project manager, unit supervisor, supply chain analyst, purchasing or materials manager, quality specialist, planner or scheduler, and logistics specialist or manager. Even if you do not pursue a career in operations or supply chain management, you'll be able to use the ideas you learn in this course to organize work, ensure quality, and manage processes. We use "Along the Supply Chain" boxes dispersed throughout the text to describe what operations and supply chain managers do, to discuss issues along the supply chain, and to highlight companies that effectively manage their internal operations and their external supply chain partners.

Along the Supply Chain

Operations and Supply Chain Management in Healthcare, Retail, and R&D

Healthcare. Claire Thielen is an operations analyst in healthcare who specializes in decision support, process improvement, and organizational performance. She facilitates interdisciplinary teams as they pursue continuous quality improvement projects and analyzes methods and systems for managing information. Her projects include determining staffing patterns and workflow for computerized scheduling systems; consolidating policies, procedures, and practices for hospital mergers; developing and implementing balanced scorecards and benchmarking reports; designing clinical studies of new medication effectiveness; and conducting training sessions on process mapping and analysis. Claire Thielen improves quality, productivity, and information in the healthcare industry.

Retail. Ada Liu is a division manager for Li & Fung, a global sourcing company. She coordinates global production and distribution for major players in the garment industry. For one particular trouser order, she had the fabric woven in China (for their unique dyeing process), chose fasteners from Hong Kong and Korea (for their durability), and sent the raw materials to Guatemala for sewing (for their basic skills, low cost, and proximity to the United States). If problems should arise, Liu can reroute the order to one of its 7500 suppliers in 37 countries. Ada Liu is a supply chain expert for Li & Fung.

R&D. Erin Hiller is a food technologist at a major branded food manufacturer. She works in research and development (R&D) devising, developing, and testing new products. For part of her job, she travels to manufacturing plants across the country to monitor the ramp-up of production for consumer food products with new formulas or ingredients. She verifies that correct procedures are being

followed, samples and tests output for quality and consistency, and revises formulaic recipes as required. She also evaluates new and emerging technologies and determines whether they would be beneficial to product lines and manufacturing operations. Erin Hiller brings fresh designs to the market, keeps operations up to date, and ensures the safety and quality of the foods you eat every day.

Sources: Adapted from Claire Theilen, LinkedIn, accessed January 4, 2019; Joanne Lee-Young, "Furiously Fast Fashions," *The Industry Standard Magazine*, (June 22, 2001); Interview with Erin Hiller (January 3, 2019).

Now that you are aware of how operations might relate to your interests, let's take a brief look at how the field of operations and supply chain management (OSM) has evolved to its present state.

1.2 The Evolution of Operations and Supply Chain Management

LEARNING OBJECTIVE 1.2

Discuss the key factors that have contributed to the evolution of operations and supply chain management.

Although history is full of amazing production feats (the pyramids of Egypt, the Great Wall of China, the roads and aqueducts of Rome), the widespread production of consumer goods—and thus, operations management—did not begin until the Industrial Revolution in the 1700s. Prior to that time, skilled craftspersons and their apprentices fashioned goods for individual customers from studios in their own homes. Every piece was unique, hand-fitted, and made entirely by one person, a process known as **craft production**. Although *craft production* still exists today, the availability of coal, iron ore, and steam power set into motion a series of industrial inventions that revolutionized the way work was performed. Great mechanically powered machines replaced the laborer as the primary factor of production and brought workers to a central location to perform tasks under the direction of an "overseer" in a place called a "factory." The revolution first took hold in textile mills, grain mills, metalworking, and machine-making facilities.

craft production The process of handcrafting products or services for individual customers.

Around the same time, Adam Smith's *Wealth of Nations* (1776) proposed the **division of labor**, in which the production process was broken down into a series of small tasks, each performed by a different worker. The specialization of the workers on limited, repetitive tasks allowed them to become very proficient at those tasks and further encouraged the development of specialized machinery.

division of labor Dividing a job into a series of small tasks each performed by a different worker.

The introduction of **interchangeable parts** by Eli Whitney (1790s) allowed the manufacture of firearms, clocks, watches, sewing machines, and other goods to shift from customized one-at-a-time production to volume production of standardized parts. This meant the factory needed a system of measurements and inspection, a standard method of production, and supervisors to check the quality of the worker's production.

interchangeable parts The standardization of parts initially as replacement parts enabled mass production.

Advances in technology continued through the 1800s. Cost accounting and other control systems were developed, but management theory and practice were virtually nonexistent.

In the early 1900s, an enterprising laborer (and later chief engineer) at Midvale Steel Works named Frederick W. Taylor approached the management of work as a science. Based on observation, measurement, and analysis, he identified the best method for performing each job. Once determined, the methods were standardized for all workers, and economic incentives were established to encourage workers to follow the standards. Taylor's philosophy became known as **scientific management**. His ideas were embraced and extended by efficiency experts Frank and Lillian Gilbreth, Henry Gantt, and others. One of Taylor's biggest advocates was Henry Ford.

scientific management The systematic analysis of work methods proposed by Frederick Taylor in the early 1900s.

Henry Ford applied scientific management to the production of the Model T in 1913 and reduced the time required to assemble a car from a high of 728 hours to 1½ hours. A Model T chassis moved slowly down a conveyor belt with six workers walking alongside it, picking up parts from carefully spaced piles on the floor and fitting them to the chassis.[1] The short assembly time per car allowed the Model T to be produced in high volumes, or "en masse," yielding the name **mass production**.

mass production The high-volume production of a standardized product for a mass market.

American manufacturers became adept at mass production over the next 50 years and easily dominated manufacturing worldwide. The human relations movement of the 1930s, led by Elton Mayo and the Hawthorne studies, introduced the idea that worker motivation, as well as the technical aspects of work, affected productivity. Theories of motivation were developed by Frederick Herzberg, Abraham Maslow, Douglas McGregor, and others. Quantitative models and techniques spawned by the operations research groups of World War II continued to develop and were applied successfully to manufacturing and services. Computers and automation led still another upsurge in technological advancements applied to operations. These events are summarized in **Table 1.1**.

From the Industrial Revolution through the 1960s, the United States was the world's greatest producer of goods and services, as well as the major source of managerial and technical expertise. But in the 1970s and 1980s, industry by industry, U.S. manufacturing superiority was challenged by lower costs and higher quality from foreign manufacturers, led by Japan. Several studies published during those years confirmed what the consumer already knew—U.S.-made products of that era were inferior and could not compete on the world market. Early rationalizations that the Japanese success in manufacturing was a cultural phenomenon were disproved by the successes of Japanese-owned plants in the United States, such as the Matsushita purchase of a failing Quasar television plant in Chicago from Motorola. Part of the purchase contract specified that Matsushita had to retain the entire hourly workforce of 1000 persons. After only two years, with the identical workers, half the management staff, and little or no capital investment, Matsushita doubled production, cut assembly repairs from 130% to 6%, and reduced warranty costs from $16 million a year to $2 million a year. You can bet Motorola took notice, as did the rest of U.S. industry.

quality revolution An emphasis on quality and the strategic role of operations.

The **quality revolution** brought with it a realization that production should be tied to consumer demand. Product proliferation, shortened product lifecycles, shortened product development times, changes in technology, more customized products, and segmented markets did not fit mass production assumptions. Using a concept known as just-in-time, Toyota changed the rules of production from mass production to **lean production**, a system that prizes flexibility (rather than efficiency) and quality (rather than quantity).

lean production An adaptation of mass production that prizes quality and flexibility.

The renewed emphasis on quality and the *strategic importance* of operations made some U.S. companies competitive again. Others continued to stagnate, buoyed temporarily by the expanding economies of the Internet era and globalization. Productivity soared as return on investment in information technology finally came to fruition. New types of businesses and business models emerged, such as Amazon, Google, and eBay, and companies used the Internet to connect with customers and suppliers around the world. The inflated expectations of the dot-com era came to an end and, coupled with the terrorist attacks of 9/11 and their aftermath, brought many companies back to reality, searching for ways to cut costs and survive in a global economy. They found relief in the emerging economies of China and India and began accelerating the outsourcing of not only goods production, but also services, such as information technology, call centers, and other business processes. The outsourcing of business processes brought with it a new awareness of business-to-business (B2B) services.

supply chain management Managing the flow of information, products, and services across a network of customers, enterprises, and supply chain partners.

With more and more activities taking place outside the enterprise in factories, distribution centers, offices, and stores overseas, managers needed to develop skills in coordinating operations across a global supply chain. The field of **supply chain management** was born to manage the flow of information, products, and services across a network of customers, enterprises, and supply chain partners. In Figure 1.1, we depicted operations as a transformation process.

[1]David Halberstam, *The Reckoning* (New York: William Morrow, 1986), pp. 79–81.

TABLE 1.1 Historical Events in Operations Management

Era	Events/Concepts	Dates	Originator
Industrial Revolution	Steam engine	1769	James Watt
	Division of labor	1776	Adam Smith
	Interchangeable parts	1790	Eli Whitney
Scientific Management	Principles of scientific management	1911	Frederick W. Taylor
	Time and motion studies	1911	Frank and Lillian Gilbreth
	Activity scheduling chart	1912	Henry Gantt
	Moving assembly line	1913	Henry Ford
Human Relations	Hawthorne studies	1930	Elton Mayo
	Motivation theories	1940s	Abraham Maslow
		1950s	Frederick Herzberg
		1960s	Douglas McGregor
Operations Research	Linear programming	1947	George Dantzig
	Digital computer	1951	Remington Rand
	Simulation, waiting line theory, decision theory, PERT/CPM	1950s	Operations research groups
	MRP	1960s	Joseph Orlicky, IBM, and others
	EDI,CIM	1970s	Auto industry, DARPA
Quality Revolution	JIT (just-in-time)	1970s	Taiichi Ohno (Toyota)
	TQM (total quality management)	1980s	W. Edwards Deming, Joseph Juran
	Strategy and operations		Wickham Skinner, Robert Hayes
	Reengineering	1990s	Michael Hammer, James Champy
	Six Sigma	1990s	GE, Motorola
Internet Revolution	Internet, WWW	1990s	ARPANET, Tim Berners-Lee
	ERP, supply chain management		SAP, Oracle, Dell, Apple
	E-commerce, social networking	2000s	Amazon, Yahoo!, eBay, Google, Facebook, YouTube, Twitter, etc.
Globalization	World Trade Organization	1990s	GATT, 164 countries
	European Union		Europe
	Global supply chains	2000s	China, India
	Outsourcing		Emerging economies
Sustainability and Resilience	Global warming	2010s	Numerous companies, scientists, statesmen, and governments
	Carbon footprint		
	Green products	Today	
	Corporate social responsibility (CSR)		World Economic Forum, Kyoto Protocol
	UN Global Compact		United Nations
	Global pandemic (Loss of 6 million people worldwide)		
Digital Revolution	Big data, 3D printing, Internet of Things (IoT), Smart cities,	Today	Google, Apache, P&G, MIT, NSF, Amazon, and others
	Autonomous vehicles, drones, Privacy and security		

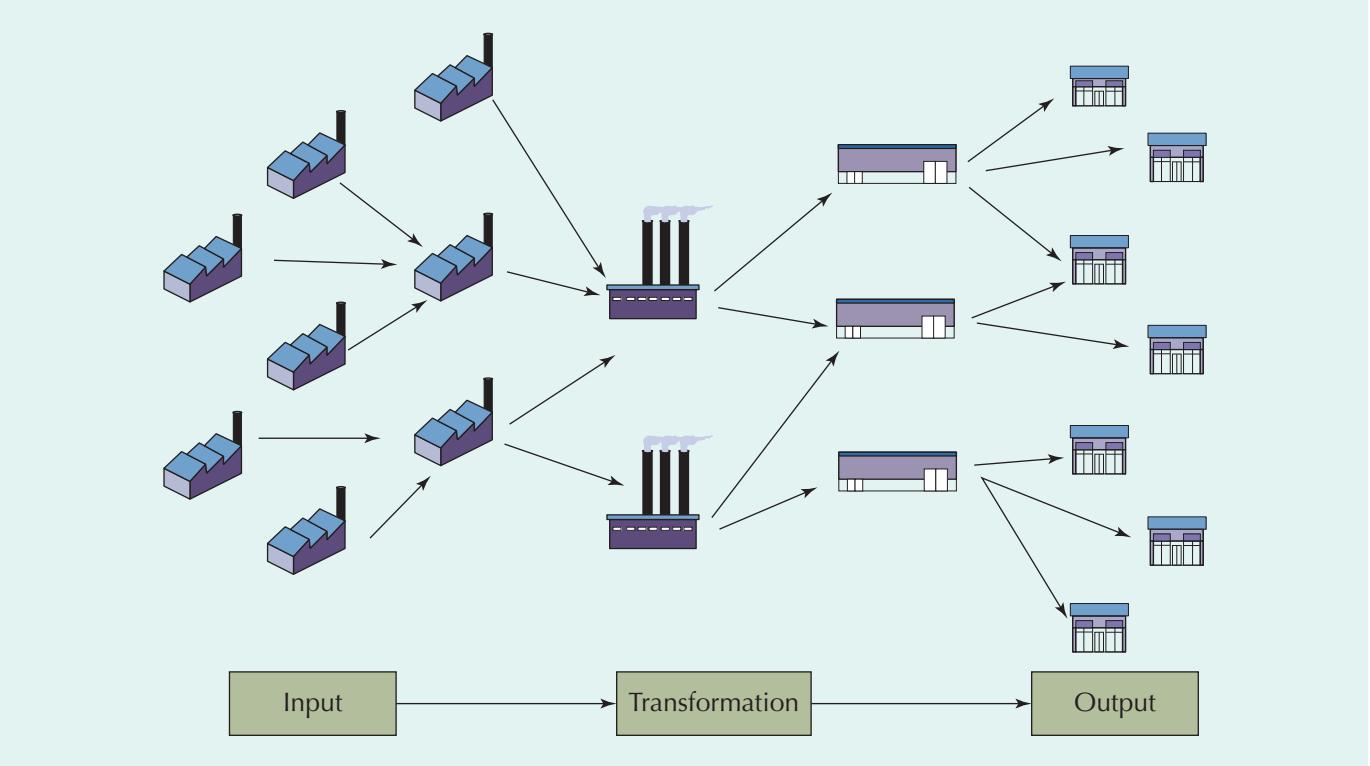

FIGURE 1.4 **Supply Chain Management**

Extending that analogy in **Figure 1.4**, supply chain management concentrates on the input and output sides of transformation processes. Increasingly, however, as the transformation process is performed by suppliers who may be located around the world, the supply chain manager is also concerned with the timeliness, quality, and legalities of the supplier's operations.

The era of globalization was in full swing in 2008 when a financial crisis brought on by risky loans, inflated expectations, and unsavory financial practices brought the global economy to a standstill. Operations and supply chain management practices based on assumptions of growth had to be reevaluated for declining markets and resources. Companies began to reassess the value of their business, their customers, and their suppliers with an eye toward focusing on the most critical factors to sustain their business through the downturn.

Thus began the *era of sustainability*, in which countries, companies, and industries evaluated what it takes to sustain the health of their enterprise or people in the long term. This is especially important in light of climate change, natural and man-made disasters, scarcity of resources, and the competitive landscape. Nike CEO Mark Parker calls sustainability the "defining issue for our generation."

resilience The ability to bounce back, change, or adapt in response to a disaster, failure, or disruption.

A concept related to sustainability is **resilience**, the ability to bounce back, change, or adapt in response to a disaster, failure, or disruption. Globalization has increased the risk of disruptions in operations and supply chain activities, but it has also provided more flexibility in responding to disruptions. Resilience became an important battle cry as the world dealt with a global pandemic and a subsequent global recession. Companies that can embed resilience into their processes stand a better chance of recovering quickly when a severe disruption occurs.

In the midst of a global concern about trade and sustainability comes dramatic new technology ushering in the *digital revolution*. Smart materials, smartphones, smart appliances, smart cars, even smart cities contain sensors that collect data, connect with networks, and have the ability to control processes and affect behavior. This explosion of the Internet of Things (IoT) has been accompanied by new platforms for consuming products and services, the immediacy of which has raised expectations and amped up innovation. Wearable technology, 3D printing, 5G networks, the sharing economy, and autonomous vehicles are just some of the results. This is indeed an exciting time for innovation and technology.

We discuss technology at length in Chapter 6 of the text but we should note that new technologies also bring risk. The ubiquitous collection of huge amounts of data on individuals leads to privacy concerns. Companies permitted to collect data must also be stewards of that data.

Concentrating the power of technology in a few dominant corporations is a risky situation, especially when it may be difficult to regulate industries whose technology may not be fully understood. The digital revolution also highlights a digital divide that may form between those who can afford the new technology and those who cannot. It is wise to be diligent as we make technology decisions for ourselves, our communities, and our nation. In the next section, we delve more deeply into the effect of globalization on operations and supply chain management.

1.3 Globalization

LEARNING OBJECTIVE 1.3

Discuss how and why businesses operate globally, and the importance of globalization in supply chain management.

More than two-thirds of today's businesses operate globally through global markets, global operations, global financing, or global supply chains. Globalization can take the form of selling in foreign markets, producing in foreign lands, purchasing from foreign suppliers, or partnering with foreign firms. Companies "go global" to take advantage of favorable costs, to gain access to international markets, to be more responsive to changes in demand, to build reliable sources of supply, and to keep abreast of the latest trends and technologies.

Falling trade barriers and the Internet paved the way for globalization. The World Trade Organization (WTO) has opened up the heavily protected industries of agriculture, textiles, and telecommunications, and extended the scope of international trade rules to cover services, as well as goods. The European Union (EU) requires that strict quality and environmental standards be met before companies can do business with member countries. Strategic alliances, joint ventures, licensing arrangements, research consortia, supplier partnerships, and direct marketing agreements among global partners have proliferated. However, this high degree of global cooperation is threatened by pandemic-related barriers, scarce resources, broken supply chains, worker shortages, logistics delays, aggressive states, and global conflicts with subsequent sanctions. As companies reevaluate their operations and supply chain strategies in light of these occurrences, it becomes even more apparent how interconnected our supply chains and economic fortunes are. Let's look more closely at the health of the global economy in terms of trade and the manufacture of goods worldwide.

One of the first factors considered in whether to outsource production to other countries is the cost of labor. **Figure 1.5** shows the hourly wage rates (including benefits) in U.S. dollars for production workers in 20 selected countries. Wage rates in Switzerland are the highest at $60 an hour, followed by Norway at almost $49 per hour. The average wage rate in the United States is $39 an hour. Mexico, the Philippines, and India exhibit the lowest wage rates of $3.91,

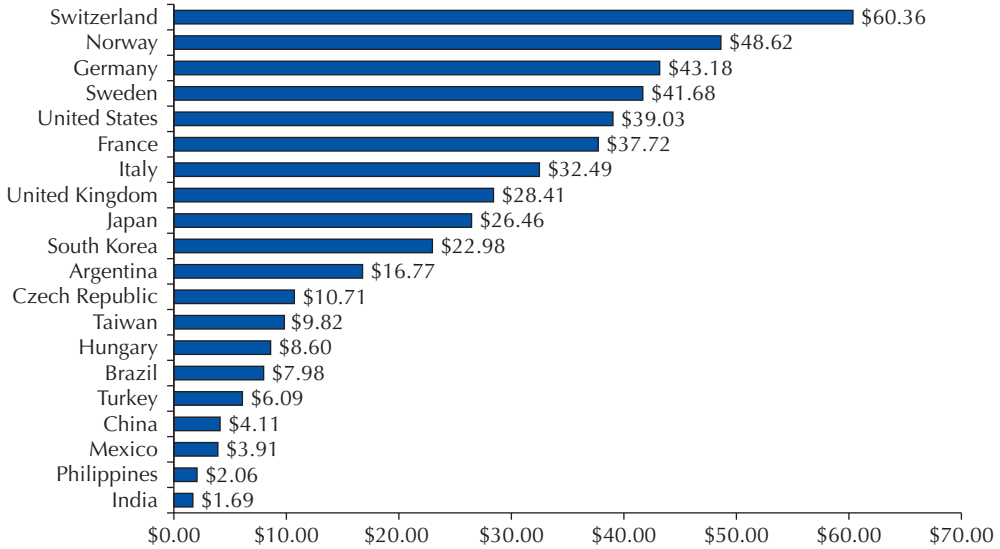

FIGURE 1.5 Hourly Wage Rates of Production Workers in Select Countries

Source: Based on information from the Conference Board Total Economy Database™ (adjusted version), March 2018, (accessed March 28, 2022).

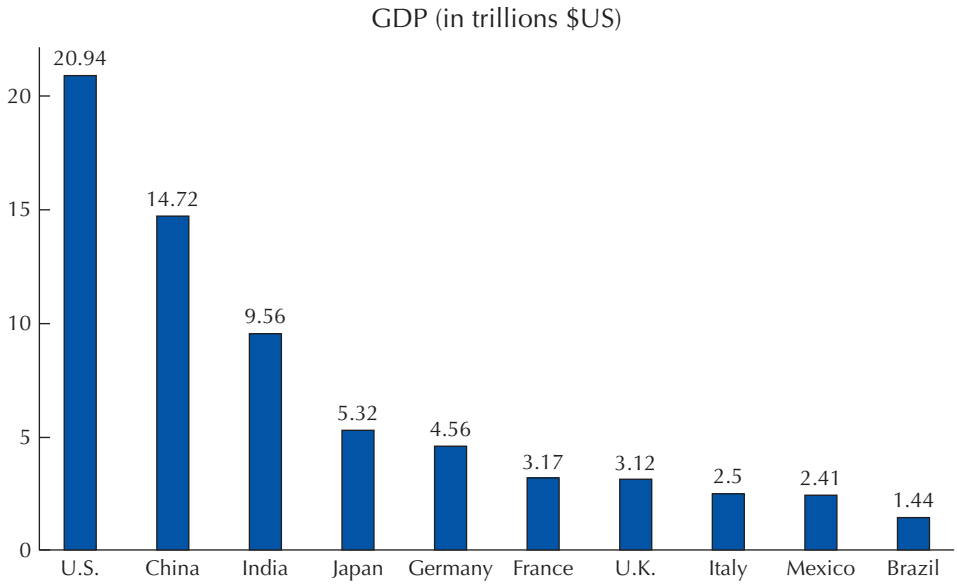

FIGURE 1.6 **GDP, current prices (in $U.S. trillions), 2020**
Source: Data from World Bank, https://data.worldbank.org/indicator/NY.GDP.MKTP.CD (accessed March 28, 2022).

$2.06, and $1.69 an hour. Rising wage rates in China are sending low-cost manufacturers to Asian neighbors Vietnam, Cambodia, and Malaysia. Other manufacturers are returning home in a phenomenon called *near shoring*, which we will discuss later in the text.

Gross domestic product (GDP) measures the total output of goods and services for a country and is widely used over time to measure both the size of an economy and its economic health. **Figure 1.6** shows the GDP for select economies in 2020. Note that the United States and China have the largest economies, followed by India, Japan, and Germany. We see a different dynamic in **Figure 1.7** that shows trade as a % of GDP. Of these major goods-producing economies, Germany and Mexico produce the majority of their goods for consumption elsewhere, 81% and 78%, respectively. China and India have at times traded most of the goods they produced, but today sell only 34% and 36% outside their own country. Japan, the United States, and Brazil have always produced more goods and services for their own markets than for export.

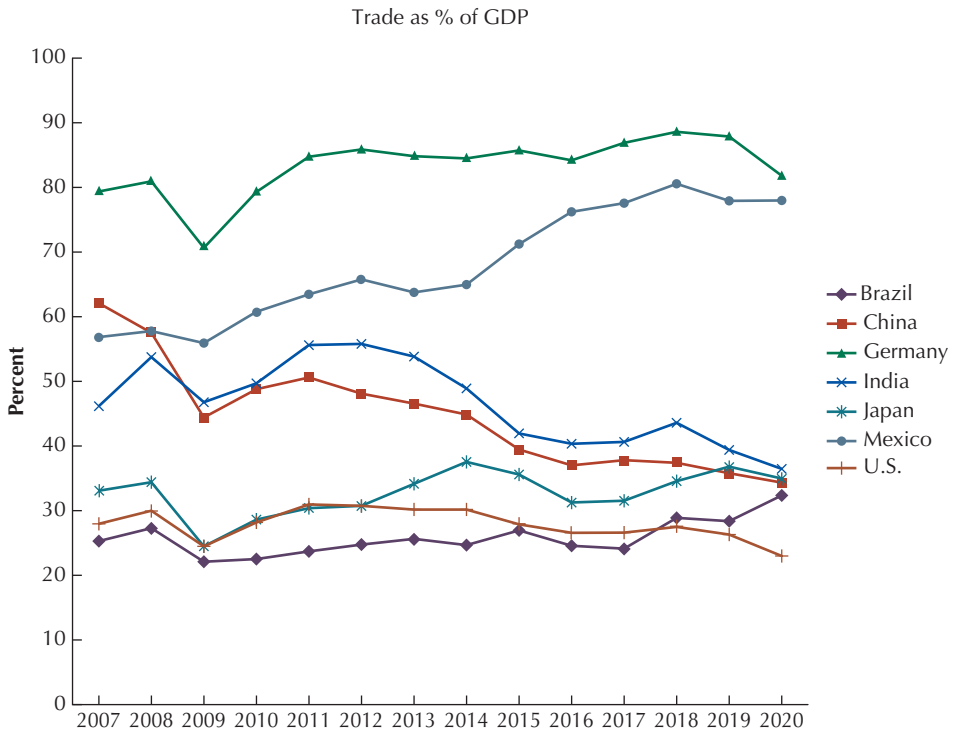

FIGURE 1.7 **Trade as a % of GDP**
Source: Data from World Bank National Accounts data, and OECD National Accounts data files, https://data.worldbank.org/indicator/NE.TRD.GNFS.ZS (accessed March 28, 2022).

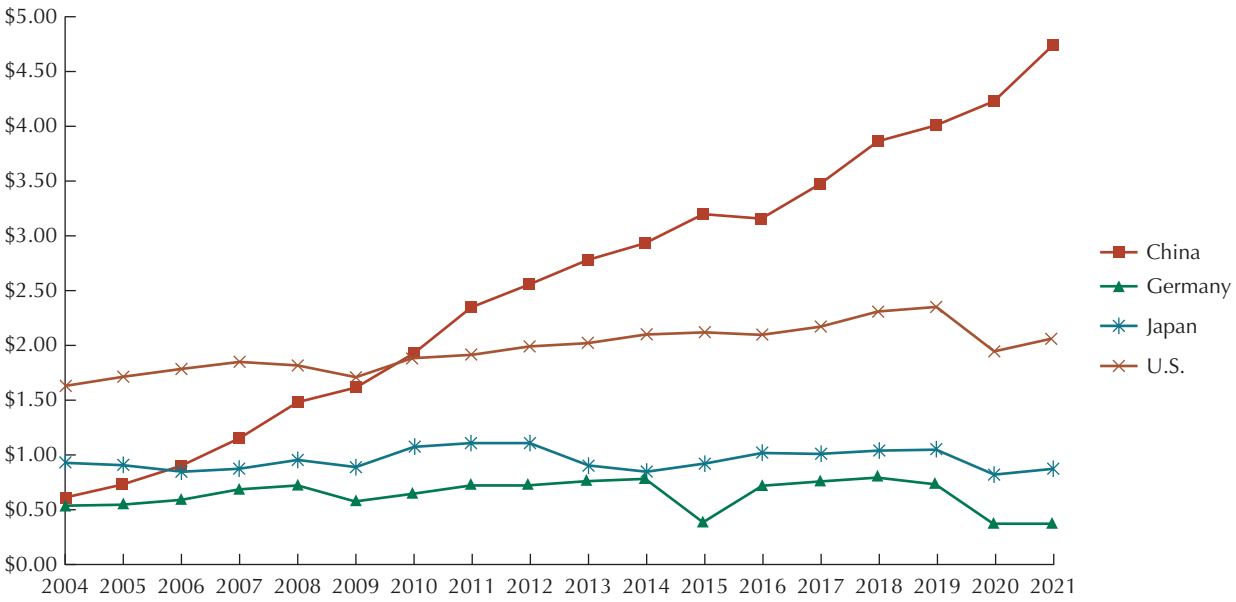

FIGURE 1.8 **Manufacturing Output, 2004–2021 (in $U.S. trillions)**
Source: Data from United Nations, National Accounts Aggregates Database, http://unstats.un.org/unsd/snaama (accessed March 29, 2022).

Finally, let's examine production output from 2004 to 2021 for the world's largest manufacturing economies, shown in **Figure 1.8**. In 2004, China held a slight edge over Germany as the world's third largest manufacturing economy. By 2006, China had surpassed Germany and was tied with Japan as the second largest manufacturer. In 2010, China edged ahead of the United States, producing 19.8% of the world's goods as compared to the United States' 19.4%. Since that time, the manufacturing output of Germany, Japan, and, the United States have remained relatively stable, while China's output has skyrocketed. Today, China produces over $4 trillion worth of manufactured goods per year. The U.S. is second with over $2 trillion, Japan is third at $8 billion and Germany is fourth with $4 billion. Undeniably, China is the world's manufacturing powerhouse.

China employs more production workers than the United States, United Kingdom, Germany, Japan, Italy, Canada, and France combined. Its 1.4 billion people represent not only an immense labor market, but a huge consumer market as well. As China's industrial base multiplies, so does its need for machinery and basic materials, and as more companies move to China, so do their suppliers and their supplier's suppliers. Although initially the preferred location for the production of low-tech goods such as toys, textiles, and furniture, China has moved on to more sophisticated electronics products and appliances, as well as cars, automated vehicles, and sustainable energy products.

The scale of manufacturing in China is mind-boggling. For example, Foxconn (the trade name of Taiwan's Hon Hai Precision Industry Company) has several enormous industrial complexes in mainland China. The Guangdong Province site employs and houses approximately 270,000 workers, with its own dormitories, restaurants, hospital, police force, chicken farm, and soccer stadium. There are 40 separate production facilities "on campus," each dedicated to one of its major customers such as Apple, Dell, Motorola, Sony, Nintendo, and HP. Foxconn is the world's largest electronics manufacturer and China's largest exporter. It also represents a shorter supply chain because it *makes* components as well as *assembles* final products. Currently, Foxconn has expanded production into Mexico and Brazil, and has purchased Sharp Electronics to start offering its own brand of TVs, PCs, and other products.

Low labor costs, economies of scale, and a strong infrastructure have drawn goods production to China. But while China's manufacturing prowess may seem unbeatable, its aging workforce and increased standard of living are causing labor costs to rise and low-cost manufacturing to move to such countries as India, Bangladesh, Indonesia, Vietnam, and to some extent, Eastern Europe. Because of its proximity to the United States, Mexico and several Central American countries are seeing a resurgence in orders, as well. Quality, reliability, and security problems present additional challenges to managing global operations, as do questions of worker rights and environmental concerns. Physical distance and different mores, laws, and legal systems in other countries can make it harder to maintain control over a global supply chain.

ABCDstock/Adobe Stock

With over 26 million people, 5,000 skyscrapers, and the world's largest deep sea container port, Shanghai is China's largest city and the financial heart of the burgeoning economy.

1.4 Productivity and Competitiveness

LEARNING OBJECTIVE 1.4

Calculate and interpret productivity measures used for measuring competitiveness.

A global marketplace for products and services means more customers and more intense competition. In the broadest terms, we speak of competitiveness in reference to other *countries* rather than to other companies. That's because how effectively a nation competes in the global marketplace affects the economic success of the nation and the quality of life for its citizens. The OECD (Organisation for Economic Co-operation and Development) defines **competitiveness** as "the degree to which a nation can produce goods and services that meet the test of international markets while simultaneously maintaining or expanding the real incomes of its citizens." The most common measure of competitiveness is productivity. Increases in productivity allow wages to grow without producing inflation, thus raising the standard of living. Productivity growth also represents how quickly an economy can expand its capacity to supply goods and services.

competitiveness The degree to which a nation can produce goods and services that meet the test of international markets.

productivity The ratio of output to input.

Productivity is calculated by dividing units of output by units of input.

$$\text{Productivity} = \frac{\text{Output}}{\text{Input}}$$

Output can be expressed in units or dollars in a variety of scenarios, such as sales made, products produced, customers served, meals delivered, or calls answered. *Single-factor productivity* compares output to individual inputs, such as labor hours, investment in equipment, material usage, or square footage. *Multifactor productivity* relates output to a combination of inputs, such as (labor + capital) or (labor + capital + energy + materials). Capital can include the value of equipment, facilities, inventory, and land. *Total factor productivity* compares the total quantity of goods and services produced with all the inputs used to produce them. These productivity formulas are summarized in **Table 1.2**. Note when several factors are included in a formula, they should be expressed in common terms, such as dollars.

The most common input in productivity calculations is labor hours. In fact, when a publication quotes productivity rates, it is referring to labor productivity when not otherwise stated. Labor is an easily identified input to virtually every production process. If labor is used as the basis for productivity calculations consistently over time, changes in other factors of production will be reflected in the changes in labor.

TABLE 1.2 Measures of Productivity

Single-Factor Productivity		
$\frac{\text{Output}}{\text{Labor}}$	$\frac{\text{Output}}{\text{Materials}}$	$\frac{\text{Output}}{\text{Capital}}$
Multifactor Productivity		
$\frac{\text{Output}}{\text{Labor + Materials + Overhead}}$		$\frac{\text{Output}}{\text{Labor + Energy + Capital}}$
Total Factor Productivity		
$\frac{\text{Goods and services produced}}{\text{All inputs used to produce them}}$		

There are many ways in which productivity statistics can be misleading. Examining the formula for productivity, *output/input,* it becomes apparent that productivity can be increased in different ways. For example, a country or firm may increase productivity by decreasing input faster than output. Thus, although a country or firm may be retrenching, its productivity is increasing. Seldom is this avenue for increasing productivity sustainable. Let's look at some recent global productivity statistics.

Figure 1.9 shows productivity per hour of labor in U.S. dollars for select countries. Norway is the most productive, with $96 worth of goods produced with one hour of labor. The United States and Germany are next, producing $72 and $70 worth of goods for each hour of labor. India is the least productive, using one hour of labor to produce only $9 of output. This makes sense considering that fully developed nations are more invested in automation and thus use fewer labor hours in the production process. Productivity expressed in labor hours (which is the norm) can be misleading since it does not include the cost of the labor.

Productivity statistics also assume that if more input were available, output would increase at the same rate. This may not necessarily be true, as there are limits to output in addition to those on which the productivity calculations are based. Furthermore, productivity emphasizes *output produced,* not *output sold*. If products produced are not sold, inventories pile up and increases in output can actually accelerate a company's decline. Finally, productivity is a relative measure, which is why statistics provided in government reports typically measure percent *changes* in productivity from month to month, quarter to quarter, year to year, or over a number of years.

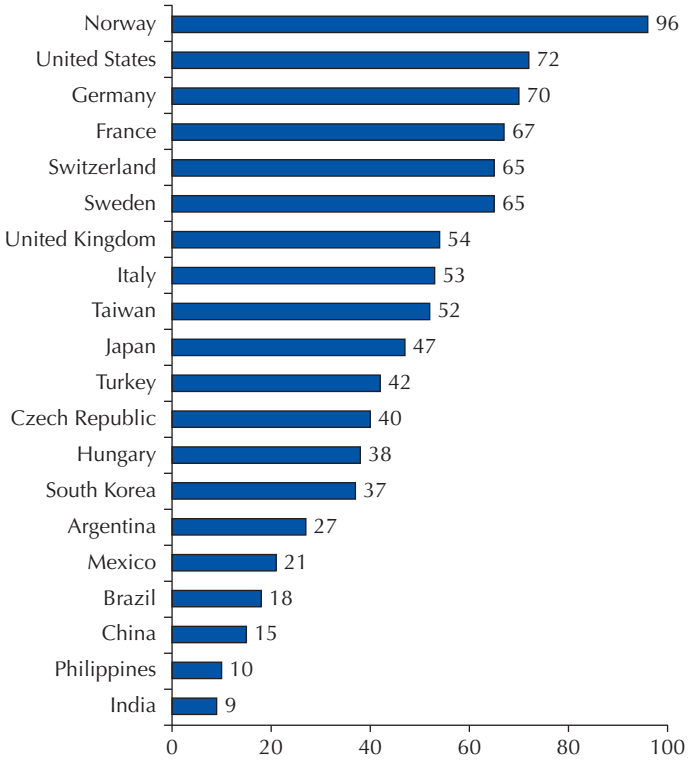

FIGURE 1.9 Productivity per Hour ($U.S.) for Select Countries
Source: Data from The Conference Board Total Economy Database™ (adjusted version), November 2018 (accessed March 2022).

EXAMPLE 1.1 Calculating Productivity

Osborne Industries is compiling the monthly productivity report for its board of directors. From the following data, calculate (a) labor productivity, (b) machine productivity, and (c) the multifactor productivity of output per dollars spent on labor, machine, materials, and energy. The average labor rate is $15 an hour, and the average machine usage rate is $10 an hour.

Units produced	100,000
Labor hours	10,000
Machine hours	5,000
Cost of materials	$35,000
Cost of energy	$15,000

Solution

a. $$\text{Labor productivity} = \frac{\text{Output}}{\text{Labor hours}} = \frac{100,000}{10,000} = 10 \text{ units/hour}$$

b. $$\text{Machine productivity} = \frac{\text{Output}}{\text{Machine hours}} = \frac{100,000}{5,000} = 20 \text{ units/hour}$$

c. $$\text{Multifactor productivity} = \frac{\text{Output}}{(\text{Labor costs} + \text{Machine costs} + \text{Material costs} + \text{Energy costs})}$$
$$= \frac{100,000}{(10,000 \times \$15) + (5,000 \times \$10) + \$35,000 + \$15,000}$$
$$= \frac{100,000}{\$250,000} = 0.4 \text{ units per dollar spent}$$

The Excel solution to this problem is shown in **Exhibit 1.1**.

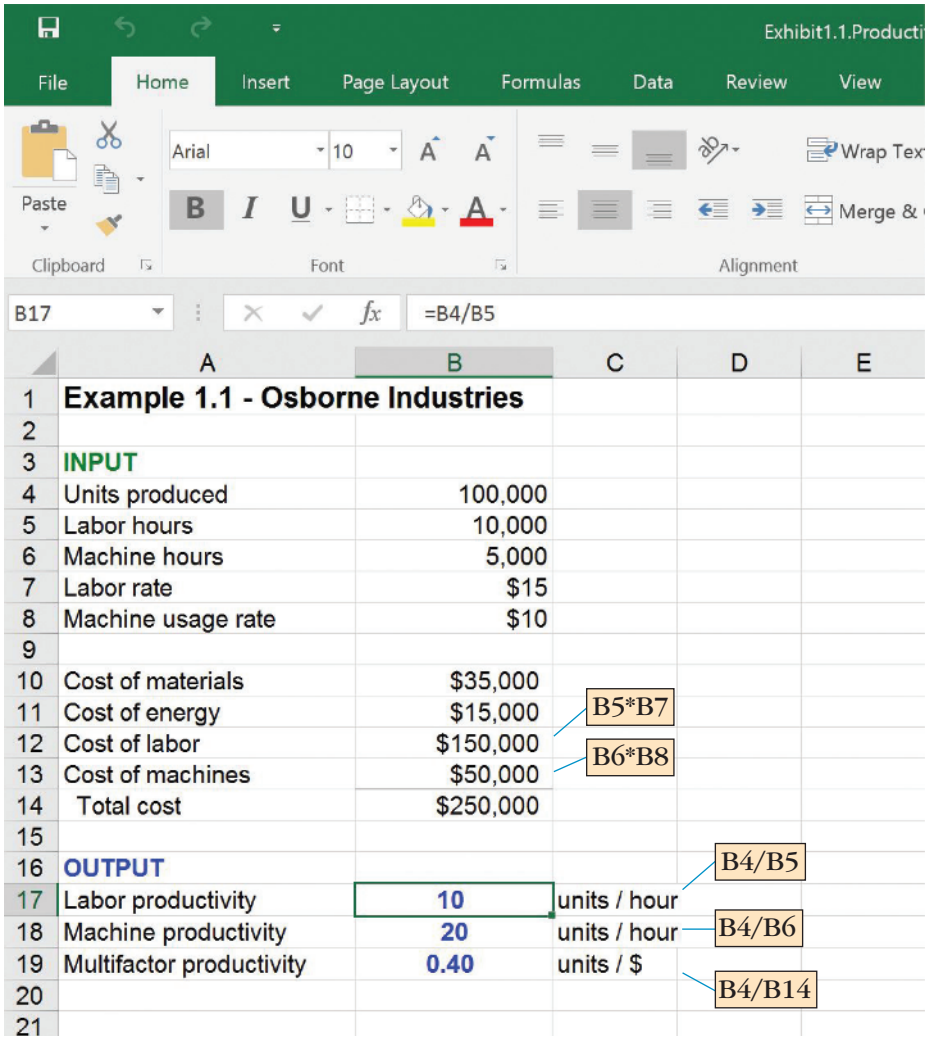

EXHIBIT 1.1 Osborne Industries Excel

As the business world becomes more competitive, firms must find their own path to sustainable competitive advantage. Effectively managed operations are important to a firm's competitiveness. How a firm chooses to compete in the marketplace is the subject of the next section: *Strategy and Operations*.

1.5 Strategy and Operations

LEARNING OBJECTIVE 1.5

Discuss the importance of operations and supply chain management to a firm's strategy and the process of developing, aligning, and deploying strategy.

Strategy is how the mission of a company is accomplished. It unites an organization, provides consistency in decisions, and keeps the organization moving in the right direction. Operations and supply chain management play an important role in corporate strategy.

strategy A common vision that unites an organization, provides consistency in decisions, and keeps the organization moving in the right direction.

As shown in **Figure 1.10**, the strategic planning process involves a hierarchy of decisions. Senior management, with input and participation from different levels of the organization, develops a corporate strategic plan in concurrence with the firm's mission and vision, customer requirements (voice of the customer), and business conditions (voice of the business). The strategic plan focuses on the gap between the firm's vision and its current position. It identifies and prioritizes what needs to be done to close the gap, and it provides direction for formulating strategies in the functional areas of the firm, such as marketing, operations, and finance. It is important that strategy in each of the functional areas be internally consistent as well as consistent with the firm's overall strategy.

Strategy formulation consists of five basic steps:

1. Defining a primary task.
2. Assessing core competencies.
3. Determining order winners and order qualifiers.
4. Positioning the firm.
5. Deploying the strategy.

Primary Task

The **primary task** represents the purpose of a firm—what the firm is in the business of doing. It also determines the competitive arena. As such, the primary task should not be defined too narrowly. For example, Norfolk Southern Railway is in the business of transportation, not railroads. Paramount is in the business of communication, not making movies.

primary task The task that is most central to the operation of a firm; it defines the business that a firm is in and is often expressed in a mission statement.

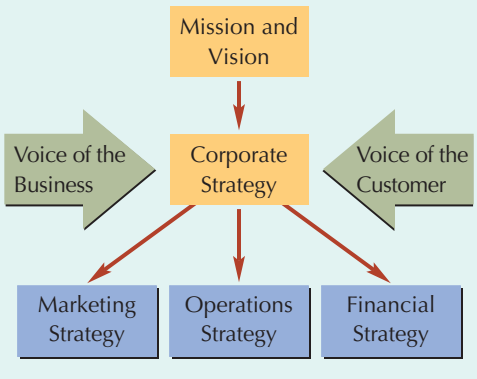

FIGURE 1.10 **Strategic Planning**

Amazon's business is providing the fastest, easiest, and most enjoyable shopping experience, while Disney's is making people happy! The primary task is usually expressed in a firm's *mission* statement.

Mission statements clarify what business a company is in—for Google, it's "organizing the world's information"; for Hallmark, it's creating a "more emotionally connected world"; for Twitter, it's giving "everyone the power to create and share ideas and information instantly, without barriers"; and for Merck, it's "saving and improving human life." Mission statements are the "constitution" for an organization, the corporate directive, but they are no good unless they are supported by strategy and converted into action. Thus, the next step in strategy formulation is assessing the core competencies of a firm.

Core Competencies

core competency The essential capabilities that create a firm's sustainable competitive advantage.

Core competency is what a firm does better than anyone else, its *distinctive competence*. A firm's core competence can be exceptional service, higher quality, faster delivery, or lower cost. One company may strive to be first to the market with innovative designs, whereas another may look for success arriving later but with better quality.

Based on experience, knowledge, and know-how, core competencies represent *sustainable competitive advantages*. For this reason, products and technologies are seldom core competencies. The advantage they provide is short-lived, and other companies can readily purchase, emulate, or improve on them. Core competencies are more likely to be *processes*, a company's ability to *do* certain things better than a competitor. Thus, while a particular product is not a core competence, the process of developing new products is. For example, while the iPod was a breakthrough product, it is Apple's ability to turn out hit product after hit product (e.g., iPhone, iPad, MacBook, iWatch, etc.) that gives it that competitive advantage.

Core competencies are not static. They should be nurtured, enhanced, and developed over time. Close contact with the customer is essential to ensuring that a competence does not become obsolete. Core competencies that do not evolve and are not aligned with customer needs can become *core rigidities* for a firm. Walmart and Dell, seemingly unstoppable companies in their field, went astray when they failed to update their competencies to match changes in customer desires. For Dell, the low cost and mail-order delivery of computers did not match the customer's desire to see and test computers before purchase or to receive personalized after-purchase customer service. For Walmart, their big-box retail model is being challenged by Amazon's online shopping model. Walmart tried smaller stores with little success and may now convert some of their larger stores into warehouses for shipping out customer orders. To avoid these problems, companies need to continually evaluate the characteristics of their products or services that prompt customer purchase; that is, the order qualifiers and order winners.

Order Winners and Order Qualifiers

A firm is in trouble if the things it does best are not important to the customer. That's why it's essential to look toward customers to determine what influences their purchase decision.

order qualifiers The characteristics of a product or service that qualify it to be considered for purchase.

order winner The characteristic of a product or service that wins orders in the marketplace.

Order qualifiers are the characteristics of a product or service that qualify it to be considered for purchase by a customer. An **order winner** is the characteristic of a product or service that wins orders in the marketplace—the final factor in the purchasing decision. For example, when purchasing a TV, customers may determine a price range (order qualifier) and then choose the product with the most features (order winner) within that price range. Or they may have a set of features in mind (order qualifiers) and then select the least expensive player (order winner) that has all the required features.

Order winners and order qualifiers can evolve over time, just as competencies can be gained and lost. Japanese and Korean automakers initially competed on price but had to ensure certain levels of quality before the U.S. consumer would consider their product. Over time, the consumer was willing to pay a higher price for the assurance of a superior-quality Japanese car. Price became a qualifier, but quality won the orders. Today, high quality, as a standard of the automotive industry, has become an order qualifier, and innovative design or alternative fuel sources wins the orders.

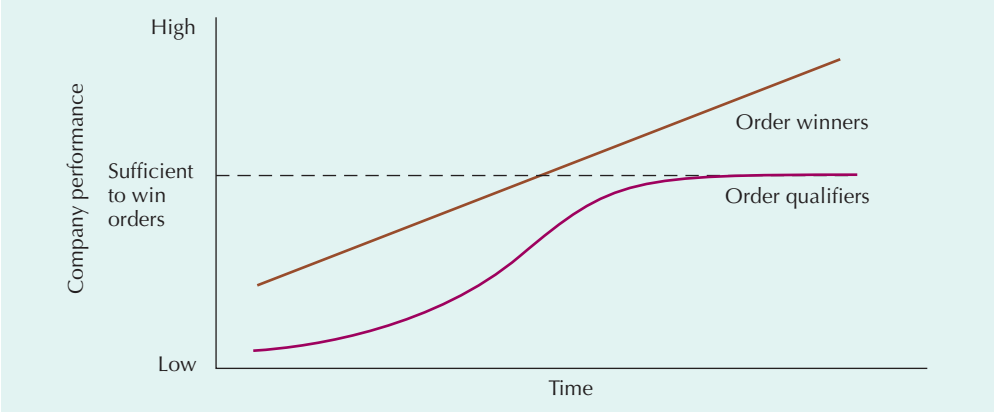

FIGURE 1.11 Order Winners and Order Qualifiers
Source: Adapted from *Operations and Process Management*, Nigel Slack, Stuart Chambers, Robert Johnston, and Alan Betts, ©2006 *Prentice Hall*.

As shown in **Figure 1.11**, order qualifiers will only take a firm so far. The customer expects the qualifiers, but is not "wowed" by them. For example, a low price might be a qualifier, but reducing the price further may not win orders if the features or design are not adequate. At a minimum, a firm should meet the qualifiers. To excel, the firm needs to develop competencies that are in tune with the order winners. Marketing helps to identify these qualifiers and winners. Oftentimes, these characteristics are in the purview of operations and supply chain management, such as cost, speed to the market, speed of delivery, or customization. Other characteristics such as product or service design are supported by operations and supply chain management, but are not completely under their control.

Positioning the Firm

positioning Determining how a firm will compete in the marketplace.

No firm can be all things to all people. Strategic **positioning** involves making choices—choosing one or two important things on which to concentrate and doing them extremely well. A firm's positioning strategy defines how it will compete in the marketplace—what unique value it will deliver to the customer. An effective positioning strategy considers the strengths and weaknesses of the organization, the needs of the marketplace, and the positions of competitors.[2]

Let's look at firms that have positioned themselves to compete on cost, speed, quality, and flexibility.

Competing on Cost

Companies that compete on cost relentlessly pursue the elimination of all waste. In the past, companies in this category produced standardized products for large markets. They improved yield by stabilizing the production process, tightening productivity standards, and investing in automation. Today, the entire cost structure is examined for reduction potential, not just direct labor costs. High-volume production and automation may or may not provide the most cost-effective alternative. A lean production system provides low costs through disciplined operations.

Competing on Speed

More than ever before, speed has become a source of competitive advantage. Amazon has conditioned customers to expect instock availability and rapid product shipment. Service organizations such as Chipotle Warby Parker, and FedEx have always competed on speed. Now manufacturers are discovering the advantages of *time-based competition,* with build-to-order production and efficient supply chains. In the fashion industry where trends are temporary, a normal six-month time-to-market can no longer compete with the nine-day design-to-rack lead time of Spanish retailer Zara.

Competing on Quality

Most companies approach quality in a defensive or reactive mode; quality is confined to minimizing defect rates or conforming to design specifications. To compete on quality, companies must view it as an opportunity to please the customer, not just a way to avoid problems or reduce rework costs.

[2]These factors can be depicted in a SWOT matrix, which lists the current strengths (S) and weaknesses (W) internal to the company and the opportunities (O) and threats (T) external to the company.

To please the customer, one must first understand customer attitudes toward and expectations of quality. One good source is the American Customer Satisfaction Index compiled each year by the American Society for Quality and the National Quality Research Center. Examining recent winners of the Malcolm Baldrige National Quality Award and the criteria on which the award are based also provides insight into companies that compete on quality.

The Ritz-Carlton Hotel Company is a Baldrige Award winner and a recognized symbol of quality. The entire service system is designed to understand the individual expectations of more than 500,000 customers and to "move heaven and earth" to satisfy them. Every employee is empowered to take immediate action to satisfy a guest's wish or resolve a problem. Processes are uniform and well defined. Teams of workers at all levels set objectives and devise quality action plans. Each hotel has a quality leader who serves as a resource and advocate for the development and implementation of those plans.

Competing on Flexibility Marketing always wants more variety to offer its customers. Manufacturing resists this trend because variety upsets the stability (and efficiency) of a production system and increases costs. The ability of manufacturing to respond to variation has opened up a new level of competition. **Flexibility** has become a competitive weapon. It includes the ability to produce a wide variety of products, to introduce new products and modify existing ones quickly, and to respond to customer needs.

flexibility In operations, the ability to adjust to changes in product mix, production volume, or product and process design.

Shoes, bicycles, and suits are examples of standard products that can be built or "tailored" to individual customers. Republic Bikes, Villy Customs (a shark tank winner), and Mission Bikes are but a few of the customized biking shops that fit bicycles to exact customer measurements and encourage customized colors, handlebars, frames, and other design options. Bicycle manufacturers typically offer customers a choice among 20 or 30 different models. Handcrafted customer–designed bicycles can be configured in thousands of different ways. Computer-aided design (CAD) and computer-aided manufacturing (CAM) allow customized products to be essentially mass produced. The popular term for this phenomenon is **mass customization**.

mass customization The mass production of customized products.

Competing on Innovation Companies that compete on innovation establish a corporate culture that encourages risk taking, challenges the status quo, accepts failure as part of the learning process, and celebrates successes. Three such companies are Apple, Google, and 3M. Apple *thinks different* to create incredibly fresh, beautiful game-changing designs. Google's open culture promotes "10x thinking" believing that true innovation happens when you try to improve something by 10 times rather than by 10%. 3M defines itself as a global innovation company that never stops inventing. Ranging from Post-It Notes to micro-needle skin patches designed to replace hypodermic needles, 3M produces hundreds of small innovations each year that improve how products or services operate. Like Google, 3M sets aside 20% of its engineers' time to be spent on projects of their own choosing. 3M also gives out $100,000 genius grants to its employees and has its own venture capitalist program that supports disruptive, early-stage innovations outside of the company's existing portfolio.

Innovation is exciting; however, it is not a competitive advantage if it cannot be transformed into marketable and profitable products or services (read about Xiaomi and its competitor OPPO in the "Along the Supply Chain" box). That's where operations and supply chain management come into play. We'll discuss their role more directly in Chapter 4 on Product Design.

Strategy Deployment

Implementing strategy can be more difficult than formulating strategy. Strategies unveiled with much fanfare may never be followed because they are hard to understand, too general, or unrealistic. Strategies that aim for results five years or so down the road mean very little to the worker who is evaluated on his or her daily performance. Different departments or functional areas in a firm may interpret the same strategy in different ways. If their efforts are not coordinated, the results can be disastrous.

Consider Schlitz Brewing Company, whose strategy called for reduced costs and increased efficiency. Operations achieved its goals by dramatically shortening its brewing cycle—and, in the process, lost 6 of every 10 customers when the clarity and taste of the beer suffered. The efficiency move that was to make the company the most profitable in its industry instead caused its stock value to plummet from $69 per share to $5 per share. Schiltz has since been sold to Pabst Brewing Company, who combed through company documents and interviewed retired Schlitz brewmasters and taste-testers to derive and reintroduce the original 1960s "with gusto" formula.

Along the Supply Chain

New Players Disrupt with Innovation

Prashanth Vishwanathan/Bloomberg/Getty Images

New companies entering an established market often disrupt how products are perceived, made, or delivered. Apple and Samsung are still the world's leading smartphone manufacturers, but as the market for smartphones matures, look out for high performers Xiaomi and OPPO. Business is, after all, played out on a global landscape. So what do these newcomers bring to the table?

For one thing, Xiaomi, an Android-based product, updates its operating system once a week, and each week the batch of phones shipped by Xiaomi are "incrementally better" than the last batch. Yes, every Friday, Xiaomi delivers unmatched responsiveness to an expanding base of loyal customers who provide input in online forums and company-sponsored community engagements. Online sales account for 70% of Xiaomi's orders. These pre-orders allow the company to purchase materials only after orders are placed and basically build each phone to order. The reduced risk of forecast errors and surplus material saves costs and lets the company look for other ways to add value. For example, the phone's platform is now available in more than 20 languages. Retail prices have been kept very close to manufacturing costs.

OPPO has a different strategy, focusing on Southeast Asia, South Asia, Africa, and the Middle East. In India alone, OPPO has 35,000 sales outlets and close to 200 service centers. Branding its products the "OPPO Camera Phone" and "Selfie Expert," the company knows that a superior camera is the most important feature for India's market and that experiencing the phone is the key to building market share. OPPO designs, develops, manufactures, markets, and sells its products with full control over the entire supply chain. It's also the number-three producer of wearables, behind Fitbit and Apple.

Apple is no longer the shining star of cell phones in China. Finding a gap, choosing a strategy, and supporting it through a corresponding operations and supply chain strategy can lead to results, even if your competitor is the venerable Apple.

Source: Adapted from John Hagel, John Brown, Duleesha Kulasooriyam, Craig Giffi, and Menmend Chen, "The Future of Manufacturing: Making things happen in a changing world," Deloitte University Press, 2015, p. 32; "OPPO Launches F1 'Selfie Expert' in India," *Indian News and Times*, January 29, 2016; Company website, www.oppo.com (accessed February 8, 2016); Kara Swisher, "Is This the End of the Age of Apple?" *New York Times*, January 3, 2019.

Strategy deployment converts a firm's positioning strategy and resultant order winners and order qualifiers into specific performance requirements. Companies struggling to align day-to-day decisions with corporate strategy have found success with two types of planning systems—policy deployment and the balanced scorecard.

Policy Deployment

Policy deployment, also known as hoshin planning, is adapted from Japan's system of *hoshin kanri*, which is roughly translated from Japanese as "shining metal pointing direction"—a compass.

Policy deployment tries to focus everyone in an organization on common goals and priorities by translating corporate strategy into measurable objectives throughout the various functions and levels of the organization. As a result, everyone in the organization should understand the strategic plan, be able to derive several goals from the plan, and determine how each goal ties into their own daily activities.

policy deployment A planning system for converting strategy to measurable objectives throughout all levels of an organization.

Suppose the corporate strategic plan of competing on speed called for a reduction of 50% in the length of the supply chain cycle. Senior management from each functional area would assess how their activities contribute to the cycle, confer on the feasibility of reducing the cycle by 50%, and agree on each person's particular role in achieving the reduction. Marketing might decide that creating strategic alliances with its distributors would shorten the average time to release a new product. Operations might try to reduce its purchasing and production cycles by reducing its supplier base, certifying suppliers, using e-procurement, and implementing a just-in-time (JIT) system. Finance might decide to eliminate unnecessary approval loops for expenditures, begin prequalifying sales prospects, and explore the use of electronic funds transfer (EFT) in conjunction with operations' lean strategy.

The process for forming objectives would continue in a similar manner down the organization with the *means* of achieving objectives for one level of management becoming the *target*, or objectives, for the next level. The outcome of the process is a cascade of action plans (or **hoshins**) aligned to complete each functional objective, which will, in turn, combine to achieve the strategic plan.

hoshins The action plans generated from the policy deployment process.

blickwinkel/Alamy Stock Photo

Is your company pointed in one direction? AT&T uses the analogy of migrating geese to explain the concept of policy deployment. Naturalists believe the instinctive V-formation allows the geese to follow one leader and migrate in a cohesive unit toward their destination. Policy deployment does the same thing—it enables business leaders to mobilize the organization toward a common destination, aligning all employees behind a common goal and a collective wisdom.

Figure 1.12 shows an abbreviated operations action plan for reducing supply chain cycle time. Policy deployment has become more popular as organizations become more geographically dispersed and culturally diverse.

balanced scorecard A performance assessment that includes metrics related to customers, processes, and learning and growing, as well as financials.

Balanced Scorecard

The **balanced scorecard**, developed by Robert Kaplan and David Norton,[3] examines a firm's performance in four critical areas:

1. *Finances*—How should we look to our shareholders?
2. *Customers*—How should we look to our customers?

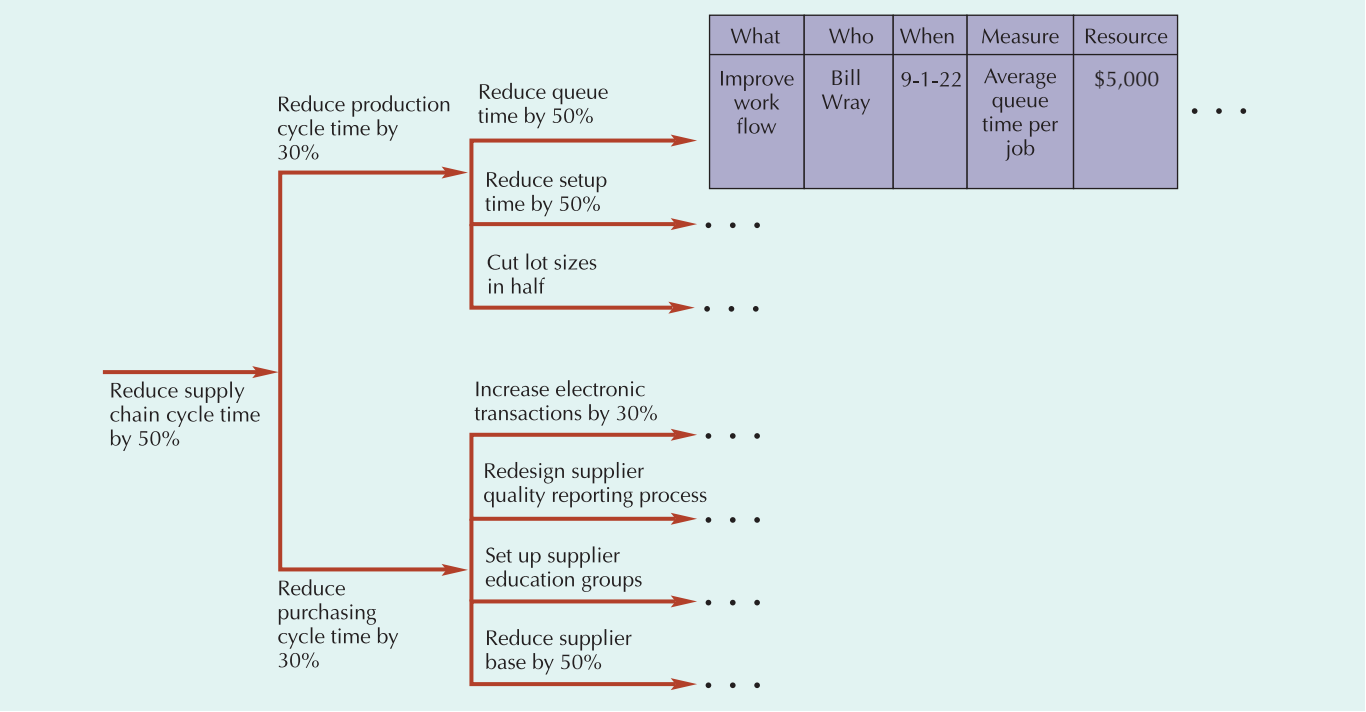

FIGURE 1.12 **Derivation of an Action Plan Using Policy Deployment**

[3]See Robert S. Kaplan and David P. Norton, "Transforming the Balanced Scorecard from Performance Measurement to Strategic Management." *Accounting Horizons* (March 2001), pp. 87–104; and Robert S. Kaplan and David P. Norton, "Having Trouble with Your Strategy? Then Map It," *Harvard Business Review* (September/October 2000), pp. 167–176.

3. *Processes*—At which business processes must we excel?
4. *Learning and Growing*—How will we sustain our ability to change and improve?

It's called a *balanced* scorecard because more than financial measures are used to assess performance. Operational excellence is important in all four areas. How efficiently a firm's assets are managed, products produced, and services provided affects the financial health of the firm. Identifying and understanding targeted customers helps determine the processes and capabilities the organization must concentrate on to deliver value to the customer. The firm's ability to improve those processes and develop competencies in new areas is critical to sustaining competitive advantage.

Table 1.3 is a balanced scorecard worksheet. The worksheet selects areas of the strategy map to incorporate in annual objectives for the company. The objectives are then operationalized with **key performance indicators (KPI)**. The goals for the year are given, and the KPI results are recorded. The score converts the different performance measures into percentage completed. For example, if the goal is to achieve 12 inventory turns a year and the company manages only 6, then the goal is 50% achieved. The mean performance column averages the score for each

key performance indicators (KPI) A set of measures that help managers evaluate performance in critical areas.

TABLE 1.3 The Balanced Scorecard Worksheet

	Dimension	Objectives	Key Performance Indicator	Goal for 2025	KPI Results to Date	Score	Mean Performance
Finances	Productivity	Become industry cost leader	% reduction in cost per unit	20%	10%	50%	65%
	Growth	Increase market share	Market share	50%	40%	80%	
Customers	Quality	Zero defects	% good quality first pass	100%	80%	80%	87%
	Timeliness	On-time delivery	% on-time deliveries	95%	90%	95%	
Processes	Suppliers	Integrate into production	% orders delivered to assembly	50%	40%	80%	73%
		Reduce inspections	% suppliers ISO 9000 certified	90%	60%	67%	
	Products	Reduce time to produce	Cycle time	10 mins.	12 mins.	83%	52%
		Improve quality	# warranty claims	200	1000	20%	
	Distribution	Reduce transportation costs	% FTL shipments	75%	30%	40%	40%
	Service	Improve response to customer inquiries	% queries satisfied on first pass	90%	60%	67%	67%
	Risk	Reduce inventory obsolescence	Inventory turnover	12	6	50%	50%
		Reduce customer backlog	% orders backlogged	10%	20%	50%	
Learning & Growing	Human capital	Develop quality improvement skills	# of Six Sigma Black Belts	25	2	8%	35%
			% trained in SPC	80%	50%	63%	
	Information capital	Provide technology to improve processes	% customers who can track orders	100%	60%	60%	61%
			% suppliers who use EDI	80%	50%	63%	
	Organizational capital	Create innovative culture	# of employee suggestions	100	60	60%	55%
			% products new this year	20%	10%	50%	

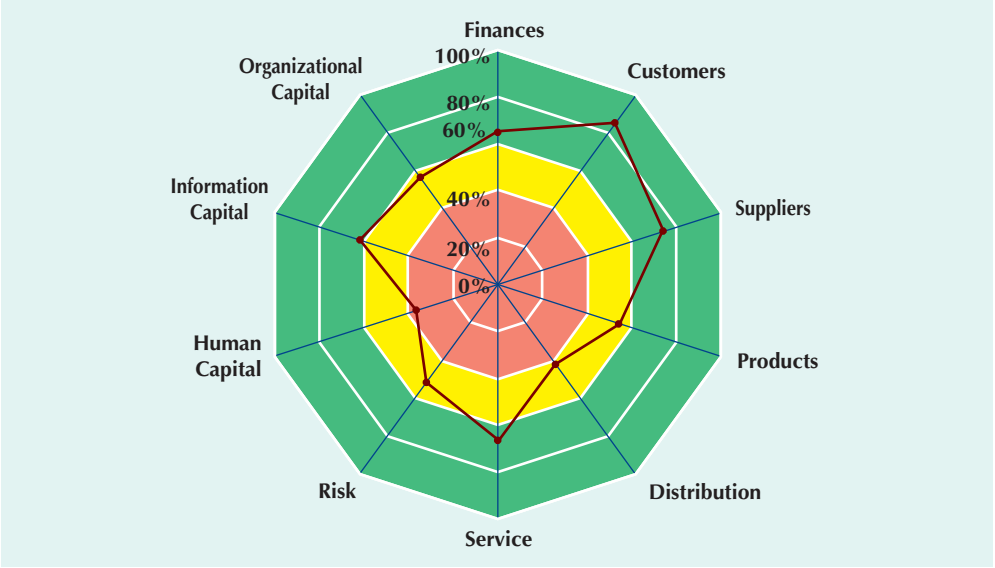

FIGURE 1.13 A Radar Chart of the Balanced Scorecard

dimension. The scorecard performance can be visualized in many ways, two of which are illustrated in **Figures 1.13** and **1.14**.

Figure 1.13 is a radar chart of the balanced scorecard. Goals 0% to 40% achieved appear in the red "danger" zone, 40% to 80% achieved are in the yellow "cautionary" zone, and 80% to 100% achieved are in the green "moving ahead" zone. In this example, the company is in the danger zone for human capital and distribution, but is doing well with growth, quality, timeliness, and service. Figure 1.14 shows the same information in an alternative format. The dashboard presents each scorecard perspective in a different graphic. The red zone is set at 25% or less goal achievement, yellow from 25% to 75%, and green in excess of 75%, although different limits can be set for each perspective. The company excels in growth, quality, and timeliness, and is not in danger on any measure. Note that in addition to setting different limits for each gauge, measures other than percentages can be used. Dashboards are popular ways for managers to quickly interpret the massive amounts of data collected each day and in some cases can be updated in real time. They often consist of graphs and other visual representations of performance.

Operations Strategy

The operations function helps strategy evolve by creating new and better ways of delivering a firm's competitive priorities to the customer. Once a firm's competitive priorities have been established, its operating system must be configured and managed to provide for those priorities. This involves a whole series of interrelated decisions on products and services, processes

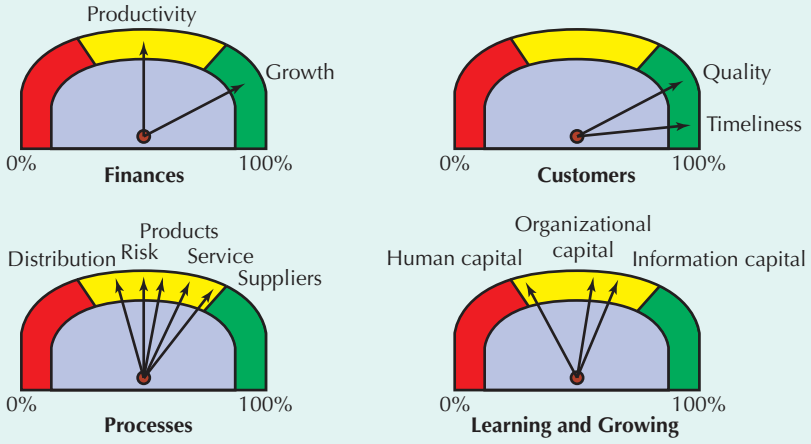

FIGURE 1.14 A Dashboard for the Balanced Scorecard

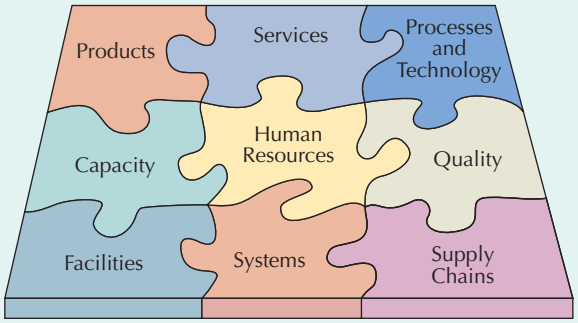

FIGURE 1.15 **An Integrated Operations Strategy**

and technology, capacity and facilities, human resources and quality, operating systems and supply chains. As shown in **Figure 1.15**, all these decisions should "fit" like pieces in a puzzle. A tight strategic fit means competitors must replicate the entire system to obtain its advantages. Thus, the competitive advantage from an integrated operating system is more sustainable than short-lived products or technologies.

Summary of Learning Objectives

Learning Objective 1.1

Describe what the operations function is and how it relates to other business functions. Operations can be viewed as a transformation process that converts inputs into outputs of greater value. Operations management is the study of processes directly related to the creation and distribution of goods and services. Increasingly, these operations are taking place outside of the boundaries of a traditional enterprise. Thus, while today's managers need to understand how to efficiently manage operations within their own firm, they also need to develop skills in coordinating operations across a global supply chain. This text teaches students how to analyze processes, ensure quality, create value, and manage the flow of information, products, and services across a network of customers, enterprises, and supply chain partners.

Learning Objective 1.2

Discuss the key factors that have contributed to the evolution of operations and supply chain management. Before the Industrial Revolution, products were made by skilled craftpersons and their apprentices, one at a time. With the rise of factories, though, came division of labor, where workers were only responsible for one small part of the total production process. For many years, factories were dominated by the concept of mass production, but this eventually gave way to the realization that production should be tied to customer demands and that quality is as important as quantity. Lean production emerged as an alternative way of organizing work. Globalization and the internet expanded the reach of customers and suppliers and brought about a new field of study called supply chain management that planned and monitored the flow of information, products and services across a network of customers, enterprises, and supply chain partners.

Learning Objective 1.3

Discuss how and why businesses operate globally, and the importance of globalization in supply chain management. More than two-thirds of today's businesses operate through global markets, global operations, global financing, and global supply chains. Many companies are now outsourcing much of their production and service functions to other countries to be nearer to their markets, to access resources or expertise, or to take advantage of cost savings.

Learning Objective 1.4

Calculate and interpret productivity measures used for measuring competitiveness. Competitiveness is defined by the OECD as "the degree to which a nation can produce goods and services that meet the test of international markets while simultaneously maintaining or expanding the real incomes of its citizens." The most common measure of competitiveness is productivity, which is the ratio of output to input.

Learning Objective 1.5

Discuss the importance of operations and supply chain management to a firm's strategy, and the process of developing, aligning, and deploying strategy. Firms choose to compete in different ways. A firm's strategy defines how it will compete in the marketplace—its own best way. Strategy formulation involves defining the primary task, assessing core competencies, determining order winners and order qualifiers, and positioning the firm. An effective strategy meets the order qualifiers and excels on the order winners. A competitive position is not sustainable unless the operating system that supports it is configured and managed effectively.

Policy deployment is a planning system that helps align day-to-day operating decisions with the company's overall strategy. The *balanced scorecard* reinforces a firm's strategy by providing customer-oriented and process-oriented measures of performance, in addition to traditional financial measures.

Key Terms

balanced scorecard A performance assessment that includes metrics related to customers, processes, and learning and growing, as well as financials.

competitiveness The degree to which a nation can produce goods and services that meet the test of international markets.

core competencies The essential capabilities that create a firm's sustainable competitive advantage.

craft production The process of handcrafting products or services for individual customers.

division of labor Dividing a job into a series of small tasks each performed by a different worker.

flexibility In operations, the ability to adjust to changes in product mix, production volume, or product and process design.

hoshins The action plans generated from the policy deployment process.

interchangeable parts The standardization of parts initially as replacement parts enabled mass production.

key performance indicators (KPI) A set of measures that help managers evaluate performance in critical areas.

lean production An adaptation of mass production that prizes quality and flexibility.

mass customization The mass production of customized products.

mass production The high-volume production of a standardized product for a mass market.

operations A function or system that transforms inputs into outputs of greater value.

operations management The design, operation, and improvement of productive systems.

order qualifiers The characteristics of a product or service that qualify it to be considered for purchase.

order winner The characteristic of a product or service that wins orders in the marketplace.

policy deployment A planning system for converting strategy to measurable objectives throughout all levels of an organization.

positioning Determining how a firm will compete in the marketplace.

primary task The task that is most central to the operation of a firm; it defines the business that a firm is in and is often expressed in a mission statement.

productivity The ratio of output to input.

quality revolution An emphasis on quality and the strategic role of operations.

resilience The ability to bounce back, change, or adapt in response to a disaster, failure, or disruption.

scientific management The systematic analysis of work methods proposed by Frederick Taylor in the early 1900s.

strategy A common vision that unites an organization, provides consistency in decisions, and keeps the organization moving in the right direction.

supply chain management Managing the flow of information, products, and services across a network of customers, enterprises, and supply chain partners.

value chain A series of activities from supplier to customer that add value to a product or service.

Questions

1.1. What activities are involved in the operations function? How does operations interact with other functional areas?

1.2. What constitutes "operations" at (a) a bank, (b) a retail store, (c) a hospital, (d) a cable TV company?

1.3. Briefly describe how operations has evolved from the Industrial Revolution to the Digital Revolution.

1.4. What is productivity? How is it measured?

1.5. Read about the Smart Cities Initiative and other smart technologies. Write a thought piece on the impact of new digital technologies on business operations, supply chains, and consumers.

1.6. Describe the global activities of a corporation of your choice. How many foreign plants or suppliers do they have? Where are they located? How much of their business is foreign? Are any global strategies evident?

1.7. Choose an industry on which you will be the class "expert" for the duration of this course. Write an initial profile of major players, customers, structure, and competitive issues.

1.8. Find an interesting website related to the operations function in a firm with which you are familiar. Write a summary of what you find.

1.9. Look for articles related to supply chains online or at *Fortune, Bloomberg, Businessweek,* or *The Economist*. How do they relate to the primary topics discussed in this chapter? If your university has access to Bloomberg terminals, map out the supply chain for a company of your choosing.

1.10. The World Bank ranks countries in terms of globalization. Go to the research section of www.worldbank.org and choose four countries to compare.

1.11. The World Trade Organization has its advocates and its adversaries. Find out more about the organization by visiting its website at www.wto.org. What kinds of activities does the organization support? What rules and regulations does it enforce? Who are its member states, and how is membership achieved?

1.12. Cultural differences can make it difficult to do business in other countries. Go to www.worldbusinessculture.com and choose a country to explore. Share your discoveries with your professor and classmates in a one- to two-page write-up.

1.13. Much of the negotiation in trade agreements centers on ethical/legal issues such as intellectual property protection, bribery and payoffs, and copyright and patent infringement. Transparency International at www.transparency.org publishes bribe payers by country. Report on which countries and industries are most susceptible to bribery.

1.14. Ethics is easier when there are laws to fall back on. Search the Internet for information on the Foreign Corrupt Practices Act. Briefly describe what it entails. Then find two companies that explicitly state a code of conduct on their website and, in particular, reference the Foreign Corrupt Practices Act. How does each company approach the issue?

1.15. Gather mission or vision statements from four different companies. What do they tell you about the organizations? Is their mission or vision reflected in the way they do business?

1.16. List and explain the five steps of strategy formulation. Follow the steps to outline a strategy for a company or organization with which you are familiar.

1.17. Explain the concept of core competencies in your own words. Provide examples of a core competency for a bank, a retail store, and an auto manufacturer.

1.18. What is your core competency? Make a list of the core competencies you will need to compete successfully in the job market. Design a strategy for developing the competencies that you do not have and capitalizing on the competencies that you do have.

1.19. What is the difference between an order winner and an order qualifier? Tell how you have used the two concepts in a purchasing decision.

1.20. Discuss the requirements from an operations perspective of competing on (a) quality, (b) cost, (c) flexibility, (d) speed, (e) innovation, and (f) service. Give examples of manufacturing or service firms that successfully compete on each of the criteria listed.

1.21. What role should operations play in corporate strategy?

1.22. Name several strategic decisions that involve operations and supply chain management.

1.23. Why do companies need policy deployment? What does it do?

1.24. What is the balanced scorecard? How does it relate to operations?

1.25. Examine the annual reports of a company of your choosing over three years. Use quotes from the reports to describe the company's overall strategy and its specific goals each year. Pay special attention to global, digital, or big data strategies. How well do you think the company deploys its strategy?

1.26. Use either policy deployment or a balanced scorecard to map out a personal strategy for your future.

Problems

1.1. Tried and True Clothing has opened four new stores in college towns across the state. Data on monthly sales volume and labor hours are given below. Which store location has the highest labor productivity?

Store	Annandale	Blacksburg	Charlottesville	Danville
Sales volume	$40,000	$12,000	$60,000	$25,000
Labor hours	250	60	500	200

1.2. Tried and True's accountant (from Problem 1.1) suggests that monthly rent and hourly wage rate also be factored into the productivity calculations. Annandale pays the highest average wage at $15 an hour. Blacksburg pays $10 an hour, Charlottesville $9, and Danville $8.50. The cost to rent store space is $2,800 a month in Annandale, $1,200 a month in Blacksburg, $2,000 a month in Charlottesville, and $800 a month in Danville.

a. Which store is most productive?

b. Tried and True is not sure it can keep all four stores open. Based on multifactor productivity, which store would you close? What other factors should be considered?

1.3. At last year's bass tournament, Jim caught 12 bass in a four-hour period. This year he caught 15 in a six-hour period.

a. In which year was he most productive?

b. If the average size of the bass last year was 20 lb and the average size this year was 25 lb, would your decision change?

1.4. It is time for the annual performance review of Go-Com's account executives. Account values and hours spent each week acquiring and servicing accounts are shown in the next table. Each agent works approximately 45 weeks out of the year, but the time spent on accounts each week differs considerably.

a. How would you rate the performance of each individual? Which agent is most productive?

b. Which agents show the most potential? Why?

Agents	Albert	Bates	Cressey	Duong
New accounts	$100,000	$40,000	$80,000	$200,000
Existing accounts	$40,000	$40,000	$150,000	$100,000
Labor hours	40	20	60	80

1.5. The Bureau of Labor Statistics collects input and output data from various countries for comparison purposes. Labor hours are the standard measure of input. Calculate the output per hour from the following data. Which country is most productive?

	Labor Hours	Units of Output
United States	89.5	136
Germany	83.6	100
Japan	72.7	102

1.6. Omar Industries maintains production facilities in several locations around the globe. Average monthly cost data and output levels are given in the following tables.

a. Calculate the labor productivity of each facility.

b. Calculate the multifactor productivity of each facility.

c. If Omar needed to close one of the plants, which one would you choose?

Units (in 000s)	Cincinnati	Frankfurt	Guadalajara	Beijing
Finished goods	10,000	12,000	5,000	8,000
Work-in-process	1,000	2,200	3,000	6,000

Costs (in 000s)	Cincinnati	Frankfurt	Guadalajara	Beijing
Labor costs	$3,500	$4,200	$2,500	$800
Material costs	$3,500	$3,000	$2,000	$2,500
Energy costs	$1,000	$1,500	$1,200	$800
Transportation costs	$250	$2,500	$2,000	$5,000
Overhead costs	$1,200	$3,000	$2,500	$500

1.7. Rushing yardage for three Heisman Trophy candidates is given below. Which candidate is the most productive running back? How did you measure productivity?

Candidates	Henry	McCaffrey	Fournette
Rushing yards	2,110	3,623	6,925
No. of carries	105	875	1,186
No. of touchdowns	15	20	70

1.8. Carpet City recorded the following data on carpet installations over the past week. Use the data to calculate the average rate (in yards per hour) at which carpet can be installed. Be sure to consider the number of workers as well as the hours each worker works.

Installation	1	2	3
Square yards	1,225	1,435	2,500
No. of workers	4	3	5
No. of hours per worker	3	5	6

1.9. Merrifield Post Office is evaluating the productivity of its mail processing centers. The centers differ in the degree of automation, the type of work that can be performed, and the skill of the workers.

Center	1	2	3
Pieces processed/hr	1,000	2,000	3,000
No. of workers/hr	10	5	2
Hourly wage rate	$5.50	$10	$12
Overhead rate/hr	$10	$25	$50

a. Calculate the multifactor productivity for each center.

b. Workers in Center 1 are scheduled to receive a 10% pay raise next month. How will that affect productivity?

c. A new processing machine is available for Center 3 that would increase the output to 5,000 pieces an hour at an additional overhead rate of $30 an hour. Should Merrifield install the new processing machine?

1.10. Posey Ceramics makes ceramic vases for a chain of department stores. The output and cost figures over the past four weeks are shown here. Labor costs $10 an hour, and materials are $4 a pound. Calculate the (a) labor productivity (in hrs), (b) material productivity (in lbs), and (c) multifactor productivity for each week. Comment on the results.

Week	1	2	3	4
Units of output	2,000	4,000	5,000	7,000
No. of workers	4	4	5	6
Hours per week per worker	40	48	56	70
Material (lbs)	286	570	720	1,000

1.11. Jake and his friends sell newspaper ads for the *Campus Times* to supplement their income each year. From the data below, determine which person is the most productive.

	Jake	Josh	Jennifer	John
No. ads sold	100	50	200	35
No. hours spent	40	15	85	10

1.12. Nicholas is the facilities manager for Green Market Groceries. The store is remodeling and wants to determine which brand of freezer to use for its frozen goods section. The freezers vary by size, cabinet type, accessibility, refrigerant, and interliner. These variables affect both the purchase cost and the operating cost (e.g., energy consumption) of each freezer. Currently, the cost of energy per kilowatt hour (kwh) is $0.10. Green Market expenses capital purchases over a three-year period. Given the cost and capacity data below, calculate the "productivity" (i.e., the cubic feet of freezer space per dollar) for each freezer alternative. Which freezer brand would you recommend to Nicholas?

	Alaskan Seal	BRR Frost	Cold Case	Deep Freeze
Purchase cost	$3,270	$4,000	$4,452	$5,450
Daily energy consumption (kwh)	3.61	3.88	6.68	29.07
Volume (cu ft)	25	35	49	72

1.13. Sweet Tooth Inc., a leading chocolatier, can produce 100 lbs of chocolate powder from 1,000 lbs of cocoa beans in 10 hours of processing. Not satisfied with this output, the company is contemplating switching to a more automated process that would yield 200 lbs of chocolate powder per 1,800 lbs of cocoa beans and take 15 hours to process. The cost of processing is $25 per hour. Cocoa beans cost $6.80 per lb. Calculate:

a. The labor productivity of the current process

b. The labor productivity of the proposed process

c. The multifactor productivity of the current process

d. The multifactor productivity of the proposed process

e. Should Sweet Tooth Inc. continue with the existing process or switch to the new process?

1.14. True Value Jeans currently produces 60 pairs of jeans in an 8-hour day. The costs of production include:

Raw material	$10.00/pair
Labor	3 workers, $20/hour, 8 hours/day
Energy	$1/hour of machine time
Machines	3 machines, $10/hour, 8 hours/day

a. Calculate the labor productivity for True Value, that is, the number of jeans that can be produced with one hour of labor.

b. What is the per unit cost of manufacturing True Value jeans?

c. What is the multifactor productivity for True Value? Explain in your own words what multifactor productivity means.

1.15. Use the data contained in Figure 1.6 and Figure 1.10 to calculate productivity in terms of output per $ spent on labor for the countries listed in both figures. Which five countries are the most productive by this measure? Which five countries are the least productive?

Case Problems

Case Problem 1.1 Visualize This

Visualize This (VT) is a small start-up company specializing in virtual reality and computer visualizations. Located in the research park of a major university, the company was founded by Isaac Trice, a university professor, and staffed with the brightest of his former students. By all accounts the technology is cutting edge. Facilities include a lab of 14 high-end computer workstations adjacent to a CAVE (computer-aided virtual environment) and a small office. A conference room and central lobby are shared with other tenants in the building. Originally, the company had partnered with the Swedish firm Salvania to create virtual environments for medical and industrial design. Trice and his staff would develop the software for each application, create a visual database supported with engineering or medical data, and run design sessions for their clients in the CAVE. Salvania provided the capital, generated the clients, and handled the business end of the operations.

In its first two years of business, VT completed four projects. With each project, VT advanced its skills in visualization and developed customized tools to help its clients design intricate products. The clients were pleased but did not anticipate repeating the intensive design process for several years. Unfortunately, Salvania was unable to remain solvent and dissolved its partnership with VT. VT was able to keep its workstations (whose salvage value was low), but gave up its rights to the CAVE and furloughed all but three employees. To stay afloat, VT needed new clients and a steady stream of income. Trice hit the streets and came back with the following possibilities:

- Designing computer-based training sessions for bank tellers of an international finance institution
- Conducting software certification for the sales staff of a large software vendor
- Designing virtual reality tours through history for a major museum
- Developing Web-based virtual models for a women's clothing retailer
- Creating virtual catalogs in which a customer can enlarge, rotate, and dissect a product online

"This isn't what I had in mind for my company," Trice lamented as he shared the list with his employees. "I wanted to be developing the next generation of visualization tools in concert with the brightest minds in industry, not digitizing pictures of products and making them turn around, or teaching people to use software that's not even our own!"

That said, Trice and his staff of three began going through the list analyzing the pros and cons of each alternative.

1. Help Professor Trice formulate a strategy for his company by going through the steps of strategy formulation. For ideas, search the Internet for other companies that provide visualization solutions.

2. What capabilities does VT need to develop in order to pursue the strategy developed in question 1?

3. How can Trice reconcile his goals for the organization with the needs of the marketplace?

4. Compare the processes required to satisfy each customer on Trice's client list. Consider the mix of equipment and personnel, the length and scope of each project, and the potential for future business. How do the requirements differ from the projects already completed by VT?

5. Which projects would you recommend to VT? Why?

Case Problem 1.2 Whither an MBA at Strutledge?

Strutledge is a small private liberal arts school located within 50 miles of a major urban area in the southeastern United States. As with most institutions of higher education, Strutledge's costs are rising and its enrollments are decreasing. In an effort to expand its student base, build valuable ties with area businesses, and simply survive, the Board of Regents is considering establishing an MBA program.

Currently, no undergraduate degree is given in business, although business courses are taught. The dean of the school visualizes the MBA as an interdisciplinary program emphasizing problem solving, communication, and global awareness. Faculty expertise would be supplemented by instructors from local industry. The use of local faculty would better connect the university with the business community and provide opportunities for employment of the program's graduates.

In terms of competition, a major state-funded university that offers an MBA is located in the adjacent urban area. Strutledge hopes that state budget cutbacks and perceptions of overcrowded classrooms and overworked professors at public institutions will open the door for a new entrant into the market. The Board of Regents also feels that the school's small size will allow Strutledge to tailor the MBA program more closely to area business needs.

Several members of the Board are concerned about recent reports of the dwindling value of an MBA and are wondering if a better niche could be found with another graduate degree, perhaps a master of science in business analytics or something in the education or healthcare field.

1. What action would you recommend to the Board of Regents?

2. How should Strutledge go about making a strategic decision such as this?

Case Problem 1.3 Weighing Options at the Weight Club

The Weight Club started out as a student organization of 25 individuals who gathered together to discuss fitness goals and lift weights in the campus gym. When budget cutbacks cut gym hours and equipment

availability, the students began to look elsewhere for a facility they could organize and control as they wished. They found an empty store in a small, abandoned strip mall, rented it for next to nothing, asked its members to pay dues, and began sponsoring weight-lifting contests to raise money for equipment. Off-campus now, they could recruit members from the town as well as the university. Their members had many talents, and they began sponsoring cheerleading training and other specialized training programs for athletes.

Growth of the student-run organization was phenomenal. Within six years the club had more than 4,000 members from inside and outside the university community. The facility itself extended over three additional storefronts in the now bustling mall, housing more than 50 pieces of aerobic equipment, two complete sets of Nautilus equipment for circuit training, an entire floor of free weights, a separate room for heavy weights, and a large exercise room for a full range of aerobic, step, kickboxing, and stretch and tone classes. Graduate students found the facility an excellent source of subjects for projects ranging from nutrition to exercise to lifestyle changes (after heart attacks, for instance). Members were often able to take advantage of these additional services free of charge.

The Weight Club clientele began to change as more nonuniversity students joined (from moms in the morning hours to teenagers after school and businesspersons after work). This diversity brought with it numerous requests for additional services such as child care, personal trainers, children's classes, massages, swimming and running facilities, locker rooms and showers, food and drink, sportswear, gymnastics, hotel and corporate memberships, meetings, and sponsored events.

Currently, all members pay the same $40 monthly usage fee with no other membership fees or assessments for additional services (like exercise classes). The staff consists predominantly of student members, many of whom have financed their way through school by working at the Weight Club. The organization is run by a founding member of the original weight club, who will finally graduate this year. Two other founding members have already graduated but work full-time in the area and help administer the club whenever they can, serving as an informal "board of directors." In general, this arrangement has worked well, although decisions are made by whoever is behind the desk at the time, and there is no long-range planning.

The Weight Club has no significant competition. The three remaining "administrators" wonder if they need to make any changes.

Help the Weight Club get a handle on its operations and plan for the future by creating a balanced scorecard. Make a list of possible objectives for the Weight Club in terms of finance, customers, processes, and development (i.e., learning and growing). Add key performance measures and set goals for the year. Visit an exercise facility near you for ideas as you complete this assignment.

References

AT&T Quality Steering Committee. *Policy Deployment: Setting the Direction for Change*. Indianapolis: AT&T Technical Publications Center, 1992.

Briggs, Ben, Nishita Henry, and Andy Main, "Beyond the Digital Frontier: Mapping Your Future." *Deloitte Insights* (January 16, 2019).

Christensen, Clayton. *The Innovator's Dilemma*. New York: Harper Business, 2003.

Engardio, Pete, and Dexter Roberts, "The China Price." *Business Week* (December 6, 2004).

Friedman, Thomas. *Hot, Flat, and Crowded*, New York: Farrar, Straus, and Giroux, 2008.

Friedman, Thomas. *The World Is Flat*. New York: Farrar, Straus and Giroux, 2005.

Friedman, Thomas, and Michael Mandelbaum, *That Used to Be Us*. New York: Picador, 2012.

Hammer, Michael. *Beyond Reengineering*. New York: Harper-Collins, 1996.

Hayes, Robert, Gary Pisano, David Upton, and Steven Wheelwright. *Operations Strategy and Technology: Pursuing the Competitive Edge*. Hoboken, NJ: John Wiley, 2005.

Hill, Terry. *Manufacturing Strategy: Test and Cases*, 3rd ed. Homewood, IL: Irwin, 2000.

Jones, Patricia, and Larry Kahaner. *Say It and Live It: The 50 Corporate Mission Statements That Hit the Mark*. New York: Currency Doubleday, 1995.

Kaplan, Robert, and David Norton. *Strategy Maps: Converting Intangible Assets into Tangible Outcomes*. Boston: Harvard Business School Press, 2004.

King, Bob. *Hoshin Planning*: *The Developmental Approach*. Springfield, MA: GOAL/QPC, 1989.

Leonard-Barton, Dorothy. *Wellsprings of Knowledge: Building and Sustaining the Sources of Innovation*. Boston: Harvard Business School Press, 1995.

Manufacturing Studies Board. *Towards a New Era in Manufacturing: The Need for a National Vision*. Washington, DC: National Academy Press, 1986.

Midler, Paul. *Poorly Made in China*. Hoboken, NJ: John Wiley and Sons, Inc., 2011.

Peters, Tom. *Thriving on Chaos*. New York: Alfred A. Knopf, 1987.

Porter, Michael. *On Competition*. Boston: Harvard Business School Publishing, 2008.

Quade, Walter. "Beginner's Guide to the Asian Supply Chain." *Inside Supply Management* (March 2004), pp. 8–9.

Schwab, Klaus. "The Fourth Industrial Revolution: What It Means, How to Respond," *Foreign Affairs*, December 12, 2015.

Skinner, Wickham. *Manufacturing: The Formidable Competitive Weapon*. New York: John Wiley, 1985.

Skinner, Wickham. "Three Yards and a Cloud of Dust: Industrial Management at Century End." *Production and Operations Management* 5(1; Spring 1996):15–24.

Voss, Christopher. "Operations Management—from Taylor to Toyota—and Beyond." *British Journal of Management* 6 (December 1995), S17–S29.

Womack, James, Daniel Jones, and Daniel Roos. *The Machine That Changed the World*. New York: Macmillan, 1990.

Zysmann, John, and Martin Kenney, "The Next Phase in the Digital Revolution: Intelligent Tools, Platforms, Growth and Employment." *Communications of the ACM* (February 2018), pp. 54–63.

Answers to Odd Numbered Problems

1.1. Blacksburg

1.3. **a.** last year

b. yes

1.5. United States

1.7. Henry; Fournette

1.9. **a.** 15.38, 26.67, 40.54

b. decreases

c. yes

1.11. John

1.13. **a.** 10

b. 13.33

c. .014

d. .016

1.15. Most productive — Turkey, Mexico, India, Taiwan, and Philippines. Least productive — Switzerland, Sweden, Argentina, South Korea, and Germany.