Chapter 17: Operations Management: Putting It All Together (pp. 272-0)

LEARNING OBJECTIVES

After studying this chapter, you will be able to…

LO1 Define operations management and describe how the role of operations management has changed over the past fifty years

LO2 Discuss the key responsibilities of operations managers

LO3 Describe how operations managers face the special challenges posed by the provision of services

LO4 Explain how changes in technology have revolutionized operations management

LO5 Describe the strategies operations managers have used to improve the quality of goods and services

LO6 Explain how lean and green practices can help both the organization and the environment
LO1 Operations Management: Producing Value in a Changing Environment

Operations management is concerned with managing all of the activities involved in creating value by producing goods and services and distributing them to customers. When operations managers do their job well, their firms produce the right goods and services in the right quantities and distribute these to the right customers at the right time—all the while keeping quality high and costs low. Obviously, the decisions of operations managers can have a major impact on a firm's revenues and its costs, and thus on its overall profitability.

Responding to a Changing Environment

The practice of operations management has changed dramatically over the past half century. New technologies, shifts in the structure of the economy, challenges posed by global competition and concerns about the impact of production on the environment have fueled this revolution. Let's begin by identifying the key changes that have characterized the practice of operations management over the past fifty years.

From a Focus on Efficiency to a Focus on Effectiveness

To operations managers, efficiency means producing a product at the lowest cost. Effectiveness means producing products that create value by providing customers with goods and services that offer a better relationship between price and perceived benefits. In other words, effectiveness means finding ways to give customers more for their money—while still making a profit.

In the 1960s the focus of operations management was mainly on efficiency. The goal was to keep costs low so the firm could make a profit while keeping its prices competitive. In today's highly competitive global markets, efficiency remains important. But operations managers now realize that keeping costs (and prices) low are only part of the equation. Customers usually buy goods that offer the best value—and these aren't always the same as the goods that sell for the lowest price. A product that offers better features, more attractive styling and higher quality may provide more value—and attract more customers—than a product with a lower price. Thus, today's operations managers have broadened their focus to look at benefits as well as costs.

From Goods to Services

Goods are tangible products that you can see and touch. Durable goods are expected to last three years or longer; examples include
furniture, cars and appliances. **Nondurable goods**, such as toothpaste, apples, and paper towels, are used up more quickly and are often perishable. **Services** are activities that yield benefits but don’t directly result in a physical product. Examples include legal advice, entertainment, and medical care. Goods are consumed, while services are experienced.

In the 1960s, the U.S. economy was a manufacturing powerhouse, with more than a third of its labor force employed in the goods-producing sector. But over the past fifty years, the American economy has experienced a fundamental shift away from the production of goods and toward the provision of services. By 2010, less than 15% of the nonfarm labor force worked in the goods-producing sector. By contrast, employment in the service sector had risen to well over 80% of the labor force.¹

**From Mass Production to Mass Customization**

Fifty years ago, one common production strategy was to keep costs low by producing large quantities of standardized products. The goal of this *mass production* strategy was to achieve reductions in average cost by taking advantage of specialization and the efficient use of capital. But today's technologies allow many firms to pursue *mass customization*—the production of small quantities of customized goods and services that more precisely meet the needs of specific customers—with very little increase in costs.

**From Local Competition to Global Competition**

For the first twenty-five years after World War II, American firms dominated key markets. This strength was based partly on the fact that the United States possessed a rich base of natural resources, a growing and increasingly well-educated labor force, excellent infrastructure, and the strong incentive system inherent in a market economy. But it also reflected the fact that the production facilities and infrastructure in many European and Asian nations had been severely damaged during the war.

By the early 1970s, the economies of Japan, Germany, and other war-ravaged nations had been rebuilt, with many of their major companies boasting efficient new production facilities with state-of-the-art technology. In addition, many Japanese firms had adopted new techniques that greatly improved the quality of their products. With lower labor costs, impressive technology and world-class quality, these foreign producers quickly began to take market share from American firms. In more recent years, firms in Korea, India, and China have also become formidable competitors.

**From Simple Supply Chains to Complex Value Chains**

Over the past fifty years, the increasingly competitive and global nature of markets has brought about major changes in how firms produce and distribute their goods and services. Many supply chains today span multiple organizations located in many different countries. The shift from a cost perspective to a value perspective has led operations managers to extend their view beyond the traditional supply chain to encompass a broader range of processes and organizations known as a *value chain*. 

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From Exploiting the Environment to Protecting the Environment In the 1960s, many operations managers viewed the natural environment as something to exploit. The emphasis on keeping costs low made it tempting to dispose of wastes as cheaply as possible—often by dumping them into rivers, lakes, or the atmosphere. But the serious consequences of environmental pollution have become increasingly apparent. Operations managers at socially responsible companies have responded by adopting a variety of green practices to produce goods and services in more environmentally responsible ways.

Exhibit 17.1 summarizes the discussion of the key ways in which operations management has changed over the past fifty years. We'll look at these changes in greater detail as we move through this chapter. But first let's take a look at some of the key tasks operations managers perform.
LO2 What Do Operations Managers Do?

Understanding the marketing definition of product plays a pivotal role in understanding what operations managers do. A product consists of all of the tangible and intangible features (sometimes called the customer benefit package) that create value for consumers by satisfying their needs and wants. For example, when you purchase a car made by General Motors, you not only get the physical automobile, you also get (among other things) a warranty and (for many models) a year of OnStar services.

Marketing research typically determines which features a product should include to appeal to its target customers. Although operations managers don't normally have the primary responsibility for designing these goods and services, they provide essential information and advice during the product-design process, especially regarding the challenges and constraints involved in creating actual products on time and within budget.

Once the actual goods and services are designed, operations managers must determine the processes needed to produce them and get them to the customer. A process is a set of related activities that transform inputs into outputs, thus adding value. Once these processes are designed, operations managers also play a key role in determining where they will be performed, what organizations will perform them, and how the processes will be organized and coordinated.

The most obvious processes are those directly involved in the production of goods and services. But there are many other processes that play necessary “supporting roles.” For example, purchasing and inventory management processes ensure that the firm has an adequate supply of high-quality materials, parts, and components needed to produce the goods without delays or disruptions.

Let's take a closer look at some of the functions that operations managers perform to move goods and services from the drawing board to the final user.

**Process Selection and Facility Layout**

Once a product is designed, operations managers must determine the best way to produce it. This involves determining the most efficient processes, deciding the best sequence in which to arrange those processes, and designing the appropriate layout of production and distribution facilities. Well-designed processes and facility layouts enable a firm to produce high-quality products effectively and efficiently, giving it a competitive advantage. Poorly designed processes can result in production delays, quality problems, and high costs.

There are several ways to organize processes. The best approach depends on considerations such as the volume of production and the degree of standardization of the product.

- **Firms** often use a *product layout* when they produce goods that are relatively standardized and produced in large volumes. This type of layout organizes machinery, equipment, and other resources according to the specific sequence of operations that must performed. The machinery used in this type of layout is often highly specialized, designed to perform one specific task very efficiently. One classic example of a product layout is an assembly line, where the product being produced moves from one station to another in a fixed sequence, with the machinery and workers at each station performing specialized tasks. Services that provide a high volume of relatively standardized products also use flow-shop processes. For example, fast food restaurants often use a simple product layout to prepare sandwiches, pizzas, or tacos in a standard sequence of steps.
- **A process layout** is used by many firms that need to produce small batches of goods that require a degree of customization. This approach arranges equipment according to the type of task performed. For example, in a machine shop all of the drills may be located in one area, all of the lathes in another area, and all
The Bureau of Labor Statistics forecasts the U.S. service sector will generate 14.5 million new jobs between 2008 and 2018, while employment in the goods producing sector will remain unchanged over the same period.

— Bureau of Labor
of the grinders in yet another. Unlike assembly lines and other product layouts, a process layout doesn't require work to be performed in a specific sequence; instead, the product can be moved from one type of machinery to another in whatever sequence is necessary. Thus, process layouts can be used to produce a variety of products without the need for expensive retooling. But this flexibility sometimes comes at the cost of longer processing times and more complex planning and control systems. Also, because the machinery and equipment used in a process layout is usually more general-purpose in nature and may be used to produce a greater variety of goods, the process layout requires workers to be more versatile than those employed in a product layout.

- A cellular layout falls between the product layout and the process layout. It groups different types of machinery and equipment into self-contained cells. A production facility might have several cells, each designed to efficiently produce a family of parts (or entire products) that have similar processing requirements. Like an assembly line, the product moves from one station in the cell to the next in a specific sequence. However, unlike most assembly lines, cells are relatively small and are designed to be operated by a few workers who perform a wider array of tasks than assembly line workers.

- A fixed position layout is used for goods that must be produced at a specific site (such as a building or a dam) or that are so large and bulky that it isn't feasible to move them from station to station (such as a ship or commercial airplane). Even some services, such as concerts or sporting events that are performed at a specific location use this approach. In a fixed position layout, the good or service stays in one place, and the employees, machinery, and equipment are brought to the fixed site when needed during various stages of the production process.

Facility Location

There is an old saying in real estate that the three most important factors determining the value of a property are “location, location, and location.” There is no doubt that the location is also important to operations managers. The location of facilities can have an important influence on the efficiency and effectiveness of an organization's processes.

For some types of facilities, the location decision is dominated by one key consideration. A coalmine, for instance, must be located where there's coal. But for many other types of facilities, the decision is more complex. Exhibit 17.2 identifies some key factors that operations managers evaluate when they decide where to locate a facility, but importance of each factor varies depending on the specific industry. For instance, many service firms place primary interest on locating close to their markets, while manufacturing firms are often more concerned about the cost and availability of land and labor and access to highways, railways, and port facilities.

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EXHIBIT 17.2 Factors That Affect Location © Cengage Learning 2013

Inventory Control: Knowing When to Hold'Em

Inventories are stocks of goods or other items held by an organization. Manufacturing firms usually hold inventories of raw materials, components and parts, work in process, and finished goods. Retail firms don't normally hold work in process or raw materials, but they do hold inventories of the finished goods they sell as well as basic supplies that they need.

Deciding how much inventory to hold can be a real challenge for operations managers because increasing (or decreasing) the amount of inventory involves both benefits and costs. For example, benefits of holding larger inventories include:

- Smoother Production Schedules: A candy maker might produce more candy than it needs in August and September and hold the excess in inventory so that it can meet the surge in demand for Halloween treats without investing in more
production capacity.

- **Protection Against Stock-Outs and Lost Sales:** Holding larger inventories reduces the chance of stock-outs and lost sales due to supply disruptions or unexpected surges in demand.

- **Reduced Ordering Costs:** Every time a company orders supplies, it incurs paperwork and handling costs. Holding a larger average inventory reduces the number of orders the firm must make and thus reduces ordering costs.

But holding larger inventories involves costs as well as benefits:

- **Tied-Up Funds:** Items in inventory don’t generate revenue until they're sold, so holding large inventories can tie up funds that could be better used elsewhere within the organization.

- **Additional Holding Costs:** Bigger inventories require more storage space, which can mean extra costs for heating, cooling, taxes, insurance, and more.

- **Increased Risk:** Holding large inventories exposes the firm to the risk of losses due to spoilage, depreciation, and obsolescence.

Operations managers determine the optimal amount of inventory by comparing the costs and benefits associated with different levels of inventory. In our discussion of lean manufacturing, we'll see that one recent trend has been toward finding ways to reduce inventory levels at every stage of the supply chain.

### Project Scheduling

Projects such as constructing a new production facility, developing a new commercial airliner or filming a movie are complex and expensive endeavors. It's vital to monitor them carefully to avoid major delays or cost overruns. The critical path method (CPM) is one of the most important tools that operations managers use to manage such projects. We can illustrate the basic idea behind this tool by looking at a simple example in which a theater company wants to stage a play. Exhibit 17.3 presents the steps involved in this project.

Notice that Exhibit 17.3 identifies **immediate predecessors** for all of the activities except activity A. **Immediate predecessors** are activities that must be completed before another activity can begin. For example, it is clear that the cast for the play cannot be determined until the play has been selected, so activity A (selecting the play) is an immediate predecessor to activity B (selecting the cast). Similarly, since sets can’t be built without lumber, paint, and other materials, activity E (buying materials for the sets) is an immediate predecessor for activity G (building the sets).

### Using the Critical Path Method to Focus Efforts

Now look at Exhibit 17.4, which is a CPM network for the theater project. This network shows how all of the activities in the theater project are related to each other. The direction of the arrows shows the immediate predecessors for each activity. Notice that arrows go from activities B (selecting the cast) and F (purchasing material for the costumes) to activity H (making the costumes). This indicates that **both** of these activities are immediate predecessors for activity H—the costumes can’t be made without material, and they must be made in the correct sizes to fit the actors. But also notice that no arrow links activities B and C. This shows that these are independent activities; in other words, the theater company doesn’t have to select the cast before it designs the sets (or vice versa).

We can use Exhibit 17.4 to illustrate some basic concepts used in CPM analysis. A **path** is a sequence of activities that **must be completed in the order specified by the arrows** for the overall project to be completed. You can trace several paths in our example by following a series of arrows from start to finish. For example, one path is A → B → I → J → K, and another path is A → C → E → G → J → K.

The **critical path** consists of the sequence of activities that takes the longest to complete. A **delay in any activity on a critical path is likely to delay the completion of the entire project.** Thus, operations managers watch activities on the
EXHIBIT 17.3 Activities involved in Presenting a Play © Cengage Learning 2013

critical path very carefully and take actions to help ensure that they remain on schedule. We've shown the critical path for the theater project (A → D → F → H → J → K) with red arrows on our diagram.

Distinguishing between the critical path and other paths can help operations managers allocate resources more efficiently. Activities that aren't on the critical path can be delayed without causing a delay in the overall completion of the project—as long as the delay isn't too great. In CPM terminology, these activities have slack. When operations managers see delays in critical path activities, they may be able to keep the project on track by diverting manpower and other resources from activities with slack to activities on the critical path.

EXHIBIT 17.4 A CPM Network for Staging a Play

Designing and Managing Value Chains

Perhaps the most important function of operations management is the design and management of value chains. A value chain is the network of relationships that channels the flow of inputs, information, and financial resources through all of the processes directly or indirectly involved in producing goods and services and distributing them to customers.

An organization's value chain clearly includes its supply chain, which consists of the organizations, activities, and processes involved in the physical flow of goods, from the raw materials stage to the final consumer. In fact, some organizations use the terms value chain and supply chain interchangeably. But a value chain is a broader concept; in addition to the supply chain, it includes activities and processes involved in acquiring customers—such as contract negotiations and customer financing—as well as activities and processes involved in keeping customers by providing

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services after the sale, such as performing warranty repairs, offering call center assistance, and helping customers recycle used goods. In a value chain, the main focus is on the customer; in contrast, the supply chain is more oriented toward traditional production relationships.\(^2\)

One of the most important issues that operations managers examine when they design value chains is the trade-off between vertical integration and outsourcing. **Vertical integration** occurs when a firm attempts to gain more control over its value chain by either developing the ability to perform processes previously performed by other organizations in the chain or by acquiring those organizations. **Outsourcing** is essentially the opposite of vertical integration; it involves arranging for other organizations to perform value chain functions that were previously performed internally.

In recent years, the trend in value chain design has been to rely more on outsourcing and less on vertical integration. Outsourcing allows a firm to shed functions it doesn't perform well in order to focus on its areas of strength. It also frees people, money, and other resources that had been tied up in the outsourced activities, allowing these resources to be employed in more profitable ways.

Even when a firm decides to perform processes itself, it still faces a choice: should it perform these functions domestically, or should it offshore these activities? **Offshoring** means moving processes previously performed domestically to a foreign location. It is important to realize that off-shoring is *not* the same thing as outsourcing processes to other organizations. Offshoring doesn't require outsourcing; a firm often offshore processes by directly investing in its *own* foreign facilities. Similarly, outsourcing doesn't require a firm to go offshore; activities can be outsourced to other *domestic* firms. Despite this distinction, many firms have combined these approaches by hiring organizations in other countries to perform some of the processes that they previously performed at their own domestic facilities.

It is also worth noting that offshoring can go in both directions. Just as American firms offshore processes to other countries, some foreign companies offshore some of their processes to the U.S. For example, several Japanese, European, and Korean automakers now have extensive design and production facilities in the U.S.

One common reason for offshoring by U.S. firms is to take advantage of less expensive labor. But other factors can also play a role. Land and other resources also may be less expensive in developing nations than in the United States. And some foreign governments, eager to attract American investments, may offer financial incentives or other inducements. In addition, many foreign markets are growing much more rapidly than the relatively mature U.S. market. Firms often find it advantageous to locate production facilities close to these rapidly growing markets.

While foreign outsourcing can often reduce costs, it also can complicate value chains and create coordination problems. And it can expose the firm to certain types of risks. When a firm outsources important functions, it may have to entrust others in its value chain with confidential information and intellectual property, such as copyrighted material or patented designs. These strategic assets have less legal protection in some countries than in the United States, so providing access to foreign firms may increase the risk that the firm's intellectual property will be pirated or counterfeited. This issue has been of greatest concern when firms have outsourced some of their supply chain functions to organizations in China.\(^3\)

Given the trend toward offshoring and outsourcing, value chains (and the supply chains at their core) have become increasingly complex, often involving many

![Image](https://via.placeholder.com/150)

*Offshoring involves moving activities previously performed domestically to a foreign location.* © Mark Elias/Bloomberg via Getty Images
different organizations and processes located in many different countries. Modern operations managers rely on sophisticated supply chain management software to streamline the communications among supply chain participants and to help them plan and coordinate their efforts.

The newest versions of enterprise resource planning (ERP) software take supply chain management to its highest level. ERP initially focused on integrating the flow of information among all aspects of a single organization's operations—accounting, finance, sales and marketing, production, and human resources. But the newest versions go beyond a single organization to help manage activities along an entire supply chain or value chain. The common information system makes it easier for organizations throughout the chain to communicate and coordinate their activities.

ERP systems do have some drawbacks. They are complex, expensive, and difficult to implement, and they require users to learn new ways to enter and access data. Productivity can actually fall until users become accustomed to these new methods. But despite these challenges, ERP systems have become very popular. And they continue to evolve and take advantage of new technologies. One of the newest developments is the arrival of Web-based ERP systems that can be “rented” from online providers—a strategy that reduces the need to invest in new hardware and software. The use of Web-based ERP services is an example of a relatively new trend in information technology known as cloud computing.

LO3 Implications of a Service-Based Economy: Responding to Different Challenges

Exhibit 17.5 illustrates how services differ from tangible goods. These differences present a number of challenges to service providers. One key challenge arises because customers often participate in the provision of services, which means that service providers have less control over how the process is carried out, how long it takes to complete, and whether the result is satisfactory. For instance, the accuracy of a doctor's diagnosis depends on how honestly and completely the patient answers the doctor's questions. And the amount of time the doctor spends with each patient will depend on the seriousness of the problem and the complexity of the diagnosis and treatment.

Designing the Servicescape

Because of the interaction between customers and service providers, the design of service facilities often must take the experiences of the participants into account. A servicescape is the environment in which the customer and service provider interact. A well-designed servicescape can have a positive influence on the attitudes and perceptions of both the customer and those who provide the service. A poor servicescape can have the opposite effect.

The design of servicescapes centers on three types of factors: ambience; functionality; and signs, symbols, and artifacts. ©Ambience refers to factors such as decor, background music, lighting, noise levels, and even scents. For example, massage therapists often use low light, soothing background music, and pleasant scents to create a relaxing atmosphere for a massage.

- **Functionality** involves how easy it is for the customer to move through the facility and find what they are looking for.
- **Signs, symbols, and artifacts** convey information to customers and create impressions. Obviously, signs like

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<td>GOODS</td>
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<tr>
<td>Are tangible: They have a physical form and can be seen, touched, handled, etc.</td>
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<tr>
<td>Can be stored in an inventory.</td>
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<tr>
<td>Can be shipped.</td>
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<tr>
<td>Are produced independently of the consumer.</td>
</tr>
<tr>
<td>Can have at least some aspects of their quality determined objectively by measuring defects or deviations from desired values.</td>
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EXHIBIT 17.5 Differences Between Goods and Services © Cengage Learning 2013

“Place Your Order Here” and “Pick Up Your Order Here” provide useful information that helps consumers maneuver through
the service encounter. But other signs and symbols can be used to create favorable impressions. For instance, lawyers and accountants often prominently display their diplomas, professional certifications and awards in their offices to communicate their qualifications and accomplishments to their clients.

**How Big Is Big Enough?**

Because services are intangible and often must be experienced at the time they are created, service providers can't produce the service in advance and store it to meet temporary surges in demand. This can create challenges for operations managers because the demand for many types of services varies significantly, depending on the season, the day of the week, or the time of day. During peak lunch and dinner hours, popular restaurants tend to be very busy—often with crowds waiting to get a table. The same restaurants may be nearly empty during the mid-afternoon or late at night. Given such fluctuations in demand, the selection of capacity—the number of customers the service facility can accommodate per time period—becomes a crucial consideration.

If the capacity of a service facility is too small, customers facing long waits during periods of peak demand may well take their business elsewhere. But a facility large enough to handle peak capacity is more expensive to build; costs more to heat, cool, and insure; and may have substantial excess capacity during off—peak periods. Operations managers must weigh these drawbacks against the ability to handle a larger number of customers during peak hours.

Many service firms try to minimize this tradeoff by finding ways to spread out demand so that big surges don't occur. One way to do this is to give customers an incentive to use the service at off-peak times. Many bars and restaurants have “happy hours” or “early-bird specials.” Similarly, movie theaters have lower prices for matinée showings, and resort hotels offer reduced rates during their off seasons.

**LO4 The Technology of Operations**

Now let's take a close look at how technology has revolutionized operations management. Some of the new technologies involve the increasing sophistication of machinery and equipment. Others involve advances in software and information technology. The impact of these technological advances is greatest when the automated machinery is directly linked to the new software running on powerful new computers.

**Automation: The Rise of the Machine**

For the past half century, one of the biggest trends in operations management has been increased automation of many processes. Automation means replacing human operation and control of machinery and equipment with some form of programmed control. The use of automated systems has become increasingly common—and increasingly sophisticated.

Automation began in the early 1950s with primitive programmed machines. But in recent decades, robots have taken automation to a whole new level. Robots are reprogrammable machines that can manipulate materials, tools, parts, and specialized devices in order to perform a variety of tasks. Some robots have special sensors that allow them to “see,” “hear,” or “feel” their environment. Many robots are mobile and can even be guided over rugged terrain.

Robots offer many advantages to firms:

- They often perform jobs that most human workers find tedious, dirty, dangerous, or physically demanding.
- They don't get tired, so they can work very long hours while maintaining a consistently high level of performance.
- They are flexible; unlike old dogs, robots can be taught new tricks because they are reprogrammable.
Automation involves programming machines and equipment to carry out tasks previously performed by humans. © iStockphoto.com/Jonathan Heger

Robots are most commonly used for tasks such as welding, spray painting, and assembling products, but they can do many other things ranging from packaging frozen pizza to disposing of hazardous waste.

Software Technologies

Several types of software have become common in operations management, and as the processing power of computers has improved, the capabilities of these applications have become increasingly sophisticated. Some of the most common examples include:

- **computer-aided design (CAD)** software provides powerful drawing and drafting tools that enable users to create and edit blueprints and design drawings quickly and easily. Current CAD programs allow users to create 3-D drawings.

  You seldom improve quality by cutting costs, but you can often cut costs by improving quality.

  — Karl Albrecht, Author and Futurist

- **computer-aided engineering (CAE)** software enables users to test, analyze, and optimize their designs through computer simulations. CAE software can help engineers find and correct design flaws before production.

- **computer-aided manufacturing (CAM)** software takes the electronic design for a product and creates the programmed instructions that robots and other automated equipment must follow to produce that product as efficiently as possible.

A New Dimension in Production Technology

Photo by 3D Systems Corp. via Getty Images
A technology known as 3D printing is poised to take the concept of mass customization to a whole new level—and it could revolutionize operations management in the process. Unlike traditional manufacturing, 3D printing creates products by downloading computer specifications to a special “printer,” which then prints and deposits layer upon layer of material to build up the product.

3D printing was developed in the mid-1980s, but like many technologies it was initially too expensive and crude to see widespread use. But in recent years, the cost of 3D printers has dropped dramatically, and their speed and quality have improved. Leading-edge firms are now using this technology to produce everything from intricate jewelry to complex aircraft parts.

The increasing popularity of 3D production stems from its many advantages over traditional manufacturing methods. It is more energy-efficient, results in less waste, and can be faster. Most importantly, it is ideal for mass customization, since the printer can switch quickly and seamlessly from producing one product to another with virtually no retooling costs. Given these advantages, analysts predict that 3D printing will become a mainstream technology by 2020.

Some 3D enthusiasts even see a not-too-distant future when we all will have our own personal 3D printers. In this scenario, when you needed a personalized product, you’d simply download its basic design from the Internet, tweak it to meet your own specific preferences, load the appropriate “printing materials” into the printer's hopper, and press the start button. In minutes, you'd have a new cover for your iPod, a pair of running shoes that precisely fit your feet, or new designer eyeglasses complete with the correct prescription lenses.

Today, computer-aided design and computer-aided manufacturing software are often combined into a single system, called CAD/CAM. This enables CAD designs to flow directly to CAM programs, which then send instructions directly to the automated equipment on the factory floor to guide the production process.

When a CAD/CAM software system is integrated with robots and other high-tech equipment, the result is computer-integrated manufacturing (CM), in which the whole design and production process is highly automated. The speed of computers, the ability to reprogram computers rapidly, and the integration of all these functions make it possible to switch from the design and production of one good to another quickly and efficiently. CIM allows firms to produce custom-designed products for individual customers quickly and at costs almost as low as those associated with mass-production techniques, thus allowing firms to pursue the strategy of mass customization mentioned at the beginning of this chapter.

LO5 Focus on Quality

Almost everyone agrees that quality is important. But the concept of quality is tough to define—even expert opinions differ. For our purposes, we'll adopt the view that quality is defined in terms of how well a good or service satisfies customer preferences.

Why is quality so important? First, better quality clearly improves effectiveness (creates value) since consumers perceive high-quality goods as having greater value than low-quality goods. But finding ways to increase quality can also lead to greater efficiency because the cost of poor quality can be very high. When a firm detects defective products, it must scrap, rework, or repair them. And the costs of poor quality can be even higher when a firm doesn’t catch defects before shipping products to consumers. These costs include handling customer complaints, warranty repair work, loss of goodwill, and the possibility of bad publicity or lawsuits. In the long run, firms often find that improving quality reduces these costs by more than enough to make up for their investment.

These ideas aren't especially new. W. Edwards Deming, viewed by many as the father of the quality movement, first proposed the relationship between quality and business success in the early 1950s. His ideas, which came to be known as the Deming Chain Reaction, are summarized in Exhibit 17.6.

Waking Up to the Need for Quality

In the years immediately after World War II, most Japanese goods had a reputation for being cheap and shoddy. But during the 1950s, many Japanese firms sought advice from Deming and other U.S. quality gurus. They learned to view quality improvement as a continuous process that was the responsibility of all employees in the organization. During the 1950s and 1960s, the quality of Japanese goods slowly but steadily improved.

By the early 1970s, many Japanese firms had achieved a remarkable turnaround, with quality levels that exceeded those of companies in most other countries (including the U.S.) by a wide margin. This improved quality was a major reason why Japanese firms rapidly gained global market share, often at the expense of American firms that had faced little competition in years immediately following World War II.
EXHIBIT 17.6 The Deming Chain Reaction: Improved

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Ooops! What were they thinking?: Toyota Learns That Bigger Isn't Always Better
From the 1980s to the beginning of the 21st century, the name Toyota was synonymous with safe, dependable, high-quality automobiles. During this period, the company's glowing reputation for quality contributed to a spectacular rise in sales and market share. In 2009 Toyota passed General Motors to become the world's largest automaker.

But instead of being able to celebrate, the company soon found itself embarrassed by events that raised serious doubts about its commitment to quality and safety. The percentage of its models recommended by Consumer Reports dropped from 85% in 2007 to 47% in 2009. Then, in late 2009 and early 2010, the company had to recall more than 8.4 million cars because of serious safety concerns. Toyota exacerbated its troubles by being slow to react, seeming to believe the problems couldn't possibly be its own fault. This created a perception that the company was arrogant and unconcerned about consumer safety. Professor Paul Argenti of Dartmouth's Tuck School of Business summarized this decline in Toyota's image when he remarked, “I would give Toyota an F in my class for their social responsibility.”

What led to Toyota's problems? Many outside analysts—and key Toyota executives—now suggest that the decline in quality reflected a change in priorities. As the company's leadership became obsessed with becoming the biggest, they lost focus on their core value: putting quality first. The rapid growth began stretching its engineers too thin, leading to design errors and lapses in quality control. The ramped-up production schedules also created stresses—and hence more mistakes—on the company's production lines.

Faced with a major drop in sales and increasing criticism in the press and government, Toyota executives vowed to restore their reputation for quality. But just as it was beginning to get its focus back, Japan was devastated by a major earthquake and tsunami. It will be interesting to see how the company adapts to these challenges in coming years.

**How American Firms Responded to the Quality Challenge**

When operations managers at American firms realized how far they trailed the Japanese in quality, they made a real effort to change their ways. Like the Japanese a few decades earlier, American business leaders began to view improving the quality of their goods and services as a key to regaining international competitiveness.

**Total Quality Management**

The first result of this newfound emphasis on quality was the development of an approach called total quality management, better known as TQM. There are several variations, but all versions of TQM share the following characteristics:

- **Customer Focus**: TQM recognizes that quality should be defined by the preferences and perceptions of customers.
- **Emphasis on Building Quality throughout the Organization**: TQM views quality as the concern of every department and every employee.
Empowerment of Employees: Most TQM programs give teams of workers the responsibility and authority to make and implement decisions to improve quality.

Focus on Prevention Rather Than Correction: The TQM philosophy agrees with the old adage that an “ounce of prevention is worth a pound of cure.” Thus, TQM pursues a strategy of preventing mistakes that create defects.

Long-Run Commitment to Continuous Improvement: TQM requires firms to adopt a focus on making improvements in quality a way of life.

In many cases, American firms using TQM attempt to reduce defects by using poka-yokes—the Japanese term for “mistake proofing.” Poka-yokes are simple procedures built into the production process that either prevent workers from making mistakes or help workers quickly catch and correct mistakes if they do occur. One simple example of a poka-yoke would be providing assembly workers with “kits” that contain exactly enough parts to complete one unit of work at a time. If the worker completes an assembly and sees a part left over, it’s clear that a mistake has been made, and he or she can correct it on the spot.8

The Move to Six Sigma

During the 1990s, another approach to quality improvement, known as Six Sigma, became increasingly popular. Six Sigma shares some characteristics with TQM, such as an organization-wide focus on quality, emphasis on finding and eliminating causes of errors or defects (prevention rather than correction), and a long-term focus on continuous quality improvement. Also like TQM, it relies on teams of workers to carry out specific projects to improve quality. At any given time, a firm may have several Six Sigma projects under way, and the goal of each is to achieve the Six Sigma level of quality.

But Six Sigma differs from TQM in other respects. Unlike TQM, it has a single unifying measure: to reduce defects of any operation or process to a level of no more than 3.4 per million opportunities. Attaining this level of quality represents a rigorous and challenging goal. Six Sigma also differs from TQM in its reliance on extensive (and expensive) employee training and reliance on expert guidance. The techniques used in the Six Sigma approach are quite advanced, and their application requires a high level of expertise.

Quality Standards and Initiatives

Another way firms try to improve quality is to launch programs designed to achieve certification or recognition from outside authorities. Two common approaches are participation in the Baldrige National Quality Program and seeking certification under the International Organization for Standardization's ISO 9000 standards.

The Baldrige National Quality Program

Congress passed the Malcolm Baldrige National Quality Improvement Act of 1987 in an effort to encourage American firms to become more competitive in the global economy by vigorously pursuing improvements in quality and productivity. Winners of the Baldrige Award must demonstrate excellence in seven areas: leadership; strategic planning; customer and market focus; measurement, analysis, and knowledge management; human resource focus; process management; and business results.

Firms that participate in the Baldrige National Quality Program receive benefits even if they don’t win the award. Every participating firm receives a detailed report prepared by expert evaluators identifying areas of strength and areas where improvement is needed. Considering the normal fees that high-powered consulting firms charge for similar reports, the information and advice a firm gets for the fee charged to participate in the Baldrige program (which for manufacturing firms, service firms, and small businesses is $7,000) are a tremendous bargain.9

ISO 9000 Certification

Founded in 1947, ISO is a network of national standards institutes from more than 160 nations that have worked together to develop over 18,500 international standards for a wide array of industries. ISO standards ensure that goods produced in one country will meet the requirements of buyers in another country. This benefits buyers by giving them the ability to purchase from foreign sellers with confidence, thus giving them a wider array of choices. It also benefits sellers by allowing them to compete more successfully in global markets.10

Most of the standards established by the ISO are industry-specific. But in 1987 the ISO developed and published the ISO 9000

“Quality is the result of a carefully constructed cultural environment. It has to be the fabric of the organization, not part of the fabric.

— PHILIP CROSBY, 20TH-CENTURY QUALITY GURU”

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family of standards. The goal of this effort was to articulate an international consensus on good quality-management practices that could be applied to virtually any company. Similar to the other quality initiatives we've discussed, ISO 9000 standards define quality in terms of the ability to satisfy customer preferences and require the firm to implement procedures for continuous quality improvement.

There are several standards in the ISO 9000 family, but the most basic—and the only one for which organizations can be certified—is ISO 9001, which specifies the requirements for a quality-management system. (Other ISO 9000 standards are concerned with the documentation, training, and the economic and financial aspects of quality management.) As of 2009, over one million organizations worldwide had earned ISO 9001 certificates, but the number of U.S. firms with ISO 9001 certification lags that of several other nations. Only about 29,000 U.S. organizations had been certified in 2009, compared to over 257,000 in China and 130,000 in Italy.¹¹

LO6 The Move to Be Lean and Green: Cutting Cost and Cutting Waste

*Lean production* refers to a set of strategies and practices to eliminate waste, which is defined as any function or activity that uses resources but doesn't create value. Eliminating waste can lead to dramatic improvements in efficiency. For example, Sanford, the maker of Paper Mate® pens and Sharpie® markers and highlighters, used lean thinking to dramatically cut its packaging costs. Before adopting lean thinking, Sanford developed different blister packs for every single product, resulting in literally hundreds of different packages. After applying lean thinking, the company was able to cut the number of package configurations down to 15, reducing setup time for packaging by 50%, cutting tooling costs by up to 80%, and reducing warehousing costs by up to 25%.¹²

Reducing Investment in Inventory: Just-in-Time to the Rescue

One of the hallmarks of lean systems is a tight control on inventories. In part, this reflects recognition of the costs of holding large inventories that we discussed earlier. But the lean approach also offers another reason for minimizing inventories. Large inventories serve as a buffer that enables a firm to continue operations when problems arise due to poor quality, faulty equipment, or unreliable suppliers—making it easier for firms to live with these problems rather than correct them. Advocates of lean production argue that, in the long run, it is more efficient to improve quality, keep equipment in good working order, and develop reliable supply relationships than to continue compensating for these problems by holding large inventories.

Lean manufacturing avoids overproduction and holding large inventories of finished goods by using *just-in-time (JIT) production* methods. JIT produces

**Six Sigma Belts Quality Concerns**

Six Sigma quality programs rely on sophisticated techniques that require highly trained and experienced leadership. Much like karate, Six Sigma identifies the proficiency of its practitioners with belt colors:

- *Yellow Belts* have some basic training in Six Sigma concepts, but they are not proficient enough to take responsibility for a project.
- *Green Belts* have a higher level of training than Yellow Belts and work on Six Sigma projects as part of their regular jobs, but they haven't acquired the depth of training needed to become Black Belts.
- *Black Belts* have a high-enough level of training and experience to take charge of a Six Sigma team working on a specific
only enough goods to satisfy current demand. This approach is called a pull system because actual orders “pull” the goods through the production process. The workers at the end of the production process produce just enough of the final product to satisfy actual orders and use just enough parts and materials from preceding stages of production to satisfy their needs. Workers at each earlier stage are expected to produce just enough output at their workstations to replace the amount used by the processes further along in the process—and in so doing they withdraw just the needed amount of parts and other supplies from even earlier processes.

JIT techniques obviously result in very small inventories of finished goods and work in process. But lean firms also hold only small inventories of materials and parts, counting on suppliers to provide them with these items as they need them to meet current demand. In a lean system, all organizations in the supply chain use the JIT approach, so that inventories are minimized at each stage. Clearly, this type of system requires incredible coordination among all parts of the supply chain; in fact, the movement toward JIT is a key reason why supply chain management has become so crucial.

JIT does have some potential drawbacks. The most serious problem is that it can leave producers vulnerable to supply disruptions. If a key supplier is unable to make deliveries due to a natural disaster, labor strike or other problem, the firms further along the supply chain may quickly run out of parts or materials and have to shut down production.

**Lean Thinking in the Service Sector**

Employing lean principles in the service sector can be quite a challenge because customers often participate in providing the service. This means a service firm usually has less control over how processes are conducted. But many service firms have benefited from creatively applying lean techniques. Southwest Airlines is well known for its efforts to reduce waste. It uses only one type of aircraft (the Boeing 737) to standardize maintenance and minimize training costs. It also has an extremely simple ticketing system (no assigned seating) and, when possible, flies into smaller or older airports where there is less congestion. This means that less time and less fuel are spent circling airports waiting to

**“The Greening, of Supply Chains”**

Several major U.S. companies have gone beyond their own organizations to make their supply chains greener by working closely with suppliers and distributors to reduce waste and improve energy efficiency. Walmart has been the most visible practitioner of this approach. In 2005, the nation's largest retailer announced an ambitious program to improve its environmental impact by focusing on three key goals:

- Be supplied by 100% renewable energy sources
- Create zero waste
- Sell products that sustain our resources and the environment

Walmart initially pursued these goals by focusing on its internal operations. But it soon discovered that to maximize its effectiveness, it had to broaden its focus to look at its supply chain. As the company explained in its 2010 Global Sustainability Report, “In order to know the true impact of our business, we need to look at where products are sourced and manufactured, how they're shipped and packaged, how they are used and ultimately what happens to the product when it's disposed.”

One of Walmart's more interesting strategies has been to offer more locally grown agricultural products in its grocery aisles. This reduces the need to ship food long distances, thus lowering the use of fuels and the emission of greenhouse gasses. It also offers customers fresher produce and supports local economies. To achieve this result, Walmart has eliminated middlemen and has begun working directly with small local farmers.

Walmart's local farm initiative is part of a broad plan to cut emissions of greenhouse gasses throughout its supply chain by 20 million metric tons by 2015—the equivalent of removing 3.8 million cars from our nation's highways for an entire year. Land or sitting on runways waiting to take off. Despite a no-frills approach, Southwest almost always ranks near the top of the list in terms of airline customer satisfaction.
Green Practices: Helping the Firm by Helping the Environment

Many of today’s leading firms have also tried to become “greener” by finding environmentally friendly ways to carry out the processes needed to produce and distribute their goods and services. Green practices include designing facilities to be more energy efficient, using renewable energy sources such as wind, solar, or geothermal power when possible,

One way some firms have tried to make their operations greener is by making use of renewable energy sources. © Brian A Jackson/Shutterstock.com

making use of recyclable materials, switching to paints, lubricants, cleaning fluids, and solvents that are less harmful to the environment, and even providing labeling to help consumers find out which products are the most environmentally friendly.

The long-term goal of many green practices is to achieve sustainability, which means finding ways to meet the organization’s current objectives while protecting and preserving the environment for future generations. One impediment to even greater acceptance of sustainability initiatives is that some sustainability efforts—such as switching to renewable sources of energy—add to costs. But many firms have found that other sustainability efforts can actually benefit the bottom line. A recent study by Aberdeen Group, a well-known technology research firm, found that firms employing best-in-class sustainability practices not only saw an 8% drop in sustainability-related costs but also experienced a 16% increase in customer retention.

In the late 1990s, the International Organization for Standardization developed a set of standards called ISO 14000. This new set of standards focuses on environmental management. As with ISO 9000, the term ISO 14000 actually refers to a family of standards. The broadest of these is ISO 14001. In order to receive ISO 14001 certification, a firm must:

- demonstrate the ability to identify and control the environmental impact of their activities
- make a commitment to continually improve their environmental performance
- implement a systematic approach to setting environmental targets and to achieving those targets.

It is important to note that ISO 14000 standards do not establish specific goals for environmental performance; doing so would be very difficult, since ISO is intended to be a generic set of standards that apply to all industries, and each specific industry faces different environmental challenges.
The Big Picture

Operations managers are responsible for “putting it all together” by developing and implementing the processes needed to produce goods and services and distribute them to the target market. Their decisions affect both revenues and costs, going a long way toward determining whether a firm makes a profit or suffers a loss.

The responsibilities of operations managers require them to work closely with other managers throughout their organizations. For example, they must work with marketers and designers to ensure that the desired goods and services move from the drawing board to the final customer on time and within budget. They must work closely with financial managers to ensure that the company invests in the capital goods needed to produce goods and services in the most efficient manner. And they must work effectively with human resource managers to attract and develop workers who possess the knowledge and skills needed to become world-class competitors. Operations managers must even go beyond their own organization and work effectively with the suppliers and distributors who comprise the firm's value chain.

Operations managers must continuously adapt to changes in technology and in competitive conditions. Key challenges in recent years have centered on the need to continuously improve product quality while finding ways to reduce costs and protect the environment. You can expect the goals of becoming ever leaner—and ever greener—to remain a major focus of operations managers in years to come.

Careers in Operations Management

Operations management encompasses a number of different specific occupations, including quality management and control, product development, facilities management, and supply chain (or value chain) management. Operations research, which applies mathematical and statistical techniques to solving complex business problems, is a related field that might appeal to you if you have strong quantitative and problem-solving skills.

Operations managers typically need very strong technical skills and must be good problem solvers. Given the increasing use of value chain management software and computerized production methods, they also must be comfortable with information technology. Many companies require bachelor's degrees in operations management or a related field even for entry-level positions.

Job growth in operations management varies according to sector. Positions in the service sector should continue to increase more rapidly than those in the goods-producing sector.

Because operations management encompasses such a wide array of specific occupations, salaries vary widely. For many positions, the entry-level salary is in the $50,000 to $60,000 range. Experienced operations managers often earn base salaries in excess of $100,000 and may also receive substantial performance bonuses.\(^{19}\)
What else?

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Operations Management: Putting it AllTogether: Rip and Review 17

LO1 Define operations management and describe how its role has changed over the past fifty years

Operations management oversees all the activities involved in producing and distributing goods and services. When operations managers do their job well, their firms produce the right goods and services in the right quantities and distribute them to the right customers at the right time—all while keeping quality high and costs low.

Operations management has undergone profound changes over the past half century. One change has been a switch in focus from efficiency to effectiveness. Efficiency means achieving a goal at the lowest cost. Effectiveness means creating value by satisfying wants. Other key changes include more emphasis on the provision of services, a switch from mass production to customized production, a focus on global markets (and global competition), reliance on complex value chains, and recognition of the need to protect the environment.

LO2 Discuss the key responsibilities of operations managers

Operations managers often play a role in the design of products by helping designers understand the challenges and constraints involved in producing high-quality products on time and within budget. Once the design is finalized, operations managers must determine the best production processes to convert inputs into outputs, design a facility layout that creates an efficient flow of materials, parts, and work in process through the production process, select the best locations for facilities, make decisions about how much inventory to hold, determine how to allocate resources needed to complete complex projects, and manage value chains to coordinate the functions of all of the organizations and processes directly or indirectly involved in producing goods and services and distributing them to customers.

LO3 Describe how operations managers respond to the special challenges posed by the provision of services
Customers often participate in the provision of services, so service providers have only limited control over ways in which their processes are carried out, how long they take to complete, and whether the result is satisfactory. A servicescape is the environment in which the customer and service provider interact. A well-designed servicescape can create a better service experience for both the customer and the provider.

Another challenge facing service providers involves determining the proper capacity of service facilities. If the capacity of a service facility is too small, customers facing long waits during peak periods may take their business elsewhere. But a facility large enough to handle peak capacity is more expensive to build and operate and may have substantial excess capacity during off-peak periods. Many service firms try to spread out demand so that big surges don't occur by offering price discounts to customers during off-peak times.

**LO4 Explain how changes in technology have revolutionized operations management**

Rapid changes in both machinery and equipment and in software and information technologies have revolutionized operations management. The biggest change in machinery and equipment has been the increasing use of automation, which means replacing human operation and control of machinery and equipment with programmed control. The development of software applications to allow computer-aided design (CAD), computer-aided engineering (CAE), and computer-aided manufacturing (CAM) has given firms the flexibility to design, test, and produce goods more quickly and efficiently than ever before. When these powerful software applications are integrated with robots and other automated equipment, the result is called computer integrated manufacturing. This tight integration allows firms to produce customized goods quickly and at low cost, a process called mass customization.

**LO5 Describe the strategies operations managers have used to improve the quality of goods and services**

In recent years, U.S. firms have adopted programs such as total quality management (TQM) and Six Sigma to improve quality. TQM and Six Sigma both view quality operations management Managing all of the activities involved in creating value by producing goods and services and distributing them to customers.

efficiency Producing output or achieving a goal at the lowest cost.

effectiveness Using resources to create the value by providing customers with goods and services that offer a better relationship between price and perceived benefits.

goods Tangible products.

services Intangible products.

process A set of related activities that transform inputs into outputs, thus adding value.

inventory Stocks of goods or other items held by organizations.

critical path method (CPM) A project management tool that illustrates the relationships among all the activities involved in completing a project and identifies the sequence of activities likely to take the longest to complete.

immediate predecessors Activities in a project that must be completed before some other specified activity can begin.

critical path The sequence of activities in a project that is expected to take the longest to complete.

value chain The network of relationships that channels the flow of inputs, information, and financial resources through all of the processes directly or indirectly involved in producing goods and services and distributing them to customers.

vertical integration Performance of processes internally that were previously performed by other organizations in a supply chain.

outsourcing Arranging for other organizations to perform supply chain functions that were previously performed internally.

offshoring Moving production or support processes to foreign countries.

enterprise resource planning (ERP) Software-based approach to integrate an organization's (and in the sophisticated versions, a value chain's) information flows.

servicescape The environment in which a customer and service provider interact.
robot A reprogrammable machine that is capable of manipulating materials, tools, parts, and specialized devices in order to perform a variety of tasks.

computer-aided design (CAD) Drawing and drafting software that enables users to create and edit blueprints and design drawings quickly and easily.

computer-aided engineering (CAE) Software that enables users to test, analyze, and optimize their designs.

computer-aided manufacturing (CAM) Software that takes the electronic design for a product and creates the programmed instructions that robots must follow to produce that product as efficiently as possible.

computer-aided design/computer-aided manufacturing (CAD/CAM) A combination of software that can be used to design output and send instructions to automated equipment to perform the steps needed to produce this output.

computer-integrated manufacturing (CM) A combination of CAD/CAM software with flexible manufacturing systems to automate almost all steps involved in designing, testing, and producing a product.

total quality management (TQM) An approach to quality improvement that calls for everyone within an organization to take responsibility for improving quality and emphasizes the need for a long-term commitment to continuous improvement.

poka-yokes Simple methods incorporated into a production process designed to eliminate or greatly reduce errors.

Six Sigma An approach to quality improvement characterized by very ambitious quality goals, extensive training of employees, and a long-term commitment to working on quality-related issues.

Baldrige National Quality Program A national program to encourage American firms to focus on quality improvement.

ISO 9000 A family of generic standards for quality management systems established by the International Organization for Standardization.

lean production An approach to production that emphasizes the elimination of waste in all aspects of production processes.

just-in-time (JIT) production A production system that emphasizes the production of goods to meet actual current demand, thus minimizing the need to hold inventories of finished goods and work in process at each stage of the supply chain.

ISO 14000 A family of generic standards for environmental management established by the International Organization for Standardization.

Another way firms have tried to improve efficiency has been to launch programs designed to achieve certification or recognition from outside authorities. Two common approaches are to participate in the Baldrige National Quality Program and to seek certification under the International Organization for Standardization's ISO 9000 standards.
LO6 Explain how lean and green practices can help both the organization and the environment

Lean production refers to a set of strategies and practices that eliminate waste to make organizations more efficient, responsive, and flexible. Inventory control is one of the key areas where waste often occurs. Many lean firms use just-in-time production methods to minimize the amount of parts, work in process, and finished products they hold in inventory.

Many firms have also become “greener” by finding environmentally friendly ways to produce and distribute their goods and services. Green practices include designing facilities to be more energy efficient; using renewable energy; making use of recyclable materials; switching to paints, lubricants, cleaning fluids, and solvents that are less harmful to the environment; and providing labeling to help consumers find out which products are the most environmentally friendly.

Footnotes

16. One reason renewable energy is more expensive than energy from carbon-based sources such as coal or oil is that the market prices of such carbon-based sources do not reflect their environmental costs.

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