

Managing Service and Manufacturing Operations

Chapter 18

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Key Terms

Concept Check

Self-Assessment

Management Decision

Management Team Decision

Develop Your Career Potential

Take Two Video

STUDENT RESOURCES

ThomsonNOW On the Job and Biz Flix video applications, concept tutorial, and concept exercise

Xtra! Eight exhibit worksheets, author FAQs, quiz, Management News, and the video clips from the chapter with exercises

Web (<http://williams.swlearning.com>) Quiz, PowerPoint slides, and glossary terms for this chapter

Hyundai Headquarters, Seoul, South Korea.¹

Ever since *Tonight Show* host Jay Leno said that a Hyundai car is like a luge sled—it “has no room, you have to push it to get going, and it only goes downhill”—the jokes haven’t stopped. Another popular joke goes, “How do you double the value of a Hyundai? Fill it with gas!” They’re even repeating these jokes in South Korea!

Unfortunately, Hyundai’s situation is not funny. As one of your top managers said, “Car buyers have long memories and it takes a while to change their perceptions, especially when they’re bad.” And, with buyers complaining about problematic electrical systems, rusting bumpers, poor-fitting doors, and broken air conditioners, those perceptions were clearly reflected in the well-known and influential J. D. Power Survey of Initial Car Quality. Hyundai cars ranked 26th out of 35 in initial car quality, and Kia, a bankrupt South Korean car company that Hyundai had paid \$8 billion to acquire, finished dead last. Not surprisingly, because of the terrible quality

What Would You Do?

Hyundai’s U.S. sales dropped to 90,000 cars this year from 264,000 cars two years ago. As a result, even car dealers, who put up thousands of dollars to have the chance to sell Hyundais, are abandoning their Hyundai franchises as fast as they can. When customers leave in droves, you know something is wrong. When the dealers start jumping like rats fleeing a sinking ship, you know that conditions are critical. And with corporate managers telling them that “With such low prices, we don’t need higher quality,” why should the dealers stay?

Hoping to expand its U.S. presence, Hyundai is spending \$1 billion to build a new auto plant in Montgomery, Alabama. But Americans won’t buy Hyundais just because they’re built in America. Daewoo Motors, another South Korean auto company, followed a similar strategy in the 1990s, spending billions to build plants around the world. But because Daewoo never fixed its quality problems, it lost billions and filed for bankruptcy. Amazingly, Hyundai made the same mistake in Canada, spending \$1 billion to build a manufacturing plant there, only to close it three years later. Repeating that mistake in Alabama just might put the company under. Hyundai

experienced its first loss this year, and the company is short on cash and high on debt, which at \$6.6 billion is six times Hyundai’s stock market capitalization of \$1 billion. Plus, labor-management relations are still tenuous after a 47-day worker strike in Hyundai’s South Korean factories. During the strike, which cost the company \$1 billion in disrupted production, workers living in tents on the factory grounds threw Molotov cocktails to express their frustration. The company finally settled the strike by granting workers a huge 8.6 percent pay increase that will put even more strain on its finances. And those finances are likely to come under more pressure now that the South Korean government is allowing Japanese car imports for the first time.

If Hyundai is to survive, if car buyers’ perceptions are to change, and if the \$1 billion investment in the new plant in Alabama is to pay off, then quality must improve. But how do you go about making better cars? Your first goal is to change the mindset in the company by convincing managers and factory workers that quality comes first. What’s the best way to do that? Next, you have to identify the steps you need to take to improve quality. Doing that won’t be easy or quick, but it can be done. Where do you start? Finally, you have to convince customers you care, that you’re listening to their complaints, and you will be responsive. If you can’t do that, those all-important quality rankings won’t improve. **If you were in charge at Hyundai, what would you do?**

STUDY TIP

Studying for comprehensive exams doesn’t have to be a chore. Form a study group. Photocopy the glossary at the end of this text, and cut the copies into strips, one term per strip. Put all strips into a large bowl. Divide into two teams and have one team at a time draw out a strip. Quiz the opposing team and then read the correct answer. You can do the same with the chapter outlines at the beginning of each chapter. You can tabulate points, but you’ll all win!

The problems that Hyundai, Inc. faces in manufacturing its cars are not unique to the automobile industry. Airlines, furniture manufacturers, hospitals, restaurants, and many other kinds of businesses also struggle to find ways to efficiently produce quality products and services and then deliver them in a timely manner.

operations management
Managing the daily production of goods and services.

In this chapter, you will learn about **operations management**—managing the daily production of goods and services. You will begin by learning about the basics of operations management: productivity and quality. Next, you will read about managing operations, beginning with service operations, turning next to manufacturing operations, and finishing with an examination of the types, measures, costs, and methods for managing inventory.

Managing for Productivity and Quality

You're "crossing the pond" in September to visit your company's European offices and suppliers. Because business is down, your boss has given you a limited budget of \$1,600 for airfare. Your round-trip ticket from Chicago to London costs \$990 on American Airlines, but that leaves only \$610 for airfare in Europe. The total cost of flying from London to Dublin, Ireland (via British Airways), Dublin to Brussels, Belgium (via Aer Lingus), Brussels to Venice, Italy (via Lufthansa), and Venice to London (via Alitalia) is \$1,191—\$581 more than your remaining budget and \$201 more than your flight from the United States. At lunch, you're griping about the cost of European air travel when the company intern tells you to check out Ryanair, which she flew when she backpacked in Europe last summer. So, after lunch, you surf to <http://www.ryanair.com> and find that the total cost to travel to the same cities on the same dates and times is an amazing \$84, or just 7.5 percent of the cost of flying the other major European airlines!

Modeled after U.S.-based Southwest Airlines, Ryanair achieves dramatically lower prices through aggressive price cutting, much higher productivity, and quality customer service. Want a frequent-flier plan? You won't find one at Ryanair. It's too expensive. Want a meal on your flight? Pack a lunch. Ryanair doesn't even serve peanuts because it takes too much time (i.e., expense) to get them out of the seat cushions. Passengers enter and exit the planes using old-fashioned, rolling stairs because they're quicker and cheaper than extendable boarding gates. As a result of such cost-cutting moves, Ryanair does more with less and thus has higher productivity. For example, most airlines break even on their flights when they're 75 percent full, but even with its incredibly low prices, Ryanair's productivity allows it to break even when its planes are only half full. And with this low breakeven point, Ryanair attracts plenty of customers who enable it to fill most of its seats (84 percent) and earn 20 percent net profit margins. Finally, because of its extremely low prices (and its competitors' extremely high prices), Ryanair has increased passenger traffic and profits for 17 straight years.²

After reading the next two sections, you should be able to

- 1** discuss the kinds of productivity and their importance in managing operations.
- 2** explain the role that quality plays in managing operations.

1 PRODUCTIVITY

productivity
A measure of performance that indicates how many inputs it takes to produce or create an output.

At their core, organizations are production systems. Companies combine inputs, such as labor, raw materials, capital, and knowledge, to produce outputs in the form of finished products or services. **Productivity** is a measure of performance that indicates how many inputs it takes to produce or create an output.

$$\text{Productivity} = \frac{\text{Outputs}}{\text{Inputs}}$$

The fewer inputs it takes to create an output (or the greater the output from one input), the higher the productivity. For example, a car's gas mileage is a common measure of productivity. A car that gets 35 miles (output) per gallon (input) is more productive and fuel efficient than a car that gets 18 miles per gallon.

Let's examine **1.1 why productivity matters** and **1.2 the different kinds of productivity**.

1.1 Why Productivity Matters

Why does productivity matter? For companies, higher productivity, that is, doing more with less, results in lower costs. In turn, doing more with less can lead to lower prices, faster service, higher market share, and higher profits. For example, at fast-food restaurants, every second saved in the drive-through lane increases sales by 1 percent. Furthermore, increasing the efficiency of drive-through service by 10 percent adds nearly 10 percent to a fast-food restaurant's sales. And with 65 percent of all fast-food restaurant sales coming from the drive-through window, it's no wonder that Wendy's (average drive-through time of 124.7 seconds), McDonald's (average time of 152.5 seconds), and Burger King (average time of 173.2 seconds) continue to look for ways to shorten the time it takes to process a drive-through order.³

For countries, productivity matters because it results in a higher standard of living. One way productivity leads to a higher standard of living is through increased wages. When companies can do more with less, they can raise employee wages without increasing prices or sacrificing normal profits. For instance, when I wrote this chapter, recent government economic data indicated that companies were paying workers 3.5 percent more than in the previous year. But, since workers were producing 5.1 percent more than they had the year before, real labor costs had actually decreased by 1.6 percent.⁴ How much difference can productivity increases make to wages and standards of living? If productivity grows just 1 percent a year, it will take 70 years to double the standard of living. But, if productivity grows 2 percent per year, the standard of living will double in just 35 years. One way to demonstrate this is to examine the effect that productivity has on wages. For example, the average American family earned approximately \$54,821 in 2003. If productivity grows 1 percent a year, that family's income will increase to \$69,608 in 2028. But if productivity grows 2 percent a year, their annual income in 2028 will be \$88,176, more than \$18,000 higher, and that's without working longer hours.⁵ Thanks to long-term increases in business productivity, the average American family today earns 33 percent more than the average family in 1980 and 223 percent more than the average family in 1953—and that's after accounting for inflation.⁶

Rising income stemming from increased productivity creates numerous other benefits as well. For example, with productivity increases exceeding 3.8 percent per year from 1999 to 2004, the U.S. economy created 3 million new jobs.⁷ And when more people have jobs that pay more, they give more to charity. For example, in 2004 Americans donated over \$248 billion to charities, 31 percent more than they gave in 1999.⁸ Did Americans become more thoughtful, caring, conscientious, and giving between 1999 and 2004? Probably not. Yet, because of strong increases in productivity during that time, the average American family saw its income increase by 15 percent. Because more people earned more money, they were able to share their good fortune with others by giving more to charity.⁹

Another benefit of productivity is that it makes products more affordable or better. For example, while inflation has pushed the average cost of a car to about \$28,120 (after incentives and discounts), increases in productivity have actually made cars cheaper. In 1960, the average family needed 26 weeks of income to

pay for the average car. Today, the average family needs only 20.6 weeks of income—and today’s car is loaded with accessories that weren’t even available in 1960, including air bags, power steering and brakes, power windows, cruise control, stereo/CD/DVD players, seat warmers, air-conditioning, and satellite navigation.¹⁰ So, in terms of real purchasing power, productivity gains have actually made today’s \$28,120 car of today cheaper than that \$2,000 car in 1960.

1.2 Kinds of Productivity

Two common measures of productivity are partial productivity and multifactor productivity. **Partial productivity** indicates how much of a particular kind of input it takes to produce an output.

partial productivity
A measure of performance that indicates how much of a particular kind of input it takes to produce an output.

$$\text{Partial Productivity} = \frac{\text{Outputs}}{\text{Single Kind of Input}}$$

Labor is one kind of input that is frequently used when determining partial productivity. *Labor productivity* typically indicates the cost or number of hours of labor it takes to produce an output. In other words, the lower the cost of the labor to produce a unit of output, or the less time it takes to produce a unit of output, the higher the labor productivity. For example, the automobile industry often measures labor productivity by determining the average number of hours of labor needed to completely assemble a car. The three most productive auto manufacturers can assemble a car with 32 or fewer hours of labor. Toyota assembles a car in only 27.9 hours of labor, Nissan does it in 29.4 hours, and Honda in 32 hours. These manufacturers have higher labor productivity than General Motors, which needs 34.3 hours of labor to assemble a car, Daimler-Chrysler, which needs 35.8 hours, and Ford, which needs 36.9 hours.¹¹ These lower labor costs give Nissan, Honda, and Toyota an average cost advantage of \$350 to \$500 per car.¹²

Partial productivity assesses how efficiently companies use only one input, such as labor, when creating outputs. Multifactor productivity is an overall measure of productivity that assesses how efficiently companies use all the inputs it takes to make outputs. More specifically, **multifactor productivity** indicates how much labor, capital, materials, and energy it takes to produce an output.¹³

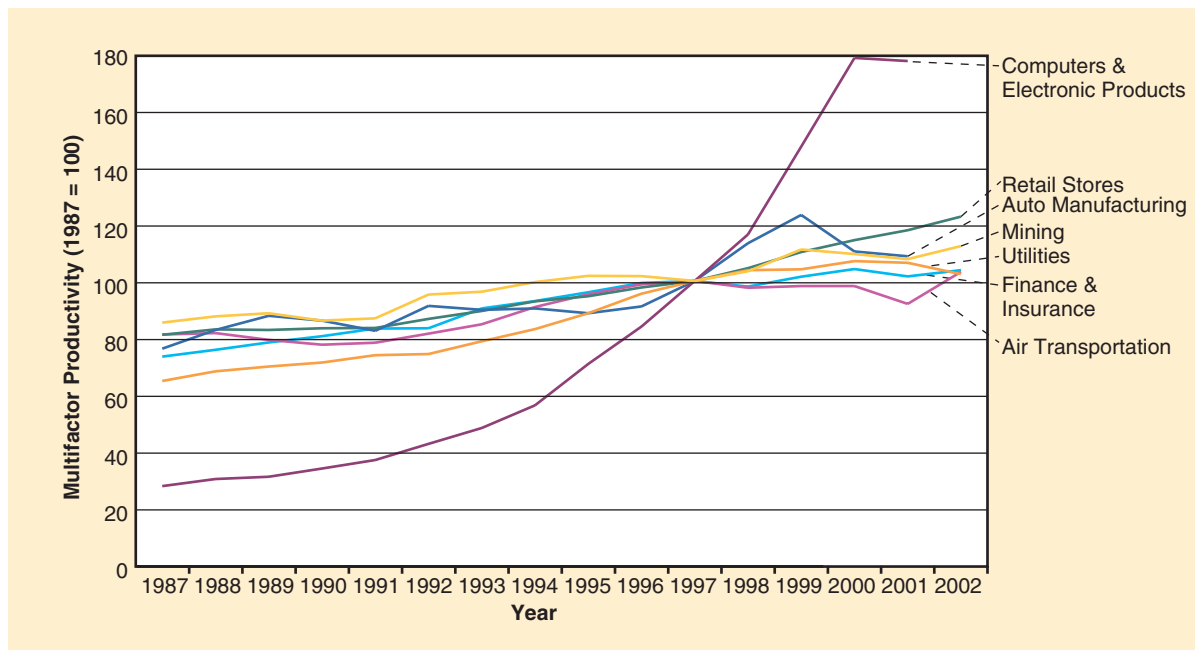
multifactor productivity
An overall measure of performance that indicates how much labor, capital, materials, and energy it takes to produce an output.

$$\text{Multifactor Productivity} = \frac{\text{Outputs}}{(\text{Labor} + \text{Capital} + \text{Materials} + \text{Energy})}$$

Exhibit 18.1 shows the trends in multifactor productivity across a number of U.S. industries since 1987. With a 78 percent increase between 1997 (scaled at 100) and 2001 (when it reached a level of 178) and nearly a sixfold increase since 1987, the growth in multifactor productivity in the computers and electronic products industry far exceeded the productivity growth in retail stores, auto manufacturing, mining, utilities, finance and insurance, and air transportation as well as most other industries tracked by the U.S. government.

Of course, the surge in productivity in the computer and electronics industry isn’t a surprise. Each round of technology advances brings significantly smaller and cheaper, yet much more powerful electronic devices. Significantly less labor, capital, materials, and energy are needed to produce computers and electronic products (e.g., computer game devices such as the PlayStation 2, cell phones, MP3 players) today than in the past. An examination of some of the components of multifactor productivity shows how firms in the computer and electronics industry, such as Dell, Inc., have achieved such large increases in productivity.

First, with respect to labor, every time Dell opens a new factory, it increases productivity by producing more computers with fewer factory workers. John Egan, who directs manufacturing and distribution for one of Dell’s most popular computer lines, says, “Every time [we open a new plant,] we get more and more efficient.”¹⁴ In fact, Dell’s plant on Parmer Lane in Austin, Texas, is twice



Source: "Productivity and Costs," Bureau of Labor Statistics, [Online] available at <http://data.bls.gov/cgi-bin/surveymost?ip>, 1 July 2005.

as productive as the plant it replaced. Likewise, Dell saves on labor costs because 95 percent of the orders processed by this plant are handled automatically when customers place their orders on the Internet.

Second, with respect to capital, multifactor productivity assesses how efficiently a company uses the money it spends on equipment, facilities (offices and operating plants), inventories, and land. Dell has greatly increased the productivity of its assembly plants by aggressively cutting costs and by building plants twice as fast as its competitors. For instance, Dell built its new assembly plant in Lebanon, Tennessee, in only 62 days. Dell cut two weeks out of the construction process by picking the architectural firm one morning and then working with the architects from noon till midnight on that same day to put together a construction schedule and budget.¹⁵

Finally, in terms of materials, that is, the components used to manufacture computers, Dell's new factories have almost no parts or finished product inventory. Computer parts are ordered when customers place their orders. And, according to Sharon Boyle, who manages Dell's new Parmer Lane plant, "More than 95 percent of the orders received are shipped within eight hours." In fact, when the plant was designed, the company completely eliminated space that would normally hold parts and finished goods.¹⁶

Should managers use multiple or partial productivity measures? In general, they should use both. Multifactor productivity indicates a company's overall level of productivity relative to its competitors. In the end, that's what counts most. However, multifactor productivity measures don't indicate the specific contributions that labor, capital, materials, or energy make to overall productivity. To analyze the contributions of these individual components, managers need to use partial productivity measures.

Review 1: Productivity

At their core, companies are production systems that combine inputs, such as labor, raw materials, capital, and knowledge, to produce outputs, such as finished products or services. Productivity is a measure of how many inputs it takes to produce or create an output. The greater the output from one input, or the fewer inputs it takes to create an output, the higher the productivity. Partial productivity measures how much of a single kind of input, such as labor, is

Exhibit 18.1

Multifactor Productivity Growth across Industries

needed to produce an output. Multifactor productivity is an overall measure of productivity that indicates how much labor, capital, materials, and energy are needed to produce an output. Increased productivity helps companies lower costs, which can lead to lower prices, higher market share, and higher profits. Increased productivity helps countries by leading to higher wages, lower product prices, and a higher standard of living.

2 QUALITY

With the average car costing more than \$28,000, car buyers want to make sure that they're getting good quality for their money. Fortunately, as indicated by the number of problems per 100 cars (PP100), today's cars are of much higher quality than earlier models. In 1981, Japanese cars averaged 240 PP100. General Motors' cars averaged 670, Ford's averaged 740, and Chrysler's averaged 870 PP100! In other words, as measured by PP100, the quality of American cars was three to four times worse than Japanese cars. By 1992, however, U.S. carmakers had made great strides, significantly reducing the number of problems to an average of 155 PP100. Japanese vehicles had improved, too, averaging just 125 PP100. Exhibit 18.2 shows the results of the 2005 J.D. Power survey of initial car quality. Lexus, with just 81 PP100, had the best quality, followed by Jaguar at 88 PP100 and BMW at 95 PP100, while Suzuki, with 151 PP100, had the worst, followed by Land Rover and Mazda at 149 PP100. The overall average was 118 PP100. American automakers, especially Buick (GM) with 100 PP100, Cadillac (GM) with 104 PP100, and Hummer (GM) with 110 PP100, continued to close the quality gap with Japanese and luxury auto companies. Lincoln, with 113 PP100, and Jeep and Mercury, both with 120 PP100, and Chrysler, with 121 PP100, were close to Honda, with 112 PP100, and equal to Nissan, with 120 PP100. Toyota, however, still had only 105 PP100.

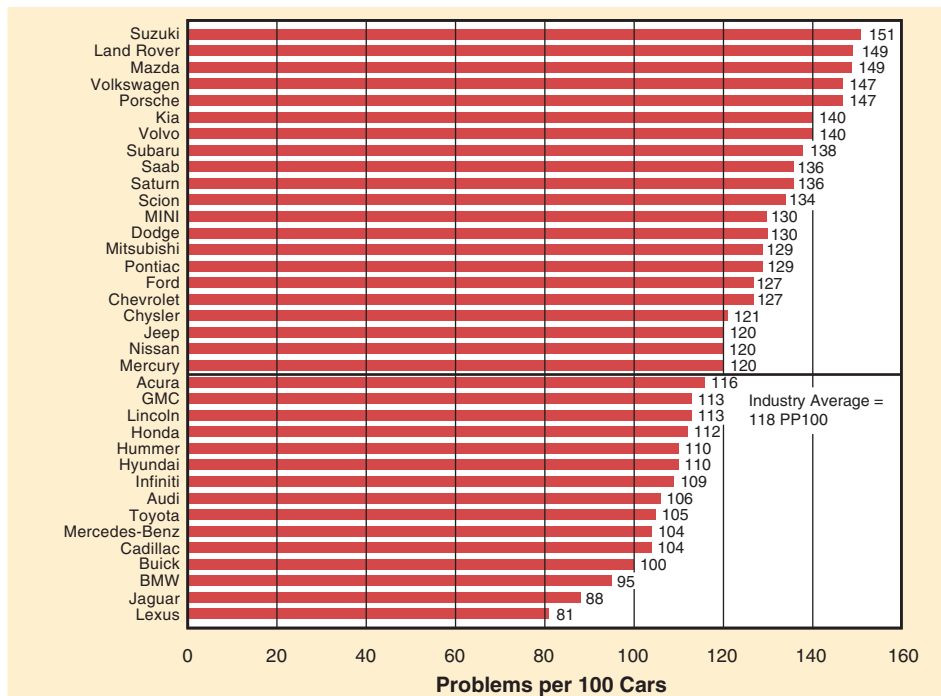
The American Society for Quality gives two meanings for **quality**. It can mean a product or service free of deficiencies, such as the number of problems per 100 cars, or it can mean the characteristics of a product or service that satisfy customer needs.¹⁷ In this sense, today's cars with their additional

quality

A product or service free of deficiencies, or the characteristics of a product or service that satisfy customer needs.

Exhibit 18.2

J.D. Power Survey of Initial Car Quality



Source: "J.D. Power and Associates 2005 Initial Quality Study (IQS)," J.D. Power and Associates, [Online] available at <http://www.jdpower.com/pdf/2005069.pdf>, 1 July 2005.

standard features (power brakes and steering, stereo/CD player, power windows and locks, air bags, cruise control, etc.) are of higher quality than those produced 20 years ago.

In this part of the chapter, you will learn about **2.1 quality-related characteristics for products and services**, **2.2 ISO 9000 and 14000**, **2.3 the Baldrige National Quality Award**, and **2.4 total quality management**.

2.1 Quality-Related Characteristics for Products and Services

As shown in Exhibit 18.3, quality products usually possess three characteristics: reliability, serviceability, and durability.¹⁸ A breakdown occurs when a product quits working or doesn't do what it was designed to do. The longer it takes for a product to break down, or the longer the time between breakdowns, the more reliable the product. Consequently, many companies define *product reliability* in terms of the average time between breakdowns. For example, Quantum Corporation sells a computer product called the SDLT 600 tape drive that customers can use to back up 600 gigabytes of data. The SDLT 600 is so reliable that the estimated mean time between breakdowns is 250,000 hours, or more than 28.5 years!¹⁹ Of course, this is just an average. Some SDLT 600 tape drives will break down much sooner, but others will last even longer than 28.5 years.

Serviceability refers to how easy or difficult it is to fix a product. The easier it is to maintain a working product or fix a broken product, the more serviceable that product is. The Reva is an electric two-seater car, built in India, for city use. It goes 50 miles on a single battery charge, which takes just five hours, and costs two-thirds less per mile than a typical gasoline-powered car. The Reva has high serviceability by virtue of a computerized diagnostic system that plugs into a portable electronic tool (PET) about the size of a personal digital assistant that assesses how well the car is running. Since the PET can be linked to a phone, customers can easily transmit their Reva's operational history to instantly find out if their car needs work and, if so, what kind. In many instances, a simple computer change downloaded to the PET and then to the Reva will fix the problem.²⁰

A product breakdown assumes that a product can be repaired. However, some products don't break down—they fail. *Product failure* means products can't be repaired. They can only be replaced. Thus, durability is a quality characteristic that applies to products that can't be repaired. *Durability* is defined as the mean time to failure. Durability is crucial for products such as the defibrillation equipment used by emergency medical technicians, doctors, and nurses to restart patients' hearts. Imagine the lost lives (and lawsuits) that would occur if this equipment were prone to frequent failure. The mean time between failures for Physio-Control's defibrillation units is 55.6 to 69.4 years.²¹ If a Physio-Control "LIFEPAK" does break, however, the company replaces it within 24 hours.

While high-quality products are characterized by reliability, serviceability, and durability, services are different. With services, there's no point in assessing durability. Unlike products, services don't last. Services are consumed the minute they're performed. For example, once a lawn service has mowed your lawn, the job is done until the mowers come back next week to do it again. Likewise, services don't have serviceability. You can't maintain or fix a service. If a service wasn't performed correctly, all you can do is perform it again. Finally, the quality of service interactions often

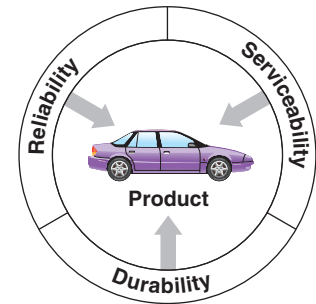


Exhibit 18.3
Characteristics of Product Quality

An electric Reva automobile drives along a city street during Bangalore's celebration of World Environment Day. Reva uses a computer diagnostic system that can sync to the owner's cell phone, indicating the type of service the vehicle needs.



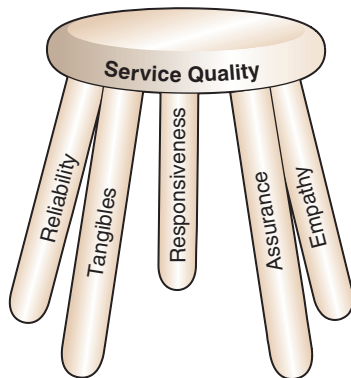


Exhibit 18.4
Characteristics of Service Quality

depends on how the service provider interacts with the customer. Was the service provider friendly, rude, or helpful? Consequently, as shown in Exhibit 18.4, five characteristics—reliability, tangibles, responsiveness, assurance, and empathy—typically distinguish a quality service.²²

Service reliability is the ability to consistently perform a service well. Studies clearly show that reliability matters more to customers than anything else when buying services. Also, although services themselves are not tangible (you can't see or touch them), services are provided in tangible places. Thus, *tangibles* refer to the appearance of the offices, equipment, and personnel involved with the delivery of a service. *Responsiveness* is the promptness and willingness with which service providers give good service. *Assurance* is the confidence that service providers are knowledgeable, courteous, and trustworthy. *Empathy* is the extent to which service providers give individual attention and care to customers' concerns and problems.

EMC Corporation makes highly reliable computers that are used by some of the largest companies in the world (e.g., banks, phone companies, auto manufacturers). If EMC's equipment goes down for even a few minutes, its customers can lose millions from vanished sales. While its equipment is incredibly reliable, what distinguishes EMC from its competition is the level of service it provides when problems occur. In other words, EMC is a standout performer in *service reliability*, the ability to consistently perform a service well. Because of its excellent service, EMC retains an amazing 99 percent of its customers from year to year. When Carl Howe of Forrester Research, a marketing research firm, asked 50 *Fortune* 500 companies about the technology companies they worked with, "EMC came out looking like God." Howe said that EMC "had the best customer-service reviews we have ever seen, in any industry."²³

EMC also excels in *responsiveness*, the promptness and willingness with which service providers give good service. When a Wisconsin bank lost access to all its data (no account numbers, no deposits, no withdrawals, nada!), which were stored on an EMC machine, EMC service engineers were on the problem within minutes (EMC's computers "call home" automatically whenever a problem arises). In four hours EMC had created a setup identical to the bank's in a \$1 billion facility designed for such purposes, where EMC engineers identified the problem and put together a software patch that had the bank up and running by the end of the day.²⁴

EMC provides quality service by virtue of clear *assurance* that it can be trusted. Every customer knows that the company follows a disciplined procedure for addressing customer problems. First, every EMC system does a self-check every two hours to make sure the system is running the way it's supposed to. If even the slightest thing is wrong, it "phones home" to tell EMC's engineers what's happening. EMC gets 3,500 such "calls" from its machines and systems every day. Second, if a problem isn't fixed within four hours, Leo Colborne, the vice president of global technical support, is notified. After six hours, Colborne's boss, the senior vice president of global customer services, is contacted. After eight hours, the company's CEO and chairman are notified. In most cases, the CEO will leave immediately to visit the customer, apologize for the problem, reassure the customer that everything is being done to solve the problem, and begin working with the customer to implement procedures or solutions to prevent the problem from recurring in the future.²⁵

Finally, EMC provides quality service because of the *empathy* it has for its customers' problems. Indeed, early in the company's history, its customers' businesses were suffering because EMC could not figure out why one of its best-selling systems had unexpectedly become unreliable. With key information systems frozen up, business ground to a halt for major customers. Rather than make excuses or empty promises, EMC gave its customers the choice between a brand new EMC computer system or a similar system, made by EMC's competitor, IBM. At the height of its problems, EMC installed more of IBM's

machines than its own. But the company benefited in the long run as customers realized that EMC would do almost anything to solve their problems. And, once EMC solved the problems with that machine, customers trusted the company enough to begin ordering again. EMC's CEO said, "What that proved to me, to all of us, was that when a customer believes in you, and you go to great lengths to preserve that relationship, they'll stick with you almost no matter what. It opened our eyes to the power of customer service."²⁶

2.2 ISO 9000 and 14000

ISO, pronounced *ice-o*, comes from the Greek word *isos*, meaning *equal, similar, alike, or identical*. Thus, **ISO 9000** is a series of five international standards, from ISO 9000 to ISO 9004, for achieving consistency in quality management and quality assurance in companies throughout the world. **ISO 14000** is a series of international standards for managing, monitoring, and minimizing an organization's harmful effects on the environment.²⁷ (For more on environmental quality and issues, see Section 3.5 on controlling waste and pollution in Chapter 16.) The ISO 9000 and 14000 standards were created by the International Organization for Standardization, an international agency that helps set standards for 151 countries. The purpose of this agency is to develop and publish standards that facilitate the international exchange of goods and services.²⁸

The ISO 9000 standards publications, which are available from the American National Standards Institute (see the end of this section), are general and can be used for manufacturing any kind of product or delivering any kind of service. Importantly, the ISO 9000 standards don't describe how to make a better-quality car, computer, or widget. Instead, they describe how companies can extensively document (and thus standardize) the steps they take to create and improve the quality of their products. Why should companies go to the trouble to achieve ISO 9000 certification? The reason is that, increasingly, their customers want them to. In fact, studies show that customers clearly prefer to buy from companies that are ISO 9000 certified. Companies, in turn, believe that being ISO 9000 certified helps them keep customers who might otherwise switch to an ISO 9000 certified competitor.²⁹

Typically, "getting" ISO 9000 means having your company certified for ISO 9000 registration by an accredited third party. ISO 9000 certification is similar to having a certified public accountant indicate that a company's financial accounts are up-to-date and accurate. Like an accountant's audit, the certification process can take months. But in this case, the certification is for quality, not accounting procedures. To become certified, a company must show that it is following its own procedures for improving production, updating design plans and specifications, keeping machinery in top condition, educating and training workers, and satisfactorily dealing with customer complaints.³⁰

Once a company has been certified as ISO 9000 compliant, the accredited third party will issue an ISO 9000 certificate that the company can use in its advertising and publications. This is the quality equivalent of the "Good Housekeeping Seal of Approval." Continued ISO 9000 certification is not guaranteed, however. Accredited third parties typically conduct periodic audits to make sure the company is still following quality procedures. If it is not, its certification is suspended or canceled.

It's estimated that more than half of mid-sized U.S. manufacturers have achieved ISO 9000 certification. Two-thirds of the certified companies say they wanted certification because it increases customer satisfaction. Accordingly, most advertise their ISO certification in their promotional materials and mention it on their Web site; some post their ISO 9000 certificate there as well. For example, Midmark Medical Equipment, a maker of examination

ISO 9000

A series of five international standards, from ISO 9000 to ISO 9004, for achieving consistency in quality management and quality assurance in companies throughout the world.

ISO 14000

A series of international standards for managing, monitoring, and minimizing an organization's harmful effects on the environment.

tables, sterilizers, electrocardiograms, and the like, has posted its certificate at <http://www.midmark.com/iso9000.asp> and states, “Midmark is proud to have the distinction of receiving the ISO 9001 certification for quality.” See the American National Standards Institute (<http://www.ansi.org>; the ISO 9000 and ISO 14000 standards publications are available here for about \$600 and \$100, respectively), the American Society for Quality (<http://www.asq.org>), and the International Organization for Standardization (<http://www.iso.ch>) for additional information on ISO 9000 guidelines and procedures.

2.3 Baldrige National Quality Award

The Baldrige National Quality Award, which is administered by the U.S. government’s National Institute for Standards and Technology, is given “to recognize U.S. companies for their achievements in quality and business performance and to raise awareness about the importance of quality and performance excellence as a competitive edge.”³¹ Each year, up to three awards may be given in these categories: manufacturing, service, small business, education, and health-care (the latter two categories were added in 1999). Exhibit 18.5 lists the latest Baldrige Award winners.

The cost of applying for the Baldrige Award is \$5,000 for manufacturing and service companies and \$2,000 for small businesses.³² At a minimum, each company that applies receives an extensive report based on 300 hours of assessment from at least eight business and quality experts. At \$6.67 an hour for small businesses and about \$16.67 an hour for manufacturing and service businesses, the *Journal for Quality and Participation* called the Baldrige feedback report “the best bargain in consulting in America.”³³ Arnold Weimerskirch, former chair of the Baldrige Award panel of judges and vice president of quality at Honeywell, says “The application and review process for the Baldrige Award is the best, most cost-effective and comprehensive business health audit you can get.”³⁴

The criteria for the Baldrige Award are different for business, education, and health-care organizations. As shown in Exhibit 18.6, businesses that apply for the Baldrige Award are judged on a 1,000-point scale based on seven criteria: leadership; strategic planning; customer and market focus; measurement, analysis, and knowledge management; human resource focus; process management; and business results.³⁵ With 450 out of 1,000 points, “business results” are clearly the most important. In other words, in addition to the six other criteria, companies must show that they have achieved superior quality when it comes to products and services, customers, financial performance and market share, treatment of employees, organizational effectiveness, and leadership and social responsibility. This emphasis on “results” is what differentiates the Baldrige Award from the

Exhibit 18.5
Latest Baldrige National Quality
Award Recipients

Sector	2003 Winner	2004 Winner
Manufacturing	Medrad, Inc.	The Bama Companies, Inc.
Education	Community Consolidated School District 15	Kenneth W. Monfort College of Business
Health care	Saint Luke’s Hospital of Kansas City Baptist Hospital, Inc.	Robert Wood Johnson University Hospital, Hamilton, Ohio
Service	Caterpillar Financial Services Corporation, U.S. Boeing Aerospace Support	(No winner)
Small business	Stoner, Inc.	Texas Nameplate

Source: “1988–2004 Award Recipients’ Contacts and Profiles,” National Institute for Standards and Technology, [Online] available at http://www.quality.nist.gov/Contacts_Profiles.htm, 2 July 2005.

ISO 9000 standards. The Baldrige Award indicates the extent to which companies have actually achieved world-class quality. The ISO 9000 standards simply indicate whether a company is following the management system it put in place to improve quality. In fact, ISO 9000 certification covers less than 10 percent of the requirements for the Baldrige Award.³⁶

Why should companies go to the trouble of applying for the Baldrige Award? Earnest Deavenport, chairman and CEO of Eastman Chemical, explains, “Eastman, like other Baldrige Award winners, didn’t apply the concepts of total quality management to win an award. We did it to win customers. We did it to grow. We did it to prosper and to remain competitive in a world marketplace.”³⁷ Furthermore, the companies that have won the Baldrige Award have achieved superior financial returns. Since 1988, an investment in Baldrige Award winners would have outperformed the Standard & Poor’s 500 stock index 80 percent of the time.³⁸ For additional information about the Baldrige Award, see the National Institute of Standards and Technology Web site at <http://www.quality.nist.gov>.

2.4 Total Quality Management

Total quality management (TQM) is an integrated organization-wide strategy for improving product and service quality.³⁹ TQM is not a specific tool or technique. Rather, TQM is a philosophy or overall approach to management that is characterized by three principles: customer focus and satisfaction, continuous improvement, and teamwork.⁴⁰

Contrary to most economists, accountants, and financiers who argue that companies exist to earn profits for shareholders, TQM suggests that customer focus and customer satisfaction should be a company’s primary goals. **Customer focus** means that the entire organization, from top to bottom, should be focused on meeting customers’ needs. The result of that customer focus should be **customer satisfaction**, which occurs when the company’s products or services meet or exceed customers’ expectations. At companies where TQM is taken seriously, such as Enterprise Rent-a-Car, paychecks and promotions depend on keeping customers satisfied.⁴¹ For example, Enterprise Rent-a-Car measures customer satisfaction with a detailed survey called the Enterprise Service Quality index. Enterprise not only ranks each branch office by operating profits and customer satisfaction, but it also makes promotions to higher-paying jobs contingent on above-average customer satisfaction scores. According to Andy Taylor, Enterprise’s chairman and CEO, “Once we showed we were serious—a couple of star performers who had achieved good growth and profit numbers but had generated below-average satisfaction scores were passed over for promotions—all doubt about the importance of the scores vanished.”⁴² Not surprisingly, this emphasis on quality increased the number of completely satisfied Enterprise Rent-a-Car customers (who are three times more likely to rent a car again) from the high 60 percent range to the high 70 percent range in just five years.

Continuous improvement is an ongoing commitment to increase product and service quality by constantly assessing and improving the processes and procedures used to create those products and services. How do companies know whether they’re achieving continuous improvement? Besides higher customer satisfaction,

2005 CATEGORIES/ITEMS	POINT VALUES
1 LEADERSHIP	(120)
Senior Leadership	70
Governance and Social Responsibilities	50
2 STRATEGIC PLANNING	(85)
Strategy Development	40
Strategy Deployment	45
3 CUSTOMER AND MARKET FOCUS	(85)
Customer and Market Knowledge	40
Customer Relationships and Satisfaction	45
4 MEASUREMENT, ANALYSIS, & KNOWLEDGE MANAGEMENT	(90)
Measurement, Analysis, and Review of Organizational Performance	45
Information and Knowledge Management	45
5 HUMAN RESOURCE FOCUS	(85)
Work Systems	35
Employee Learning and Motivation	25
Employee Well-Being and Satisfaction	25
6 PROCESS MANAGEMENT	(85)
Value Creation Processes	45
Support Processes and Operational Planning	40
7 BUSINESS RESULTS	(450)
Product and Service Outcomes	100
Customer-Focused Results	70
Financial and Market Results	70
Human Resource Results	70
Organizational Effectiveness Results	70
Leadership and Social Responsibility Results	70
TOTAL POINTS	1,000

Source: “Criteria for Performance Excellence,” *Baldrige National Quality Program 2005*, [Online] available at http://www.quality.nist.gov/PDF_files/2003_Business_Criteria.pdf, 2 July 2005.

Exhibit 18.6

Criteria for the Baldrige National Quality Award

total quality management (TQM)

An integrated, principle-based, organization-wide strategy for improving product and service quality.

customer focus

An organizational goal to concentrate on meeting customers’ needs at all levels of the organization.

customer satisfaction

An organizational goal to provide products or services that meet or exceed customers’ expectations.

continuous improvement

An organization’s ongoing commitment to constantly assess and improve the processes and procedures used to create products and services.

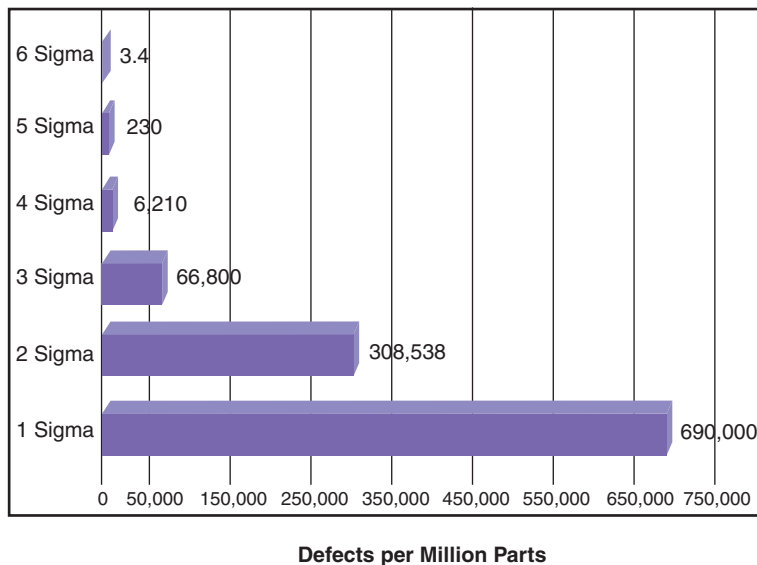


Exhibit 18.7

Number of Defects per Million with Six Sigma Quality

variation

A deviation in the form, condition, or appearance of a product from the quality standard for that product.

teamwork

Collaboration between managers and nonmanagers, across business functions, and between companies, customers, and suppliers.

continuous improvement is usually associated with a reduction in variation. **Variation** is a deviation in the form, condition, or appearance of a product from the quality standard for that product. The less a product varies from the quality standard, or the more consistently a company's products meet a quality standard, the higher the quality. At Freudenberg-NOK, a manufacturer of seals and gaskets for the automotive industry, continuous improvement means shooting for a goal of "six sigma" quality, meaning just 3.4 defective or nonstandard parts per million (PPM). Achieving this goal would eliminate almost all product variation. In a recent year, Freudenberg-NOK made over 200 million seals and gaskets with a defect rate of 9 PPM.⁴³ As Exhibit 18.7 shows, this almost puts Freudenberg-NOK at "six sigma," or 3.4 defective PPM. Furthermore, this represents a

significant improvement from seven years ago when Freudenberg-NOK was averaging 650 defective PPM. General manager Gary VanWambeke says, "The whole goal is variation reduction," so Freudenberg-NOK expects the quality of its products to continue to improve.⁴⁴

The third principle of TQM is teamwork. **Teamwork** means collaboration between managers and nonmanagers, across business functions, and between the company and its customers and suppliers. In short, quality improves when everyone in the company is given the incentive to work together and the responsibility and authority to make improvements and solve problems. At Valassis, a printing company long famous for its use of teams, management turned to employees for additional suggestions when business fell during a recession. Teams offered so many ideas to cut costs and raise quality that the company was able to avoid layoffs.⁴⁵

Together, customer focus and satisfaction, continuous improvement, and teamwork mutually reinforce each other to improve quality throughout a company. Customer-focused continuous improvement is necessary to increase customer satisfaction. At the same time, continuous improvement depends on teamwork from different functional and hierarchical parts of the company.

Review 2: Quality

Quality can mean a product or service free of deficiencies or the characteristics of a product or service that satisfy customer needs. Quality products usually possess three characteristics: reliability, serviceability, and durability. Quality service means reliability, tangibles, responsiveness, assurance, and empathy. ISO 9000 is a series of five international standards for achieving consistency in quality management and quality assurance, while ISO 14000 is a set of standards for minimizing an organization's harmful effects on the environment. The ISO 9000 standards can be used for any product or service because they ensure that companies carefully document the steps they take to create and improve quality. ISO 9000 certification is awarded following a quality audit from an accredited third party. The Baldrige National Quality Award recognizes U.S. companies for their achievements in quality and business performance. Each year, three Baldrige Awards may be given for manufacturing, service, small business, education, and health care. Companies that apply for the Baldrige Award are judged on a 1,000-point scale based on leadership; strategic planning; customer and market focus; measurement, analysis, and knowledge management; human resource focus; process management; and business results. Total quality management (TQM) is an integrated organization-wide strategy for improving

product and service quality. TQM is based on three mutually reinforcing principles: customer focus and satisfaction, continuous improvement, and teamwork.

Managing Operations

At the start of this chapter, you learned that operations management means managing the daily production of goods and services. Then you learned that to manage production, you must oversee the factors that affect productivity and quality. In this half of the chapter, you will learn about managing operations in service and manufacturing businesses. The chapter ends with a discussion of inventory management, a key factor in a company's profitability.

After reading the next three sections, you should be able to

- 3** explain the essentials of managing a service business.
- 4** describe the different kinds of manufacturing operations.
- 5** explain why and how companies should manage inventory levels.

3 SERVICE OPERATIONS

Imagine that your trusty VCR breaks down as you try to record your favorite TV show. (You're still saving your money for a TiVo.) You've got two choices. You can run to Wal-Mart and spend \$45 to \$75 to purchase a new VCR, or you can spend about the same amount (you hope) to have it fixed at a repair shop. Either way you end up with the same thing, a working VCR. However, the first choice, getting a new VCR, involves buying a physical product (a "good"), while the second, dealing with a repair shop, involves buying a service.

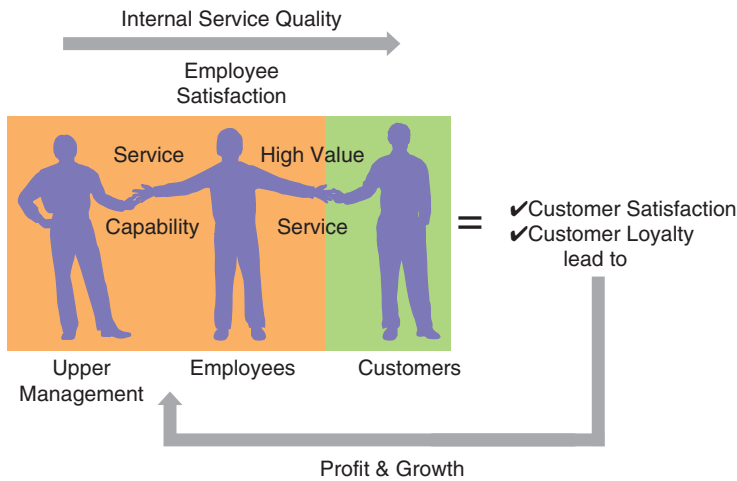
Services differ from goods in several ways. First, goods are produced or made, but services are performed. In other words, services are almost always labor-intensive: someone typically has to perform the service for you. A repair shop could give you the parts needed to repair your old VCR, but without the technician to perform the repairs, you're still going to have a broken VCR. Second, goods are tangible, but services are intangible. You can touch and see that new VCR, but you can't touch or see the service provided by the technician who fixed your old VCR. All you can "see" is that the VCR works. Third, services are perishable and unstorable. If you don't use them when they're available, they're wasted. For example, if your VCR repair shop is backlogged on repair jobs, then you'll just have to wait until next week to get your VCR repaired. You can't store an unused service and use it when you like. By contrast, you can purchase a good, such as motor oil, and store it until you're ready to use it. Finally, services account for 57.2 percent of gross national product whereas manufacturing accounts for only 32.7 percent.⁴⁶ So any review of operations management would be incomplete without an examination of how to manage service operations.

Because services are different from goods, managing a service operation is different from managing a manufacturing or production operation. Let's look at **3.1 the service-profit chain** and **3.2 service recovery and empowerment**.

3.1 The Service-Profit Chain

One of the key assumptions in the service business is that success depends on how well employees, that is, service providers, deliver their services to customers. However, the concept of the service-profit chain, depicted in Exhibit 18.8, suggests that in service businesses, success begins with how well management treats service employees.⁴⁷

The first step in the service-profit chain is *internal service quality*, meaning the quality of treatment that employees receive from a company's internal service



Sources: R. Hallowell, L. A. Schlesinger, & J. Zornitsky, "Internal Service Quality, Customer and Job Satisfaction: Linkages and Implications for Management," *Human Resource Planning* 19 (1996): 20–31; J. L. Heskett, T. O. Jones, G. W. Loveman, W. E. Sasser, Jr., & L. A. Schlesinger, "Putting the Service-Profit Chain to Work," *Harvard Business Review*, March–April 1994, 164–174.

Exhibit 18.8
Service-Profit Chain

Exhibit 18.9
Components of Internal Service Quality

Policies and Procedures	Do policies and procedures facilitate serving customers?
Tools	Has the organization provided service employees the tools they need to serve customers?
Effective Training	Is effective, useful, job-specific training made available in a timely fashion?
Rewards and Recognition	Are individuals rewarded and/or recognized for good performance?
Communication	Does necessary communication occur both vertically and horizontally throughout the organization?
Management Support	Does management aid (versus hinder) employees' ability to serve customers?
Goal Alignment	Are the goals of senior management aligned with the goals of front-line service employees?
Teamwork	Do individuals and departments engage in teamwork when necessary?

Source: R. Hallowell, L. A. Schlesinger, & J. Zornitsky, "Internal Service Quality, Customer and Job Satisfaction: Linkages and Implications for Management," *Human Resource Planning* 19 (1996): 20–31.

providers, such as management, payroll and benefits, human resources, and so forth. For example, Southwest Airlines is legendary for its positive culture and, to the surprise of many, its excellent customer service. Southwest's Chairman Herb Kelleher said, "In the old days, my mother told me that in business school they'd say, 'This is a real conundrum: Who comes first, your employees, your shareholders, or your customers?' My mother taught me that your employees come first. If you treat them well, then they treat the customers well, and that means your customers come back and your shareholders are happy."⁴⁸

Exhibit 18.9 defines the elements that constitute good internal service quality. For employees to do a good job serving customers, management must implement policies and procedures that support good customer service; provide workers the tools and training they need to do their jobs; reward, recognize, and support good customer service; facilitate communication; and encourage people and departments to work together as teams to accomplish company goals with respect to internal service quality and customer service. For example, at CVS, a large drugstore chain, the first step was to reward good customer service. CEO Tom Ryan says, "My bonus, the store manager's bonus, the assistant manager's bonus, the guys in IS . . . a significant amount is based on customer service. We are 100 percent focused on it, and we are passionate about it." As the second step, CVS developed a special monthly scorecard to measure and reward internal service quality for 19 different areas in the company. Executive vice president Deborah Ellinger explains, "The [internal] service ethic is something that we think is important throughout the company. We can't expect our stores to be good at [customer] service if we don't provide them with good [internal] service."⁴⁹ Since CVS instituted the monthly scorecard, internal service quality ratings are up by 30 percent.⁵⁰

As depicted in Exhibit 18.8, good internal service leads to employee satisfaction and service capability. *Employee satisfaction* occurs when companies treat employees in a way that meets or exceeds their expectations. In other words, the better employees are treated, the more satisfied they are, and the more likely they are to give high-value service that satisfies customers.

Service capability is an employee's perception of his or her ability to serve customers well. When an organization serves its employees in ways that help them to do their jobs well, employees, in turn, are more likely to believe that they can and ought to provide high-value service to customers. Again, Southwest Airlines not only treats its employees well, but also takes a number of direct steps to strengthen their service capability. Chairman

Herb Kelleher says, “I can’t anticipate all of the situations that will arise at the stations [airport terminals] across our system. So what we tell our people is, ‘Hey, we can’t anticipate all of these things; *you* handle them the best way possible. *You* make a judgment and use *your* discretion; we trust you’ll do the right thing. If we think you’ve done something erroneous, we’ll let you know—without criticism, without backbiting.”⁵¹

Finally, according to the service-profit chain shown in Exhibit 18.8, *high-value service* leads to *customer satisfaction* and *customer loyalty*, which, in turn, lead to *long-term profits and growth*. What’s the link between customer satisfaction and loyalty and profits? To start, the average business keeps only 70 to 90 percent of its existing customers each year. No big deal, you say? Just replace leaving customers with new customers. Well, there’s one significant problem with that solution. It costs five times as much to find a new customer as it does to keep an existing customer. Also, new customers typically buy only 20 percent as much as established customers. In fact, keeping existing customers is so cost-effective that most businesses could double their profits by simply keeping 5 percent more customers per year!⁵²

One service company that understands the relationship between high-value service, customer loyalty, and profits is USAA, a Texas-based finance/insurance company. When USAA’s customers have young children, it sends them booklets on how to save for a college education. When its customers near the age of 50, it contacts them about retirement and estate planning. And when it issues credit cards to college students, it takes the time to teach them how to manage their credit and avoid excessive credit card debt. Says USAA vice president Phyllis Stahle, “We build loyalty by convincing [customers] we’re loyal to them.”⁵³ Indeed, USAA has a 97 percent customer retention rate!

service recovery

Restoring customer satisfaction to strongly dissatisfied customers.

3.2 Service Recovery and Empowerment

When mistakes are made, when problems occur, and when customers become dissatisfied with the service they’ve received, service businesses must switch from the process of service delivery to the process of **service recovery**, that is, restoring customer satisfaction to strongly dissatisfied customers.⁵⁴ Sometimes, service recovery requires service employees to not only fix whatever mistake was made, but also perform “heroic” service acts that “delight” highly dissatisfied customers by far surpassing their expectations of fair treatment. When accountant Tom Taylor checked into his room at a Hampton Inn in Greenville, South Carolina, he wasn’t happy. The company Web site had given him incorrect directions. The lights in his room weren’t plugged in. The shower controls were backwards—“hot” was “cold” and “cold” was “hot.” And the air-conditioning was malfunctioning, so his room was freezing cold. When he complained, the employee at the front desk immediately offered him two free nights of lodging. Taylor was delighted by the offer, but since he thought it was excessive, he took just one free night.⁵⁵

Unfortunately, when mistakes occur, service employees often don’t have the discretion to resolve customer complaints. Customers who want service employees to correct or make up for poor service are frequently told, “I’m not allowed to do that,” “I’m just following company rules,” or “I’m sorry, only managers are allowed to make changes of any kind.” In other words, company rules prevent them from engaging in acts of service recovery meant to turn dissatisfied customers back into

PROTECT YOUR FRONT-LINE STAFF: THE CUSTOMER ISN’T ALWAYS RIGHT

In 1909, Harry Gordon Selfridge, an American who founded London’s famous Selfridge’s department store, coined the phrase, “The customer is always right.” Though managers and employees should do what they can to provide great service and make up for mistakes with great service recovery, the customer isn’t *always* right. Companies should fire customers who use foul language, make threats against employees or other customers, lie, demand unethical or illegal service, try to bully front-line employees into granting special favors, or are just generally belligerent. Management consultant John Curtis says, “If you don’t [fire these customers], you’re telling your employees and your other customers that you care more about money than the safety of the people in the business.” So, do the right thing. Protect your front-line staff by telling bad customers that you won’t tolerate these kinds of behavior. Ask them to leave. Close their accounts. Inform them that they’ll need to go elsewhere.⁵⁶

DOING THE RIGHT THING

COSTS	
1.	Finding service workers who are capable of solving problems and dealing with upset customers increases selection costs.
2.	Training service workers to solve different kinds of problems entails increased costs.
3.	Higher wages are needed to attract and keep talented service workers.
4.	A focus on service recovery may lead to less emphasis on service reliability, doing it right the first time. Ultimately, this could lead to slower delivery of services.
5.	In their quest to please customers, empowered service workers may cost the company money by being too eager to provide “giveaways” to make up for poor or slow service.
6.	Empowered service workers may unintentionally treat customers unfairly by occasionally being overly generous to make up for poor or slow service.
BENEFITS	
1.	Responses to customer complaints and problems are quicker.
2.	Employees feel better about their jobs and themselves.
3.	Employee interaction with customers will be warm and enthusiastic.
4.	Employees are more likely to offer ideas for improving service or preventing problems.
5.	Empowered employees who provide service recovery lead to great word-of-mouth advertising and customer retention.
6.	Satisfied employees who take good care of customers are more likely to stay with the company.

Sources: D. E. Bowen & E. E. Lawler III, “The Empowerment of Service Workers: What, Why, How, and When,” *Sloan Management Review* 33 (Spring 1992): 31–39; S. Kundu & J. Vora, “Creating a Talented Workforce for Delivering Service Quality,” *Human Resource Planning* 27 (1 January 2004): 40.

Exhibit 18.10
Costs and Benefits of Empowering
Service Workers for Service Recovery

Review 3: Service Operations

Services are different from goods. Goods are produced, tangible, and storable. Services are performed, intangible, and perishable. Likewise, managing service operations is different from managing production operations. The service-profit chain indicates that success begins with internal service quality, meaning how well management treats service employees. Internal service quality leads to employee satisfaction and service capability, which, in turn, lead to high-value service to customers, customer satisfaction, customer loyalty, and long-term profits and growth. Keeping existing customers is far more cost-effective than finding new ones. Consequently, to prevent disgruntled customers from leaving, some companies are empowering service employees to perform service recovery—restoring customer satisfaction to strongly dissatisfied customers—by giving them the authority and responsibility to immediately solve customer problems. The hope is that empowered service recovery will prevent customer defections.

4 MANUFACTURING OPERATIONS

DaimlerChrysler makes cars, and Dell does computers. Shell produces gasoline, whereas Sherwin-Williams makes paint. Boeing makes jet planes, but Budweiser makes beer. Maxtor makes hard drives, and Maytag makes appliances. The

satisfied customers. The result is frustration for customers and service employees and lost customers for the company.

Now, however, many companies are empowering their service employees.⁵⁷ In Chapter 9, you learned that *empowering workers* means permanently passing decision-making authority and responsibility from managers to workers. With respect to service recovery, empowering workers means giving service employees the authority and responsibility to make decisions that immediately solve customer problems.⁵⁸ At Hampton Inn, all employees are empowered to solve customer problems. Senior vice president Phil Cordell says, “You don’t have to call an 800 number. Just mention it at the front desk or to any employee—a housekeeper, maintenance person or breakfast hostess—and, on the spot, your stay is free.”⁵⁹

In short, the purpose of empowering service employees is zero customer defections, that is, to turn dissatisfied customers back into satisfied customers who continue to do business with the company.

Empowering service workers does entail some costs, although they are usually less than the company’s savings from retaining customers. For example, over a typical year, Hampton Inn will give back 0.5 percent of its room rental charges to dissatisfied customers. But, according to Cordell, service recovery pays off because every dollar refunded to disgruntled customers results in a \$7 payoff as those formerly dissatisfied customers return to Hampton Inn or tell their friends to stay at Hampton Inn because they were treated so well.⁶⁰ Exhibit 18.10 describes some costs and benefits of empowering service workers to act in ways that they believe will accomplish service recovery.

manufacturing operations of these companies all produce physical goods. But not all manufacturing operations, especially these, are the same. Let's learn how various manufacturing operations differ in terms of **4.1 the amount of processing that is done to produce and assemble a product** and **4.2 the flexibility to change the number, kind, and characteristics of products that are produced**.

4.1 Amount of Processing in Manufacturing Operations

As Exhibit 18.11 shows, manufacturing operations can be classified according to the amount of processing or assembly that occurs after a customer order is received. The highest degree of processing occurs in **make-to-order operations**. A make-to-order operation does not start processing or assembling products until it receives a customer order. In fact, some make-to-order operations may not even order parts until a customer order is received. Not surprisingly, make-to-order operations produce or assemble highly specialized or customized products for customers.

For example, Dell, Inc. has one of the most advanced make-to-order operations in the computer business. Dell has no finished goods inventory—it does not build a computer until someone buys it. Because Dell doesn't order parts from suppliers until machines are purchased, its computers always have the latest, most advanced components. No one who buys a Dell computer gets stuck with old technology. Also, because prices of computer components tend to fall, Dell's make-to-order operation can pass on price cuts to customers. Plus, Dell can customize all of its orders, big and small. So whether you're ordering 5,000 personal computers for your company or just one personal computer for your home, Dell doesn't make the computers until you order them.

A moderate degree of processing occurs in **assemble-to-order operations**. A company using an assemble-to-order operation divides its manufacturing or assembly process into separate parts or modules. The company orders parts and assembles modules ahead of customer orders. Then, based on actual customer orders or on research forecasting what customers will want, those modules are combined to create semicustomized products. For example, when a customer orders a new car, General Motors may have already ordered the basic parts or modules it needs from suppliers. In other words, based on sales forecasts, GM may already have ordered enough tires, air-conditioning compressors, brake systems, and seats from suppliers to accommodate nearly all customer orders on a particular day. Special orders from customers and car dealers are then used to determine the final assembly checklist for particular cars as they move down the assembly line.

The lowest degree of processing occurs in **make-to-stock operations** (also called build-to-stock). Because the products are standardized, meaning each product is exactly the same as the next, a company using a make-to-stock operation starts ordering parts and assembling finished products before receiving customer orders. Customers then purchase these standardized products, such as Rubbermaid storage containers, microwave ovens, and vacuum cleaners, at retail stores or directly from the manufacturer. Because parts are ordered and products are assembled before customers order the products, make-to-stock operations are highly dependent on the accuracy of sales forecasts. If sales forecasts are incorrect, make-to-stock operations may end up building too many or too few products, or they may make products with the wrong features or without the features that customers want.

These disadvantages are leading many companies to move from make-to-stock to build-to-order systems. Mark Simons, a vice president at Toshiba, says, "Toshiba is expanding beyond make-to-stock systems and offering a quick and easy way to customize a notebook to fit the individual needs of our customers.

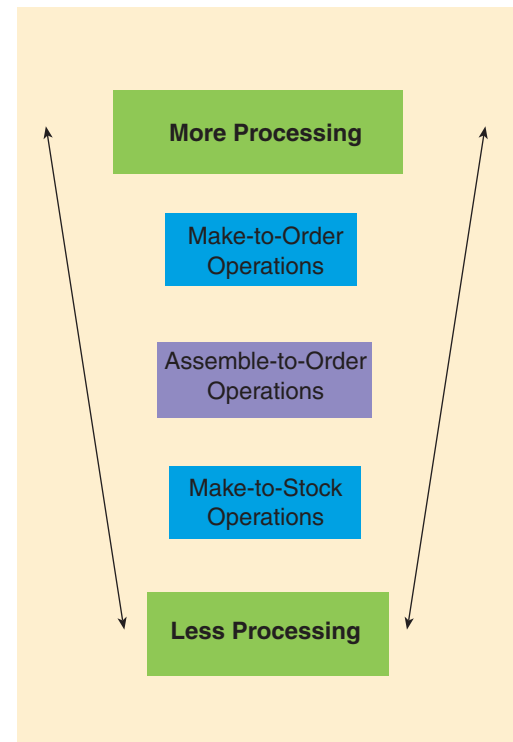


Exhibit 18.11
Processing in Manufacturing Operations

make-to-order operation

A manufacturing operation that does not start processing or assembling products until a customer order is received.

assemble-to-order operation

A manufacturing operation that divides manufacturing processes into separate parts or modules that are combined to create semicustomized products.

make-to-stock operation

A manufacturing operation that orders parts and assembles standardized products before receiving customer orders.

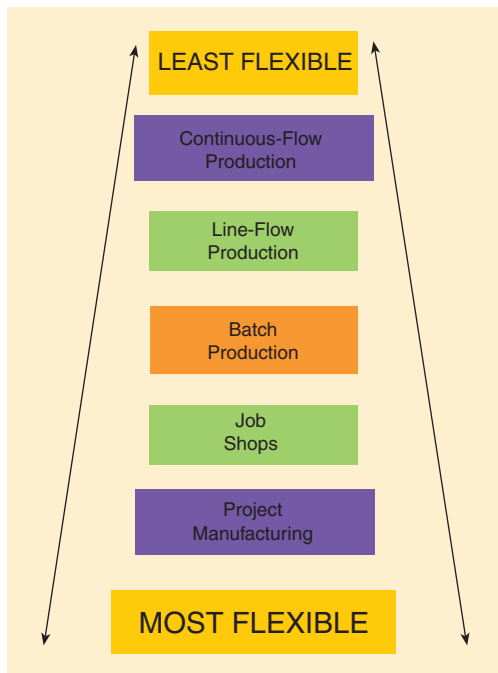


Exhibit 18.12
Flexibility of Manufacturing
Operations

manufacturing flexibility

The degree to which manufacturing operations can easily and quickly change the number, kind, and characteristics of products they produce.

Just Born, maker of Marshmallow Peeps, uses a line flow system that is also somewhat flexible. For example, by changing the mold in one part of the production line, the company can switch from making its hallmark Peep Chicks and Bunnies to making new shapes, like the pumpkins shown here.



MIKE Mergen/BLOOMBERG NEWS/LANDOV

We've listened to our customers' feedback and are answering their call to have direct access to Toshiba mobile technology on various levels and at all times."⁶¹

4.2 Flexibility of Manufacturing Operations

A second way to categorize manufacturing operations is by **manufacturing flexibility**, meaning the degree to which manufacturing operations can easily and quickly change the number, kind, and characteristics of products they produce. Flexibility allows companies to respond quickly to changes in the marketplace (i.e., competitors and customers) and to reduce the lead time between ordering and final delivery of products. There is often a tradeoff between flexibility and cost, however, with the most flexible manufacturing operations frequently having higher costs per unit and the least flexible operations having lower costs per unit.⁶² Exhibit 18.12 shows different types of manufacturing operations arranged in order from the least flexible to the most flexible: continuous-flow production, line-flow production, batch production, job shops, and project manufacturing.

Most production processes generate finished products at a discrete rate. A product is completed, and then, perhaps a few seconds, minutes, or hours later, another is completed, and so on. For instance, if you stood at the end of an automobile assembly line, nothing much would seem to be happening for 55 seconds of every minute. In that last 5 seconds, however, a new car would be started and driven off the assembly line, ready for its new owner. By contrast, in **continuous-flow production**, products are produced continuously, rather than at a discrete rate. Like a water hose that is never turned off and just keeps on flowing, production of the final product never stops. In other words, the product is always and continuously being produced. Liquid chemicals and petroleum products are examples of continuous-flow production. If you're still struggling with this concept (and it can be confusing), think of PlayDoh. Continuous-flow production is similar to squeezing PlayDoh into a toy press and watching the various shapes ooze out of the "PlayDoh machine." With continuous-flow production, the PlayDoh machine would never stop oozing or producing rectangle- or triangle-shaped PlayDoh. Because of their complexity, continuous-flow production processes are the most standardized and least flexible manufacturing operations.

Line-flow production processes are preestablished, occur in a serial or linear manner, and are dedicated to making one type of product. In this way, the 10 different steps required to make product X can be completed in a separate manufacturing process (with separate machines, parts, treatments, locations, and workers) from the 12 different steps required to make product Y. Line-flow production processes are inflexible because they are typically dedicated to manufacturing one kind of product. For example, nearly every city has a local bottling plant for soft drinks or beer. The processes or steps in bottling plants are serial, meaning they must occur in a particular order. For example, after empty bottles are sterilized, they are filled with soft drinks or beer using a special dispenser that distributes the liquid down the inside walls of the bottle. This fills the bottle from the bottom up and displaces the air that was in the bottle. The bottles are then crowned or

capped, checked for underfilling and missing caps, labeled, inspected a final time for fill levels and missing labels, and then placed in cases that are shrink-wrapped on pallets and put on trucks for delivery.⁶³

The next most flexible manufacturing operation is **batch production**, which involves the manufacture of large batches of different products in standard lot sizes. Consequently, a worker in a batch production operation will perform the same manufacturing process on 100 copies of product X, followed by 200 copies of product Y, and then 50 copies of product Q. Furthermore, these “batches” move through each manufacturing department or process in identical order. So, if the paint department follows chemical treatment, and chemical treatment is now processing a batch of 50 copies of product Q, then the paint department’s next task will be to paint 50 copies of product Q. Batch production is finding increasing use among restaurant chains. To ensure consistency in the taste and quality of their products, many restaurants have central kitchens, or commissaries, that produce batches of food, such as mashed potatoes, stuffing, macaroni and cheese, rice, quiche filling, and chili, in volumes ranging from 10 to 200 gallons. These batches are then delivered to restaurants, which serve the food to customers.

Next in terms of flexibility is the job shop. **Job shops** are typically small manufacturing operations that handle special manufacturing processes or jobs. In contrast to batch production, which handles large batches of different products, job shops typically handle very small batches, some as small as one product or process per “batch.” Basically, each “job” in a job shop is different, and once a job is done, the job shop moves on to a completely different job or manufacturing process for, most likely, a different customer. For example, Leggett & Platt Machine Products in Carthage, Missouri, is a job shop that makes coil springs, innerspring units, welded metal grids, and various other parts for mattress manufacturers around the world. Since its inception, its 225 employees have made over 25,000 *different* parts; in other words, they have completed 25,000 different jobs for customers.⁶⁴ Another example of a job shop is Heil Trailer International in Athens, Tennessee. Heil specializes in the production of custom truck trailers that carry petroleum or dry bulk. Heil also makes intermodal trailers that can be pulled by trucks and transported by trains. Steve Slaughter, Heil’s general manager, says, “Even when we get orders for multiple trailers, the trailers normally aren’t the same. The shape of the tank itself doesn’t really change that much. But with all the different weight laws and customer preferences, it’s unusual to see two identical trailers going down the same assembly line.”⁶⁵

The most flexible manufacturing operation is project manufacturing. **Project manufacturing** is an operation designed to produce large, expensive, specialized products like custom homes; military systems such as aircraft carriers and submarines; and aerospace products such as passenger planes and the space shuttle. Project manufacturing is highly flexible because each project is usually significantly different from the one before it, even if the projects involve the same general type of product, such as a submarine. Because of each project’s size, expense, and high degree of customization, project manufacturing can take an extremely long time to complete. For instance, General Dynamics uses project manufacturing when making new submarines. The U.S. Navy’s Virginia class subs, which are its newest and most advanced attack submarines, are 377 feet long and able to attain speeds greater than 25 knots (28 miles per hour/46.3 kilometers per hour). Therefore, they will be significantly quieter and faster than the Los Angeles class submarines that they replace.⁶⁶ Project manufacturing is required for submarine construction because of the tremendous cost (\$1.6 billion each), the complexity of the subs, and the length of time it takes to complete a new submarine (six years). Because of these enormous challenges, only one new Virginia class submarine is being completed each year.

continuous-flow production

A manufacturing operation that produces goods at a continuous, rather than a discrete, rate.

line-flow production

Manufacturing processes that are preestablished, occur in a serial or linear manner, and are dedicated to making one type of product.

batch production

A manufacturing operation that produces goods in large batches in standard lot sizes.

job shops

Manufacturing operations that handle custom orders or small batch jobs.

project manufacturing

Manufacturing operations designed to produce large, expensive, specialized products.

Review 4: Manufacturing Operations

Manufacturing operations produce physical goods. Manufacturing operations can be classified according to the amount of processing or assembly that occurs after receiving an order from customers. Make-to-order operations, in which assembly doesn't begin until products are ordered, involve the most processing. The next-highest degree of processing occurs in assemble-to-order operations, in which preassembled modules are combined after orders are received to produce semicustomized products. The least processing occurs in make-to-stock operations, in which standard parts are ordered, on the basis of sales forecasts, and assembled before orders are received.

Manufacturing operations can also be classified in terms of flexibility, the degree to which the number, kind, and characteristics of products can easily and quickly be changed. Flexibility allows companies to respond quickly to competitors and customers and to reduce order lead times, but it can also lead to higher unit costs. Manufacturing operations can be arranged in order from the least to the most flexible as follows: continuous-flow production, line-flow production, batch production, job shops, and project manufacturing.

5 INVENTORY

When auto sales dropped by 16 percent, General Motors shut down 14 of its 29 assembly plants and laid off half of its workers for periods ranging from one to five weeks to reduce inventories and cut costs. GM had a 116-day supply of new trucks and sports utility vehicles on hand, well over its goal of a 72-day supply. Paul Ballew, a general director for market and industry analysis at GM, said, "With sales moderating, the industry had to work through this inventory bubble."⁶⁷

inventory

The amount and number of raw materials, parts, and finished products that a company has in its possession.

Inventory is the amount and number of raw materials, parts, and finished products that a company has in its possession. General Motors made the mistake of having too much inventory on hand and had to close its plants to let existing sales draw down inventory levels to an acceptable and affordable level. In this section, you will learn about **5.1 the different types of inventory**, **5.2 how to measure inventory levels**, **5.3 the costs of maintaining an inventory**, and **5.4 the different systems for managing inventory**.

5.1 Types of Inventory

Exhibit 18.13 shows the four kinds of inventory a manufacturer stores: raw materials, component parts, work-in-process, and finished goods. The flow of inventory through a manufacturing plant begins when the purchasing department buys raw materials from vendors. **Raw material inventories** are the basic inputs in the manufacturing process. For example, to begin making a car, automobile manufacturers purchase raw materials like steel, iron, aluminum, copper, rubber, and unprocessed plastic.

Next, raw materials are fabricated or processed into **component parts inventories**, meaning the basic parts used in manufacturing a product. For example, in an automobile plant, steel is fabricated or processed into a car's body panels, and steel and iron are melted and shaped into engine parts like pistons or engine blocks. Component parts inventories are sometimes purchased directly from vendors.

The component parts are then assembled to make unfinished **work-in-process inventories**, which are also known as partially finished goods. This process is also called *initial assembly*. For example, steel body panels are welded to each other and to the frame of the car to make a "unibody," which comprises the unpainted interior frame and exterior structure of the car. Likewise, pistons, camshafts, and other engine parts are inserted into the engine block to create a working engine.

raw material inventories

The basic inputs in a manufacturing process.

component parts inventories

The basic parts used in manufacturing that are fabricated from raw materials.

work-in-process inventories

Partially finished goods consisting of assembled component parts.

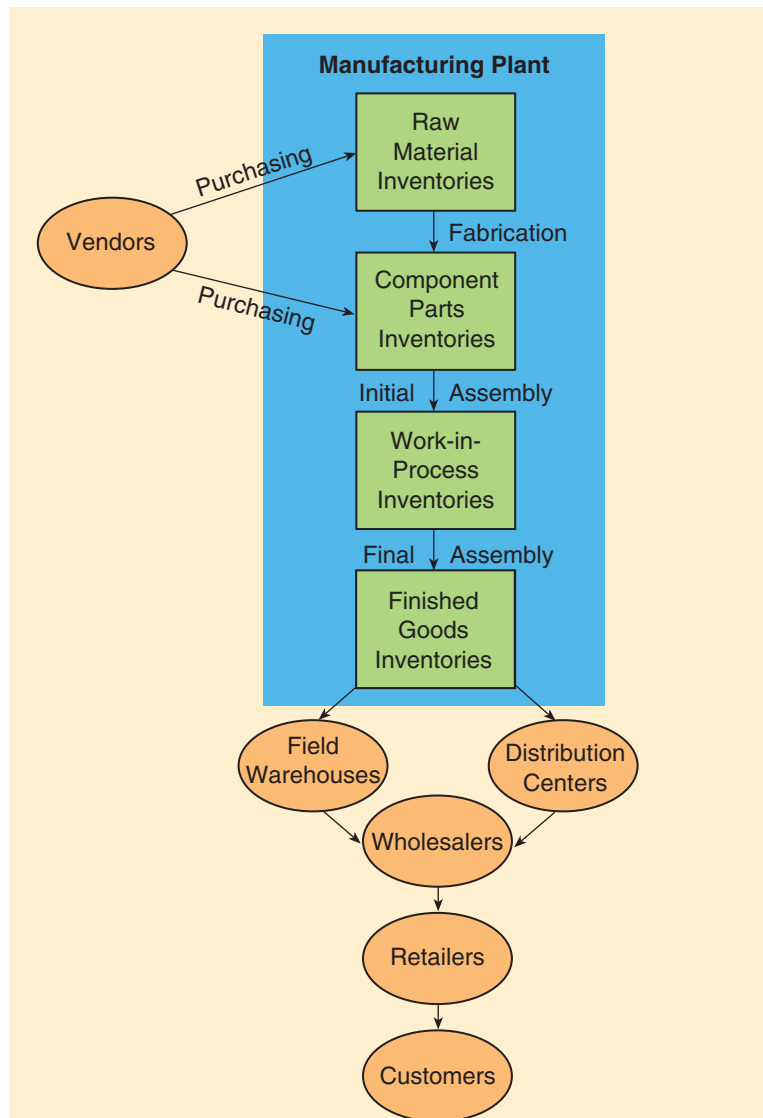
Next, all the work-in-process inventories are assembled to create **finished goods inventories**, which are the final outputs of the manufacturing process. This process is also called *final assembly*. For a car, the engine, wheels, brake system, suspension, interior, and electrical system are assembled into a car's painted unibody to make the working automobile, which is the factory's finished product. In the last step in the process, the finished goods are sent to field warehouses, distribution centers, or wholesalers, and then to retailers for final sale to customers.

5.2 Measuring Inventory

As you'll learn below, uncontrolled inventory can lead to huge costs for a manufacturing operation. Consequently, managers need good measures of inventory to prevent inventory costs from becoming too large. Three basic measures of inventory are average aggregate inventory, weeks of supply, and inventory turnover.

If you've ever worked in a retail store and had to "take inventory," you probably weren't too excited about the process of counting every item in the store and storeroom. It's an extensive task. Fortunately, "taking inventory" is somewhat easier today because of bar codes that mark items and computers that can count and track them. Nonetheless, inventories still differ from day to day. For example, an inventory count taken at the beginning of the month will likely be different from a count taken at the end of the month. Similarly, an inventory count taken on a Friday will differ from a count taken on a Monday. Because of such differences, companies often measure **average aggregate inventory**, which is the average overall inventory during a particular time period. Average aggregate inventory for a month can be determined by simply averaging the inventory counts at the end of each business day for that month. One way companies know whether they're carrying too much or too little inventory is to compare their average aggregate inventory to the industry average for aggregate inventory. For example, 72 days of inventory is the average for the automobile industry.

Inventory is also measured in terms of *weeks of supply*, meaning the number of weeks it would take for a company to run out of its current supply of inventory. In general, there is an acceptable number of weeks of inventory for a particular kind of business. Too few weeks of inventory on hand, and a company risks a **stockout**—running out of inventory. During a recent holiday season, the busiest shopping time of the year, retail and online stores ran out of Apple Computer's fast-selling iPods. Industry analyst Stephen Baker said, "Given how strong demand has been all year you would have thought [Apple] would have gotten every last one they could into stores."⁶⁸ Apple issued a statement, saying, "To try to meet the high demand, we're making and shipping iPods as fast as we can. So,



Source: R. E. Markland, S. K. Vickery, & R. A. Davis, *Operations Management*, 2nd ed. (Mason, OH: South-Western, 1998). Reprinted with permission.

Exhibit 18.13 Types of Inventory

finished goods inventories

The final outputs of manufacturing operations.

average aggregate inventory

Average overall inventory during a particular time period.

stockout

The situation when a company runs out of finished product.

if one store has run out, you may find iPods in another authorized iPod reseller.”⁶⁹ Nevertheless, iPods were in such short supply that the iPod mini was selling for \$380 on eBay, \$130 over the suggested retail price. On the other hand, a business that has too many weeks of inventory on hand incurs high costs (discussed below). For example, companies that make the linerboard used for corrugated cardboard boxes typically have too much inventory when they have more than six weeks’ supply on hand; the right amount is about four weeks’ supply.⁷⁰ Anything more than that results in excess inventory, which can be reduced only by cutting prices or temporarily stopping production.

inventory turnover

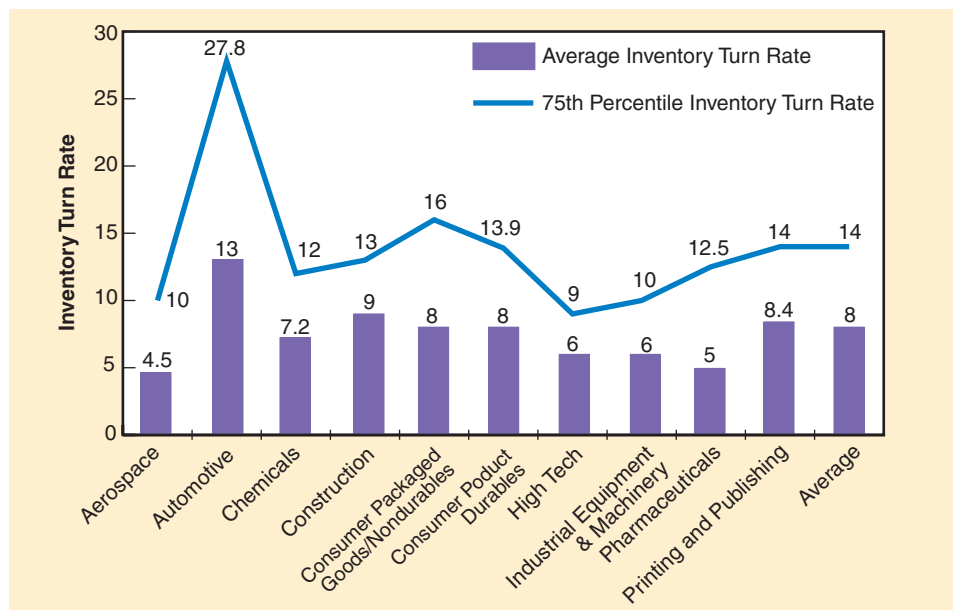
The number of times per year that a company sells or “turns over” its average inventory.

Another common inventory measure, **inventory turnover**, is the number of times per year that a company sells or “turns over” its average inventory. For example, if a company keeps an average of 100 finished widgets in inventory each month, and it sold 1,000 widgets this year, then it “turned” its inventory 10 times this year.

In general, the higher the number of inventory “turns,” the better. In practice, a high turnover means that a company can continue its daily operations with just a small amount of inventory on hand. For example, let’s take two companies, A and B, which, over the course of a year, have identical inventory levels (520,000 widget parts and raw materials). If company A turns its inventories 26 times a year, it will completely replenish its inventory every two weeks and have an average inventory of 20,000 widget parts and raw materials. By contrast, if company B turns its inventories only two times a year, it will completely replenish its inventory every 26 weeks and have an average inventory of 260,000 widget parts and raw materials. So, by turning its inventory more often, company A has 92 percent less inventory on hand at any one time than company B.

Across all kinds of manufacturing plants, the average number of inventory turns is approximately eight per year, as shown in Exhibit 18.14, although the average can be higher or lower for different industries.⁷¹ The exhibit also shows the inventory turn rates for some of the best companies in each industry (i.e., the 75th percentile). For example, whereas the average auto company turns its entire inventory 13 times per year, some of the best auto companies more than double that rate, turning their inventory 27.8 times per year, or once every two

Exhibit 18.14
Inventory Turn Rates across Industries



Source: D. Drickhamer, “Zeroing in on World-Class,” *Industry Week*, November 2001, 36.

weeks.⁷² For an auto company, turning inventory more frequently than the industry average can cut costs by several hundred million dollars per year. Finally, it should be pointed out that even make-to-order companies like Dell turn their inventory. In theory, make-to-order companies have no inventory. In fact, they've got inventory, but you have to measure it in hours. For example, in its factories, Dell turns its inventory 500 times a year, which means that on average it has 17 hours—that's hours and not days—of inventory on hand in its factories.⁷³

5.3 Costs of Maintaining an Inventory

Maintaining an inventory incurs four kinds of costs: ordering, setup, holding, and stockout. **Ordering cost** is not the cost of the inventory itself, but the costs associated with ordering the inventory. It includes the costs of completing paperwork, manually entering data into a computer, making phone calls, getting competing bids, correcting mistakes, and simply determining when and how much new inventory should be reordered. For example, ordering costs are relatively high in the restaurant business because 80 percent of food service orders (in which restaurants reorder food supplies) are processed manually. It's estimated that the food industry could save \$6.6 billion if all restaurants converted to electronic data interchange (see Chapter 17), in which purchase and ordering information from one company's computer system is automatically relayed to another company's computer system. In fact, a number of restaurants and food service trade groups have formed an interest group called Efficient Foodservice Response to encourage restaurants and food suppliers to use EDI and other methods of electronic commerce.⁷⁴

Setup cost is the cost of changing or adjusting a machine so that it can produce a different kind of inventory.⁷⁵ For example, 3M uses the same production machinery to make several kinds of industrial tape, but it must adjust the machines whenever it switches from one kind of tape to another. There are two kinds of setup costs, downtime and lost efficiency. *Downtime* occurs whenever a machine is not being used to process inventory. So, if it takes five hours to switch a machine from processing one kind of inventory to another, then five hours of downtime have occurred. Downtime is costly because companies earn an economic return only when machines are actively turning raw materials into parts or parts into finished products. The second setup cost is *lost efficiency*. Typically, after a switchover, it takes some time to recalibrate a machine to its optimal settings. It may take several days of fine-tuning before a machine finally produces the number of high-quality parts that it is supposed to. Exhibit 18.15 illustrates the tradeoff between setup costs, meaning downtime and lost efficiency, and manufacturing flexibility, that is, the number of *different* products (or inventory) that can be processed or assembled on a particular machine. The data in Exhibit 18.15 assume that four hours of downtime and 3 percent lost efficiency occur each time a machine's setup has to be changed from one product to another. So, as shown in the exhibit, each time a machine has to be changed to handle a different kind of inventory, setup costs (downtime and lost efficiency) rise.

Holding cost, also known as *carrying* or *storage cost*, is the cost of keeping inventory until it is used or sold. Holding cost includes the cost of storage facilities, insurance to protect inventory from damage or theft, inventory taxes, the cost of obsolescence (holding inventory that is no longer useful to the company), and the opportunity cost of spending money on inventory that could have been spent elsewhere in the company. For example, it's estimated that at any one time, U.S. airlines have a total of \$60 billion worth of airplane parts in stock for maintenance, repair, and overhauling their planes. The holding cost for managing, storing, and purchasing these parts is nearly \$12.5 billion—or roughly one-fifth of the cost of the parts themselves.⁷⁶

ordering cost

The costs associated with ordering inventory, including the cost of data entry, phone calls, obtaining bids, correcting mistakes, and determining when and how much inventory to order.

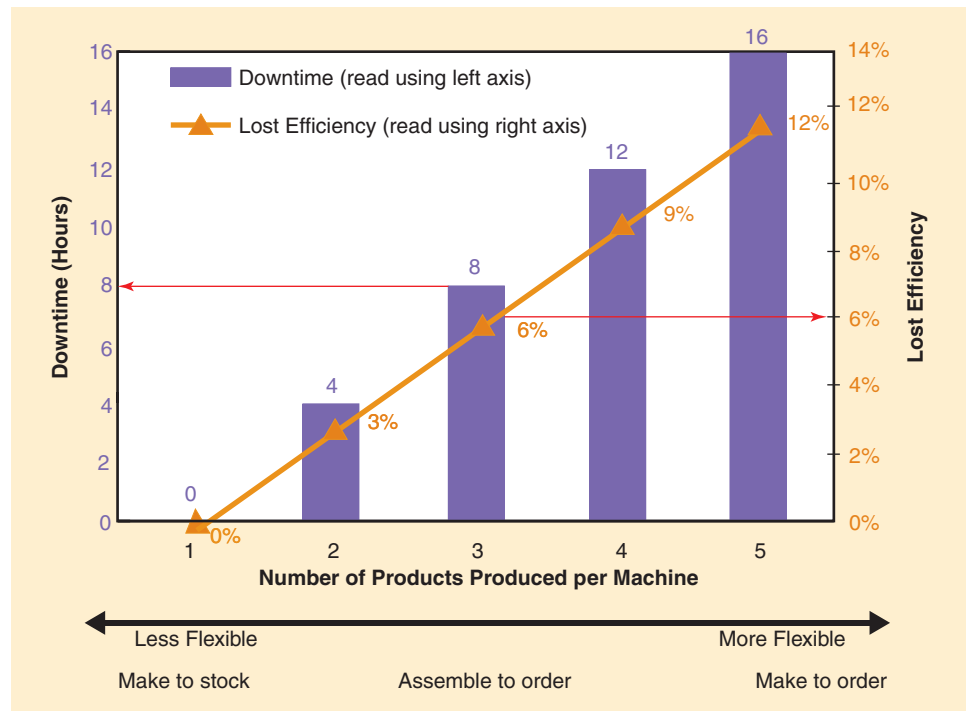
setup cost

The costs of downtime and lost efficiency that occur when a machine is changed or adjusted to produce a different kind of inventory.

holding cost

The cost of keeping inventory until it is used or sold, including storage, insurance, taxes, obsolescence, and opportunity costs.

Exhibit 18.15
Trade-off between Setup Costs and
Manufacturing Flexibility



stockout costs

The costs incurred when a company runs out of a product, including transaction costs to replace inventory and the loss of customers' goodwill.

The 6th installment in the Harry Potter series, *The Half-Blood Prince*, sold a record 6.9 million copies in its first 24 hours—averaging better than 250,000 sales per hour and smashing the record held by the previous Potter release. Scholastic Press issued a first print run of 13.5 million copies in order to avoid stockouts that plagued previous installments, which had much smaller print runs.

Stockout costs are the costs incurred when a company runs out of a product, as happened to Apple when it failed to have enough iPods during the Christmas shopping season. There are two basic kinds of stockout costs. First, the company incurs the transaction costs of overtime work, shipping, and the like in trying to quickly replace out-of-stock inventories with new inventories. The second and perhaps more damaging cost is the loss of customers' goodwill when a company cannot deliver the products that it promised. Stockouts occur more often than you might think. "In the United States, the supermarket industry's average out-of-stock rate (the percentage of items that are unavailable at a given time) is 7.9 percent, according to Market6 [a research firm] figures. More importantly, retailers can increase sales 4 percent if they eliminate their out-of-stocks. Items on promotion run at a much higher out-of-stock rate, 13.1 percent on average. Market6 estimates that in dollar terms, the problem of out-of-stocks in U.S. grocers' top 25 product categories alone amounts to an average of \$200,000 in missed revenue per year, per store."⁷⁷



GETTY IMAGES

5.4 Managing Inventory

Inventory management has two basic goals. The first is to avoid running out of stock and angering and dissatisfying customers. Consequently, this goal seeks to increase inventory levels to a "safe" level that won't risk stockouts. The second is to efficiently reduce inventory levels and costs as much as possible without impairing daily operations. Thus, this goal seeks a minimum level of inventory. The following inventory management techniques—economic order quantity (EOQ), just-in-time inventory (JIT), and materials requirement planning (MRP)—are different ways of balancing these competing goals.

Economic order quantity (EOQ) is a system of formulas that helps determine how much and how often inventory should be ordered. EOQ takes into account the overall demand (D) for a product while trying to minimize ordering costs (O) and holding costs (H). The formula for EOQ is

$$EOQ = \sqrt{\frac{2DO}{4}}$$

For example, if a factory uses 40,000 gallons of paint a year (D), ordering costs (O) are \$75 per order, and holding costs (H) are \$4 per gallon, then the optimal quantity to order is 1,225 gallons:

$$EOQ = \sqrt{\frac{2(40,000)(75)}{4}} = 1,225$$

And, with 40,000 gallons of paint being used per year, the factory uses approximately 110 gallons per day:

$$\frac{40,000 \text{ gallons}}{365 \text{ days}} = 110$$

Consequently, the factory would order 1,225 new gallons of paint approximately every 11 days:

$$\frac{1,225 \text{ gallons}}{110 \text{ gallons per day}} = 11.1 \text{ days}$$

In general, EOQ formulas do a good job of letting managers know what size or amount of inventory they should reorder to minimize ordering and holding costs. However, EOQ formulas and models can become much more complex as adjustments are made for price changes, quantity discounts, setup costs, and many other factors.⁷⁸

While EOQ formulas try to minimize holding and ordering costs, the just-in-time (JIT) approach to inventory management attempts to eliminate holding costs by reducing inventory levels to near zero. With a **just-in-time (JIT) inventory system**, component parts arrive from suppliers just as they are needed at each stage of production. By having parts arrive “just in time,” the manufacturer has little inventory on hand and thus avoids the costs associated with holding inventory. For example, by combining a JIT inventory system with its make-to-order production system, Dell, Inc. turns its inventory more than 500 times a year, as mentioned above. John Egan, who heads Dell’s inventory fulfillment center in Austin, Texas, said this about Dell’s JIT inventory system: “We used to measure our factory inventory in days; but now we manage it in hours. Our suppliers see demand changes every two hours. We try to achieve a perfect balance between [the] parts [that are] needed and what’s [already] here [in the factory].”⁷⁹

To have just the right amount of inventory arrive at just the right time requires a tremendous amount of coordination between manufacturing operations and suppliers. One way to promote tight coordination under JIT is close proximity. Most parts suppliers for Toyota’s JIT system at its Georgetown, Kentucky plant are located within 200 miles of the plant. Furthermore, parts are picked up from suppliers and delivered to Toyota as often as 16 times a day.⁸⁰

A second way to promote close coordination under JIT is to have a shared information system that allows a manufacturer and its suppliers to know the quantity and kinds of parts inventory the other has in stock. Generally, factories and suppliers facilitate information sharing by using the same part numbers and names. Ford’s seat supplier accomplishes this by sticking a bar code on each seat, which Ford then uses to route the seat through its factory.

economic order quantity (EOQ)

A system of formulas that minimizes ordering and holding costs and helps determine how much and how often inventory should be ordered.

just-in-time (JIT) inventory system

An inventory system in which component parts arrive from suppliers just as they are needed at each stage of production.

kanban

A ticket-based JIT system that indicates when to reorder inventory.

Manufacturing operations and their parts suppliers can also facilitate close coordination by using the Japanese system of kanban. **Kanban**, which is Japanese for “sign,” is a simple ticket-based system that indicates when it is time to reorder inventory. Suppliers attach kanban cards to batches of parts. Then, when an assembly-line worker uses the first part out of a batch, the kanban card is removed. The cards are then collected, sorted, and quickly returned to the supplier, who begins resupplying the factory with parts that match the order information on the kanban cards. Glenn Uminger, manager of production control and logistics at Toyota’s Georgetown, Kentucky plant, says, “We are placing orders for new parts as the first part is used out of a box.” And, because prices and batch sizes are typically agreed to ahead of time, kanban tickets greatly reduce paperwork and ordering costs.⁸¹

materials requirement planning (MRP)

A production and inventory system that determines the production schedule, production batch sizes, and inventory needed to complete final products.

A third method for managing inventory is **materials requirement planning (MRP)**. MRP is a production and inventory system that, from beginning to end, precisely determines the production schedule, production batch sizes, and inventories needed to complete final products. The three key parts of MRP systems are the master production schedule, the bill of materials, and inventory records. The *master production schedule* is a detailed schedule that indicates the quantity of each item to be produced, the planned delivery dates for those items, and the time by which each step of the production process must be completed in order to meet those delivery dates. Based on the quantity and kind of products set forth in the master production schedule, the *bill of materials* identifies all the necessary parts and inventory, the quantity or volume of inventory to be ordered, and the order in which the parts and inventory should be assembled. *Inventory records* indicate the kind, quantity, and location of inventory that is on hand or that has been ordered. When inventory records are combined with the bill of materials, the resulting report indicates what to buy, when to buy it, and what it will cost to order. Today, nearly all MRP systems are available in the form of powerful, flexible computer software.⁸²

independent demand system

An inventory system in which the level of one kind of inventory does not depend on another.

Which inventory management system should you use? Economic order quantity (EOQ) formulas are intended for use with **independent demand systems**, in which the level of one kind of inventory does not depend on another. For example, because inventory levels for automobile tires are unrelated to the inventory levels of women’s dresses, Sears could use EOQ formulas to calculate separate optimal order quantities for dresses and tires. By contrast, JIT and MRP are used with **dependent demand systems**, in which the level of inventory depends on the number of finished units to be produced. For example, if Yamaha makes 1,000 motorcycles a day, then it will need 1,000 seats, 1,000 gas tanks, and 2,000 wheels and tires each day. So, when optimal inventory levels depend on the number of products to be produced, use a JIT or MRP management system.

dependent demand system

An inventory system in which the level of inventory depends on the number of finished units to be produced.

Review 5: Inventory

There are four kinds of inventory: raw materials, component parts, work-in-process, and finished goods. Because companies incur ordering, setup, holding, and stockout costs when handling inventory, inventory costs can be enormous. To control those costs, companies measure and track inventory in three ways: average aggregate inventory, weeks of supply, and turnover. Companies meet the basic goals of inventory management (avoiding stockouts and reducing inventory without hurting daily operations) through economic order quantity (EOQ) formulas, just-in-time (JIT) inventory systems, and materials requirement planning (MRP). EOQ formulas minimize holding and ordering costs by determining how much and how often inventory should be ordered. By having parts arrive just when they are needed at each stage of production, JIT systems attempt to minimize inventory levels and holding costs. JIT systems often depend on proximity, shared information, and the Japanese system of kanban.

MRP precisely determines the production schedule, production batch sizes, and the ordering of inventories needed to complete final products. The three key parts of MRP systems are the master production schedule, the bill of materials, and inventory records. Use EOQ formulas when inventory levels are independent, and use JIT and MRP when inventory levels are dependent on the number of products to be produced.

Key Terms

assemble-to-order operation, 597	inventory turnover, 602	ordering cost, 603
average aggregate inventory, 601	ISO 9000, 589	partial productivity, 584
batch production, 599	ISO 14000, 589	productivity, 582
component parts inventories, 600	job shops, 599	project manufacturing, 599
continuous-flow production, 599	just-in-time (JIT) inventory system, 605	quality, 586
continuous improvement, 591	kanban, 606	raw material inventories, 600
customer focus, 591	line-flow production, 599	service recovery, 595
customer satisfaction, 591	make-to-order operation, 597	setup cost, 603
dependent demand systems, 606	make-to-stock operation, 597	stockout, 601
economic order quantity (EOQ), 605	manufacturing flexibility, 598	stockout costs, 604
finished goods inventories, 601	materials requirement planning (MRP), 606	teamwork, 592
holding cost, 603	multifactor productivity, 584	total quality management (TQM), 591
independent demand system, 606	operations management, 582	variation, 592
inventory, 600		work-in-process inventories, 600

Concept Check

1. What is productivity, and why does it matter?
2. Explain the difference between partial productivity and multifactor productivity.
3. How are quality-related characteristics different for products and services?
4. Compare ISO 9000 certification to the Baldrige National Quality Awards.
5. Discuss the elements of total quality management.
6. What role does the service-profit chain play in customer satisfaction and company profitability?
7. Describe two ways to categorize manufacturing operations.
8. What is inventory, and how is it typically measured?
9. Discuss the costs associated with maintaining inventories.
10. List and describe the systems organizations can use to manage their inventory. What factor determines which system should be implemented?

Self-Assessment

HOW TO HANDLE DISGRUNTLED CUSTOMERS

How a company manages its customers is an important indicator of its future success. But managing customers can be as difficult as it is critical. For example, one customer may like to be greeted by an employee and immediately helped upon entering the store. Another

might find this approach a bit aggressive. What is your style? If you were responsible for interacting with customers, which approach would you use? The Self-Assessment Appendix contains a questionnaire about interacting with customers. Flip to page 625 to begin.

Management Decision

MOVING TO A MAKE-TO-ORDER OPERATION

You've never been so energized by a sales pitch in your entire career.⁸³ Consultants from a highly reputable software developer have just given a presentation to your management team on how to integrate your supply chain, which is no mean feat. Your company, Nike, sells multiple variations of 120,000 products in four sales cycles throughout the year. Anything that can help you get this process under control is welcome. The only problem with the consultants' presentation is their underlying assumption: Nike should move from a make-to-stock operation to a make-to-order operation. That is, the consultant wants Nike to only begin making shoes after a retailer sends in an order.

In the \$16 billion U.S. running shoe market, Nike commands a full 39 percent market share, much larger than that of any other athletic shoe company. Your closest competitor, Reebok, is at a significantly lower 14 percent. Nike grew to that stature by creating a supply chain for the fragmented running shoe market of the 1970s. Nike guaranteed delivery and an inflation-proof discount in return for getting orders six months in advance. Retailers went along happily because runners typically didn't care what the shoes looked like as long as they were technically advanced. Because Nike shoes functioned impeccably, they became the standard.

After over two decades of astronomical growth, however, Nike is suffering from its own fragmentation. The company has 27 order management systems around the globe and uses tens of millions of product numbers (think number of models times available sizes). Even though the sales cycle is six months, the design and production cycle is nine months, so to meet sales deadlines, the company is building and holding a small fortune in inventory (think number of models times available sizes times cost per pair). Furthermore, today's customers want style, not just technically sophisticated shoes, and style changes a lot faster now than it did in the 1970s.

Nike's extensive inventory, which was previously a strength, is becoming a weakness, as the risks of finished inventories becoming outdated are increasing sharply.

That's why you welcomed the consultants' initial recommendations to switch to make-to-order system. But you don't want to rush headlong into such a major change based only on the recommendation of outside consultants. After all, they're trying to sell you \$400 million in software, and you have an \$11 billion business on the line.

Questions

1. What issues do you need to consider as you make this decision? If you are overwhelmed thinking of a mammoth company like Nike, keep in mind that companies much smaller than Nike wrestle with this basic operations dilemma as well.
2. Do you invest in the \$400 million software and commit to changing your manufacturing process from a make-to-stock to a make-to-order operation? (At this point, you are only considering make-to-order processing for retailers. That is, Nike wouldn't begin making shoes until a retailer, like FootLocker, actually ordered them.) Explain your rationale.
3. How would changing to make-to-order processing for retailers affect how Nike manages its inventory? Address all aspects of managing inventory.
4. The more you reflect on the sales proposal, the more you wonder why Nike would stop at make-to-order processing for retailers. Why not go all the way and do a make to order system for the consumer? Is that even feasible? Explain.
5. Think about the price of athletic shoes. If Nike began manufacturing customized products for consumers, how would you expect the changes in manufacturing operations, manufacturing flexibility, and inventory to affect the cost and final price of a pair of Nikes? Why?

Management Team Decision

RECOVERY PLAN

As you read in Chapter 5 (Planning and Decision Making), crisis management planning is an important component of business planning and corporate communication.⁸⁴ Typically, when you hear “crisis management,” you think of a company responding to catastrophic publicity, but companies also need to think about managing smaller negative encounters because those encounters play a large role in customer retention. The retention rate for customers whose complaints or problems are resolved satisfactorily is 70 percent; when complaints are resolved quickly as well—typically on the spot—the retention rate soars to 95 percent. But when complaints are not resolved to the customer’s satisfaction, customer retention falls to 46 percent. And research shows that for major purchases (defined as being over \$100), customers whose complaints are unresolved stay with the company only 19 percent of the time. So, companies should have a plan for responding to customers’ complaints and problems. Putting service recovery plans in place enables companies to respond quickly, the biggest factor in reversing the damage from negative customer experiences.

In the spa industry, customer service and satisfaction are paramount. Not only do customers have high expectations for spa and salon services such as massage, skin treatments, nail treatments, and hair coloring and cutting, but spa service tabs can quickly surpass that \$100 threshold defining major purchases. And what will upset a customer more than a horrendous haircut, botched fingernails, or blotchy skin?

For this exercise, assemble four to five students to act as the management team for a local salon and day

spa that is getting ready to expand into several new neighborhoods by adding four local salons. Your salon has always had a high reputation for service, but as you expand, your experienced staff will be spread thin. In the next month, your team plans to hire and train 25 new cosmetologists and estheticians (skin care providers). To ensure that the new stores are successful, your team has decided to map out very clear service recovery procedures. After all, during the training periods and the first few months the new stores are open, mistakes are bound to happen. How you respond to them will mean the difference between a successful expansion and possible bankruptcy.

Questions

1. As a team, brainstorm a list of service failures that could occur in a salon and day spa. (The examples of a bad haircut, damaged nails, and blotchy skin were mentioned above but there are many more possibilities.) Then, identify ways that you can resolve each problem on the list quickly and to the customer’s satisfaction.
2. There are bound to be situations that you haven’t planned for. How will you instruct your employees to handle unanticipated problems?
3. How can a complaint-response system be considered part of delivering quality service?
4. What kind of metric(s) can you create to measure the quality of your service delivery? Manufacturing companies typically measure things like on-time delivery, defects per million, production rate (how many pieces per hour), and so forth. What can a spa measure to keep its service operation in control?

Developing Your Career Potential

TAKE A FACTORY TOUR

Imagine that you arrive back at your dorm room one afternoon to find your roommate watching a *Mister Rogers* rerun. When asked why, your roommate replies, “Management homework.” That may not be as crazy as it sounds. Fred Rogers may well hold the record for factory tours. During his long career, he broadcast footage to millions of children showing how Cheerios,

plastic drinking straws, raincoats, pasta, blue jeans, spoons, and a host of other products are made. He was even at Crayola when the one-billionth crayon rolled off the production line. (He also broadcast footage of how Crayola crayons are made and packaged.)

Today, John Ratzenberger (best known for his role as Cliff Claven on *Cheers* and the voice of the piggy bank in *Toy Story*, among other things) hosts a cable

television program titled *Made in America* that features nothing but factory tours around the United States. The Food Network also broadcasts a program that describes how all kinds of food products are manufactured. Beyond the world of television, however, each year thousands of people visit corporate facilities like these:

- The Boeing Everett Tour Center outside Seattle introduces visitors to how Boeing makes its 747, 767, and 777 passenger jets.
- Steinway & Sons in Queens, New York, offers a two-and-a-half-hour tour that is like a master class. Each Steinway piano takes about a year to build, so you will be able to see pianos at every stage of the production process.
- Ben & Jerry's in Waterbury, Vermont, offers tours accompanied with a scoop of whatever flavor ice cream was made that day.
- Tabasco Factory on Avery Island, Louisiana, is part factory tour, part nature preserve. You can see how the pepper sauce is aged in oak barrels and then step outside to see Bird City, a special structure devised by E. A. McIlhenny to provide a sanctuary for snowy egrets.
- Mack Truck has an assembly plant in Macungie, Pennsylvania. The production line is a mile and a half long, so wear comfortable shoes!
- Yuengling Brewery (which you read about at the beginning of Chapter 5) in Pottsville, Pennsylvania, also offers tours, which include a trip to the cave where the nation's oldest brewery used to age its beer.
- Louisville Slugger in Louisville, Kentucky (where else?), offers a factory tour at the end of which you receive a miniature Slugger bat to take home.
- Harley-Davidson plants in Milwaukee, Kansas City, and York, Pennsylvania, offer factory tours for teens and adults.
- Carousel Magic in Mansfield, Ohio, is one of the few remaining carousel horse manufacturers and restorers.

Many companies no longer open their factories for tours. Kellogg's in Battle Creek, Michigan, ceased giving factory tours in 1986, but now the company operates a museum/activity center called Cereal City. Other companies say they offer factory tours, but in reality the tour is just a marketing device. Budweiser in St. Louis has an enormous visitor center for its tours, but you won't be able to see any of the actual production—just videos and the various outbuildings on the Anheuser-Busch campus. Still other companies offer virtual tours of their operations. Just Born, maker of Marshmallow Peeps, Mike & Ikes, and Hot Tamales, offers a static tour of the Peep production line at <http://www.marshmallowpeep.com>. Hershey Foods also has an online tour at <http://www.hersheys.com/kidztown/factorytour.shtml>.⁸⁵

Your assignment is to take a factory tour. Use the Web or other resources to locate a factory tour near you. The site <http://www.factorytoursusa.com> organizes tours by state, so locating something interesting is easy.

Questions

1. What steps or procedures does the company take to ensure the quality of its products?
2. How does the company measure productivity, and how does its productivity compare to others in the industry?
3. Using the vocabulary from the chapter, describe the basic steps used to make the finished products in this factory.
4. What did you find most impressive about this company or its manufacturing processes? Based on what you read in the chapter, describe one thing the company could do differently to improve quality, increase productivity, or reduce inventory.



Biz Flix *Casino*

Martin Scorsese's lengthy, complex, and beautifully filmed *Casino* offers a close look at the gambling casinos of Las Vegas and their organized crime connections in the 1970s. It completes his trilogy that began with *Mean Streets* (1973) and continued with *Goodfellas* (1990).⁸⁶ In *Casino*, ambition, greed, drugs, and sex ultimately destroy the mob's gambling empire. The film includes strong performances by Robert De Niro, Joe Pesci, and Sharon Stone. The violence and expletive-filled dialogue give *Casino* an R rating.

This scene, which comes from the beginning of "The Truth about Las Vegas" sequence, opens the film and establishes important background about casino operations. Listen carefully to Sam Rothstein's (De Niro) voice-over. He quickly describes the casino's operation and explains how it tries to reach its goals.

What to Watch for and Ask Yourself

1. What type of operations management does this scene show—manufacturing operations management or service operations management?
2. Are the customers directly involved in this operation? If they are, in what way? What likely effects does their involvement have on the casino's operation and its management?
3. Does the casino have independent or interdependent demand systems?



Management Workplace Texas Nameplate

Winning the Baldrige Award is a tremendous feat. Texas Nameplate did it twice. Facing environmental cleanup lawsuits, razor-thin margins, and the likely loss of a key account, Dale Crownover figured his company had nothing to lose by trying to win the National Quality Award. The simple act of applying for the award started Texas Nameplate down a path to profitability unprecedented in the company's history.

What to Watch for and Ask Yourself

1. What effect has improved quality had on Texas Nameplate?
2. Describe how Texas Nameplate uses total quality management.
3. What kind of manufacturing operation is Texas Nameplate?

Take
Two