10

Achieving World-Class Operations Management

Exhibit 10.1 (Credit: U.S. Geological Survey / flickr/ Attribution 2.0 Generic (CC BY 2.0))

Introduction

Learning Outcomes

After reading this chapter, you should be able to answer these questions:

1. Why is production and operations management important in both manufacturing and service firms?
2. What types of production processes do manufacturers and service firms use?
3. How do organizations decide where to put their production facilities? What choices must be made in designing the facility?
4. Why are resource-planning tasks such as inventory management and supplier relations critical to production?
5. How do operations managers schedule and control production?
6. How can quality-management and lean-manufacturing techniques help firms improve production and operations management?
7. What roles do technology and automation play in manufacturing and service-industry operations management?
8. What key trends are affecting the way companies manage production and operations?

EXPLORING BUSINESS CAREERS

Deborah Butler, Caterpillar

Deborah Butler is a certified Master Black Belt, but don't expect to see her working with Jet Li anytime soon. In fact, her job has little to do with martial arts. Employed by Caterpillar, "the world's leading

manufacturer of construction and mining equipment, diesel and natural gas engines, and industrial gas turbines," Butler's Master Black Belt status reflects her expertise in Six Sigma, the process Caterpillar employees use to continually manage, improve, and create processes, products, and services. "Sigma" refers to the maximum number of defects tolerated in production or service delivery; Six Sigma is the highest level of quality control, demanding no more than 3.4 defects per million parts. That means if you were to use Six Sigma in your college career, you would miss only *one half of a single question* in over four years of test-taking!

Caterpillar was the first corporation to take Six Sigma global, deploying it corporate-wide in 2001 not only to its almost 300 facilities, but also eventually to every dealer and more than 850 key suppliers throughout the world. The corporation hails the process as a key element of its overall operations management, attributing increased profits, improved customer service, and supply-chain efficiency to Six Sigma.

Caterpillar's more than 300 Master Black Belts lead projects that use Six Sigma and train the company's approximately 3,300 Black Belts in the principles of the process. Butler is currently in charge of updating and implementing *Our Values in Action: Caterpillar's Worldwide Code of Conduct*. Outlining the four core values of integrity, excellence, teamwork, and commitment, the updated code of conduct embodies two important aspects of Caterpillar's philosophy on Six Sigma.

Sigma is a Greek letter that represents a statistical unit of measurement and defines standard deviation. Caterpillar uses this standard deviation for the number of errors in a product, which equates to 3.4 errors per million. Six Sigma is designed to reduce the number of errors in a process by a step-by-step approach. Caterpillar uses the Six Sigma methodology that utilizes the process of gathering information, analyzing the data, and then making decisions based on the facts. This process ensures that Caterpillar is meeting the requirements of the customer.

Caterpillar recognizes that employees are the heart of any operation. Therefore, Caterpillar employees use Six Sigma to improve as people and as workers as much as to improve the products they produce. The core values, reflected in a series of action statements such as "We put Integrity in action when we compete fairly," are the product of a yearlong development process involving Butler's global team. As part of the project research, the team interviewed thousands of Caterpillar employees, from officers of the company to production and hourly workers, for the purpose of, as Butler says, "bringing to the surface the values that have made Caterpillar a successful enterprise, enhancing behavioral expectations, and accurately expressing Caterpillar's corporate culture."

Caterpillar is not content simply to produce *Our Values in Action* and leave it at that, however, and the second aspect of its Six Sigma philosophy is that employees must bring the process to their lives. Butler has worked to inject the code of conduct's values into employees' day-to-day work. If an employee writes about safety-related changes, for example, she would not just list the changes. Instead, she might write first: "According to Our Values In Action, we put Commitment in action when we protect the health and safety of others and ourselves. As such, we are implementing the following changes. . . ." In this way, the code becomes a living part of corporate culture, a critical component of operations management.

Sources: Heather McBroom, "6 Sigma: Foundation for Quality at Caterpillar," *Peoria Magazine*, http://www.peoriamagazines.com, accessed February 20, 2018; John Gillett, Ross Fink, and Nick Bevington, "How Caterpillar Uses 6 Sigma to Execute Strategy," *Strategic Finance Magazine,* http://sfmagazine.com, accessed February 20, 2018; company website, "Christopher Six Sigma Black

Belt," https://www.caterpillar.com, accessed February 20, 2018.

Nearly every type of business organization needs to find the most efficient and effective methods of producing the goods or services it sells to its customers. Technological advances, ongoing competition, and consumer expectations force companies to rethink where, when, and how they will produce products or services.

Manufacturers have discovered that it is no longer enough to simply push products through the factory and onto the market. Consumers demand high quality at reasonable prices. They also expect manufacturers to deliver products in a timely manner. Firms that can't meet these expectations often face strong competition from businesses that can. To compete, many manufacturers are streamlining how they make their products—by automating their factories, developing new production processes, focusing on quality-control techniques, and improving relationships with suppliers.

Service organizations also face challenges. Their customers are demanding better service, shorter waiting periods, and more individualized attention. Like manufacturers, service companies are using new methods to deliver what their customers need and want. Banks, for example, are using technology such as online banking and mobile apps to make their services more accessible to customers. Colleges offer online courses to accommodate the schedules of working students. Tax services file tax returns via the cloud.

This chapter examines how manufacturers and service firms manage and control the creation of products and services. We'll discuss production planning, including the choices firms must make concerning the type of production process they will use; the location where production will occur; the design of the facility; and the management of resources needed in production. Next, we'll explain routing and scheduling, two critical tasks for controlling production and operations efficiency. Then we will look at how firms can improve production and operations by employing quality management and lean-manufacturing techniques. Finally, we will review some of the trends affecting production and operations management.

10.1 Production and Operations Management—An Overview

1. Why is production and operations management important in both manufacturing and service firms?

Production, the creation of products and services, is an essential function in every firm. Production turns inputs, such as natural resources, raw materials, human resources, and capital, into outputs, which are products and services. This process is shown in **Exhibit 10.3**. Managing this conversion process is the role of **operations management**.

Exhibit 10.2 With new oil reserves now available through "fracking," the United States is challenging Saudi Arabia and is set to become a vast supplier of oil worldwide. Unlike the smooth petroleum that gushes from Arabian wells, however, America's black gold in the Marcellus, Bakken, and other shale regions has to be drilled horizontally through new technology. The process is rigorous: oil and gas companies drill into the ground to extract crude oil and natural gas from the shale rock that lies thousands of feet under the ground. Once the formation is reached, gallons of water, sand, and an extensive list of man-made chemicals are injected into the well under high pressure. This combination inserted in the well will fracture the rock and release crude oil and natural gas. It is estimated that the gas within these rock formations could supply the United States for generations to come as technologies evolve to drill below the earth's surface. *What are key inputs in the fracking process?* (Credit: Mark Dixon/ Flickr/ Attribution 2.0 Generic (CC BY 2.0))

The goal of customer satisfaction is an important part of effective production and operations. In the past, the manufacturing function in most companies was inwardly focused. Manufacturing had little contact with customers and didn't always understand their needs and desires. In the 1980s, many U.S. industries, such as automotive, steel, and electronics, lost customers to foreign competitors because their production systems could not provide the quality customers demanded. As a result, today most American companies, both large and small, consider a focus on quality to be a central component of effective operations management.

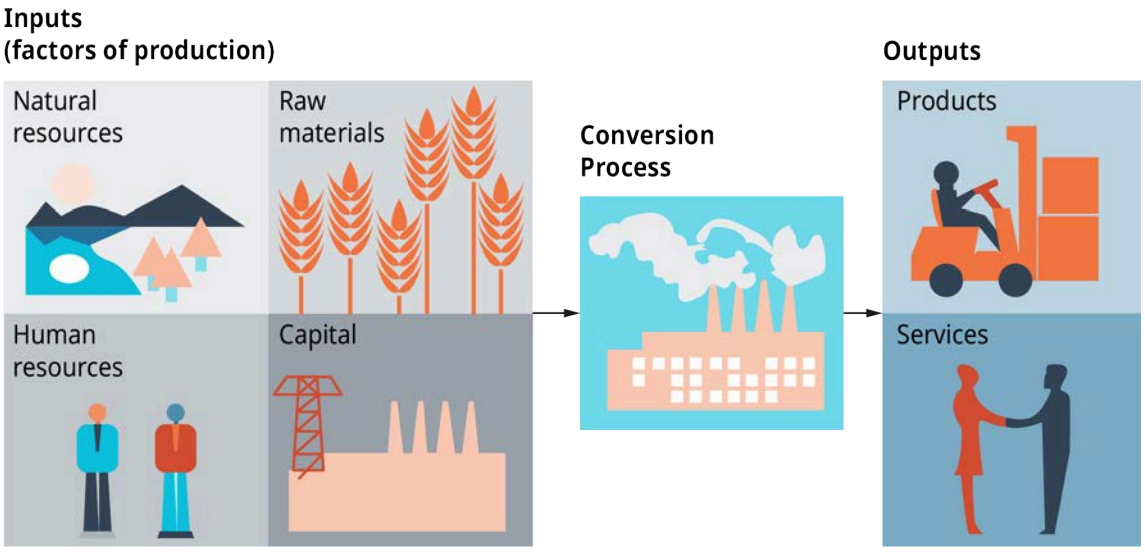

Exhibit 10.3 Production Process for Products and Services (Attribution: Copyright Rice University, OpenStax, under CC BY 4.0 license.)

Stronger links between marketing and manufacturing also encourage production managers to be more outwardly focused and to consider decisions in light of their effect on customer satisfaction. Service companies find that making operating decisions with customer satisfaction in mind can be a competitive advantage.

Operations managers, the people charged with managing and supervising the conversion process, play a vital role in today's firm. They control about three-fourths of a firm's assets, including inventories, wages, and benefits. They also work closely with other major divisions of the firm, such as marketing, finance, accounting, and human resources, to ensure that the firm produces its goods profitably and satisfies its customers. Marketing personnel help them decide which products to make or which services to offer. Accounting and human resources help them face the challenge of combining people and resources to produce high-quality goods on time and at reasonable cost. They are involved in the development and design of goods and determine what production processes will be most effective.

Production and operations management involve three main types of decisions, typically made at three different stages:

1. *Production planning.* The first decisions facing operations managers come at the *planning stage.* At this stage, managers decide where, when, and how production will occur. They determine site locations and obtain the necessary resources.
2. *Production control.* At this stage, the decision-making process focuses on controlling quality and costs, scheduling, and the actual day-to-day operations of running a factory or service facility.
3. *Improving production and operations*. The final stage of operations management focuses on developing more efficient methods of producing the firm's goods or services.

All three decisions are ongoing and may occur simultaneously. In the following sections, we will take a closer look at the decisions and considerations firms face in each stage of production and operations management.

Gearing Up: Production Planning

An important part of operations management is **production planning**. Production planning allows the firm to consider the competitive environment and its own strategic goals to find the best production methods. Good

production planning has to balance goals that may conflict, such as providing high-quality service while keeping operating costs low, or keeping profits high while maintaining adequate inventories of finished products. Sometimes accomplishing all these goals is difficult.

Exhibit 10.4 From its storied creation in post-war Italy to its big-screen immortalization in movies such as *Roman Holiday* and *Quadrophenia*, the Vespa scooter has a reputation for romance, rebellion, and style. Manufactured by Italy's Piaggio Group, the Vespa's svelte, stainless-steel chassis and aeronautic-inspired designs are seen everywhere in Europe and more and more in the United States. The Piaggio Group presently operates factories in Italy, Vietnam, India, and China. *What important production-planning decisions does Piaggio need to make as it considers expanding into more overseas markets?* (Credit: Steve Watkins/ Flickr/ Attribution-2.0 Generic (CC BY2.0))

Production planning involves three phases. Long-term planning has a time frame of three to five years. It focuses on which goods to produce, how many to produce, and where they should be produced. Medium-term planning decisions cover about two years. They concern the layout of factory or service facilities, where and how to obtain the resources needed for production, and labor issues. Short-term planning, within a one-year time frame, converts these broader goals into specific production plans and materials management strategies.

Four important decisions must be made in production planning. They involve the type of production process that will be used, site selection, facility layout, and resource planning.

CONCEPT CHECK

1. What are the three types of decisions that must be made in production planning?
2. What are the three phases of production planning?

10.2 The Production Process: How Do We Make It?

2. What types of production processes do manufacturers and service firms use?

In production planning, the first decision involves which type of **production process**—the way a good or service is created—best fits with company goals and customer demand. An important consideration is the type of good or service being produced, because different goods may require different production processes. In general, there are three types of production: mass production, mass customization, and customization. In addition to production type, operations managers also classify production processes in two ways: (1) how inputs are converted into outputs and (2) the timing of the process.

One for All: Mass Production

Mass production, manufacturing many identical goods at once, was a product of the Industrial Revolution. Henry Ford's Model-T automobile is a good example of early mass production. Each car turned out by Ford's factory was identical, right down to its color. If you wanted a car in any color except black, you were out of luck. Canned goods, over-the-counter drugs, and household appliances are other examples of goods that are mass-produced. The emphasis in mass production is on keeping manufacturing costs low by producing uniform products using repetitive and standardized processes. As products became more complicated to produce, mass production also became more complex. Automobile manufacturers, for example, must now incorporate more sophisticated electronics into their car designs. As a result, the number of assembly stations in most automobile manufacturing plants has increased.

Just for You: Customizing Goods

In **mass customization**, goods are produced using mass-production techniques, but only up to a point. At that point, the product or service is custom-tailored to the needs or desires of individual customers. For example, American Leather, a Dallas-based furniture manufacturer, uses mass customization to produce couches and chairs to customer specifications within 30 days. The basic frames in the furniture are the same, but automated cutting machinery precuts the color and type of leather ordered by each customer. Using mass-production techniques, they are then added to each frame.

Customization is the opposite of mass production. In customization, the firm produces goods or services one at a time according to the specific needs or wants of individual customers. Unlike mass customization, each product or service produced is unique. For example, a print shop may handle a variety of projects, including newsletters, brochures, stationery, and reports. Each print job varies in quantity, type of printing process, binding, color of ink, and type of paper. A manufacturing firm that produces goods in response to customer

orders is called a **job shop**.

Exhibit 10.5 Classification of Production Types (Attribution: Copyright Rice University, OpenStax, under CC BY 4.0 license.)

Mass Production	Mass Customization	Customization
Highly uniform products or services Many products made sequentially	Uniform standardized production to a point, then unique features added to each product	Each product or service produced according to individual customer requirements
Examples: Breakfast cereals, soft drinks, and computer keyboards	**Examples:** Dell Computers, tract homes, and Taylor Made golf clubs	**Examples:** Custom homes, legal services, and haircuts

Some types of service businesses also deliver customized services. Doctors, for instance, must consider the illnesses and circumstances of each individual patient before developing a customized treatment plan. Real estate agents may develop a customized service plan for each customer based on the type of house the person is selling or wants to buy. The differences between mass production, mass customization, and customization are summarized in **Exhibit 10.5**.

Converting Inputs to Outputs

As previously stated, production involves converting *inputs* (natural resources, raw materials, human resources, capital) into *outputs* (products or services). In a manufacturing company, the inputs, the production process, and the final outputs are usually obvious. Harley-Davidson, for instance, converts steel, rubber, paint, and other inputs into motorcycles. But the production process in a service company involves a less obvious conversion. For example, a hospital converts the knowledge and skills of its medical personnel, along with equipment and supplies from a variety of sources, into health care services for patients. **Table 10.1** provides examples of the inputs and outputs used by various other businesses.

There are two basic processes for converting inputs into outputs. In **process manufacturing**, the basic inputs (natural resources, raw materials) are broken down into one or more outputs (products). For instance, bauxite (the input) is processed to extract aluminum (the output). The **assembly process** is just the opposite. The basic inputs, like natural resources, raw materials, or human resources, are either *combined* to create the output or *transformed* into the output. An airplane, for example, is created by assembling thousands of parts, which are its raw material inputs. Steel manufacturers use heat to transform iron and other materials into steel. In services, customers may play a role in the transformation process. For example, a tax preparation

service combines the knowledge of the tax preparer with the client's information about personal finances in order to complete the tax return.

Production Timing

A second consideration in choosing a production process is timing. A **continuous process** uses long production runs that may last days, weeks, or months without equipment shutdowns. This is best for high-volume, low-variety products with standardized parts, such as nails, glass, and paper. Some services also use a continuous process. Your local electric company is an example. Per-unit costs are low, and production is easy to schedule.

Converting Inputs to Outputs

Type of Organization	Input	Output
Airline	Pilots, flight attendants, reservations system, ticketing agents, customers, airplanes, maintenance crews, ground facilities	Movement of customers and freight
Grocery store	Merchandise, building, clerks, supervisors, store fixtures, shopping carts, customers	Groceries for customers
High school	Faculty, curriculum, buildings, classrooms, library, auditorium, gymnasium, students, staff, supplies	Graduates, public service
Manufacturer	Machinery, raw materials, plant, workers, managers	Finished products for consumers and other firms
Restaurant	Food, cooking equipment, servers, chefs, dishwashers, host, patrons, furniture, fixtures	Meals for patrons

Table 10.1

In an **intermittent process**, short production runs are used to make batches of different products. Machines are shut down to change them to make different products at different times. This process is best for low-volume, high-variety products such as those produced by mass customization or customization. Job shops are examples of firms using an intermittent process.

Although some service companies use continuous processes, most service firms rely on intermittent processes. For instance, a restaurant preparing gourmet meals, a physician performing surgical procedures, and an advertising agency developing ad campaigns for business clients all customize their services to suit each customer. They use the intermittent process. Note that their "production runs" may be very short—one grilled salmon or one physical exam at a time.

CONCEPT CHECK

1. Describe the different types of production processes.
2. How are inputs transformed into outputs in a variety of industries?

10.3 Location, Location, Location: Where Do We Make It?

3. How do organizations decide where to put their production facilities? What choices must be made in designing the facility?

A big decision that managers must make early in production and operations planning is where to put the facility, be it a factory or a service office. The facility's location affects operating and shipping costs and, ultimately, the price of the product or service and the company's ability to compete. Mistakes made at this stage can be expensive, because moving a factory or service facility once production begins is difficult and costly. Firms must weigh a number of factors to make the right decision.

Exhibit 10.6 Facing stiff competition from rival automobile companies and sagging demand among German consumers, Germany's BMW (Bavarian Motor Works) opened a factory in Spartansburg, South Carolina. Opened in 1994, the U.S. plant recently produced it four millionth vehicle and now employs 9,000 employees in its six million square foot plant. *What factors determine where auto companies locate their operations?* (Credit: Daniel Chou/ Flickr/ Attribution-NoDerivs 2.0 Generic (CC BY-ND 2.0))

Availability of Production Inputs

As we discussed earlier, organizations need certain resources to produce products and services for sale.

Access to these resources, or inputs, is a huge consideration in site selection. Executives must assess the availability of raw materials, parts, equipment, and available manpower for each site under consideration. The cost of shipping raw materials and finished goods can be as much as 25 percent of a manufacturer's total cost, so locating a factory where these and other costs are as low as possible can make a major contribution to a firm's success.

Companies that use heavy or bulky raw materials, for example, may choose to be located close to their suppliers. Mining companies want to be near ore deposits, oil refiners near oil fields, paper mills near forests, and food processors near farms. Bottlers are discovering that rural western communities in need of an economic boost make rich water sources. In Los Lunas, New Mexico, it made sense for Niagara Purified Drinking Water to produce purified bottled water in a 166,000 square foot building that was vacant. The business helps diversify the town's economy and created 40 new, much-needed jobs.[1]

The availability and cost of labor are also critical to both manufacturing and service businesses, and the unionization of local labor is another point to consider in many industries. Payroll costs can vary widely from one location to another due to differences in the cost of living; the number of jobs available; and the size, skills, and productivity of the local workforce. In the case of the water-bottling company, a ready pool of relatively inexpensive labor was available due to high unemployment in the areas.

Marketing Factors

Businesses must evaluate how their facility location will affect their ability to serve their customers. For some firms it may not be necessary to be located near customers. Instead, the firm will need to assess the difficulty and costs of distributing its goods to customers from its chosen location. Other firms may find that locating near customers can provide marketing advantages. When a factory or service center is close to customers, the firm can often offer better service at a lower cost. Other firms may gain a competitive advantage by locating their facilities so that customers can easily buy their products or services. The location of competitors may also be a consideration. And businesses with more than one facility may need to consider how far to spread their locations in order to maximize market coverage.

Manufacturing Environment

Another factor to consider is the manufacturing environment in a potential location. Some localities have a strong existing manufacturing base. When a large number of manufacturers in a certain industry are already located in an area, that area is likely to offer greater availability of resources, such as manufacturing workers, better accessibility to suppliers and transportation, and other factors that can increase a plant's operating efficiency.

Nestlé is proposing to open a new bottled water plant in the desert city of Phoenix. The plants have provided much-needed employment to replace jobs lost in the recession of 2008. The city of Phoenix faced opposition to the plant because some locals thought that diverting water from tap water to a for-profit entity was not a sound idea. Phoenix officials contend that the source of water is adequate for decades to come.[2]

Local Incentives

Incentives offered by countries, states, or cities may also influence site selection. Tax breaks are a common incentive. A locality may reduce the amount of taxes a firm must pay on income, real estate, utilities, or payroll. Local governments may offer financial assistance and/or exemptions from certain regulations to attract or

keep production facilities in their area. For example, many U.S. cities are competing to attract a second Amazon headquarters and, in addition to touting local attractions and a strong workforce, most of them are offering a host of tax incentives.[3]

International Location Considerations

There are often sound financial reasons for considering a foreign location. Labor costs are considerably lower in countries such as Singapore, China, India, and Mexico. Foreign countries may also have fewer regulations governing how factories operate. A foreign location may also move production closer to new markets. Automobile manufacturers such as Toyota, BMW, and Hyundai are among many that build plants in the United States to reduce shipping costs.

Designing the Facility

After the site location decision has been made, the next focus in production planning is the facility's layout. The goal is to determine the most efficient and effective design for the particular production process. A manufacturer might opt for a U-shaped production line, for example, rather than a long, straight one, to allow products and workers to move more quickly from one area to another.

Service organizations must also consider layout, but they are more concerned with how it affects customer behavior. It may be more convenient for a hospital to place its freight elevators in the center of the building, for example, but doing so may block the flow of patients, visitors, and medical personnel between floors and departments.

There are three main types of facility layouts: process, product, and fixed-position. All three layouts are illustrated in **Exhibit 10.7**. Cellular manufacturing is another type of facility layout.