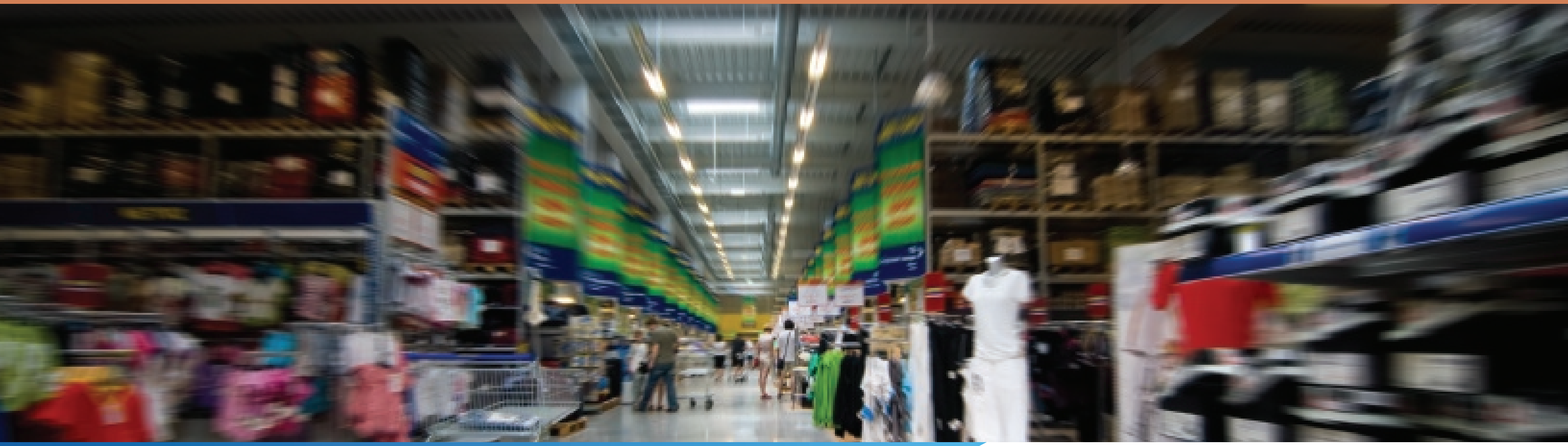

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CHAPTER
one

Introduction to Operations and Supply Chain Management

CHAPTER OUTLINE

CHAPTER OBJECTIVES

By the end of this chapter, you will be able to:

- Describe what the operations function is and why it is critical to an organization's survival.
- Describe what a supply chain is and how it relates to a particular organization's operations function.
- Discuss what is meant by operations management and supply chain management.
- Identify some of the major operations and supply chain activities, as well as career opportunities in these areas.
- Make a case for studying *both* operations management and supply chain management.

INTRODUCTION

Let's start with a question: What do the following organizations have in common?

- **Walmart,** which not only is a leading retailer in the United States but also has built a network of world-class suppliers, such as GlaxoSmithKline, Sony, and Mattel
- **FedEx,** a service firm that provides supply chain solutions and transportation services
- **Flex Ltd.,** a contract manufacturer that assembles everything from plug-in electric motorcycles to LCD and touch displays
- **SAP,** the world's largest provider of enterprise resource planning (ERP) software

While these firms may appear to be very different from one another, they have at least one thing in common: a strong commitment to superior operations and supply chain management.

In this chapter, we kick off our study of operations and supply chain management. We begin by examining what operations is all about and how the operations of an individual organization fit within a larger supply chain. We then talk about what it means to *manage* operations and supply chains. As part of this discussion, we will introduce you to the Supply Chain Operations Reference (SCOR) model, which many businesses use to understand and structure their supply chains.

In the second half of the chapter, we discuss several trends in business that have brought operations and supply chain management to the forefront of managerial thinking. We also devote a section to what this all means to you. We discuss career opportunities in the field, highlight some of the major professional organizations that serve operations and supply chain professionals, and look at some of the major activities that operations and supply chain professionals are involved in on a regular basis. We end the chapter by providing a roadmap of this book.

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Operations management and supply chain management cover a wide range of activities, including transportation services, manufacturing operations, retailing, and consulting.

1.1 WHY STUDY OPERATIONS AND SUPPLY CHAIN MANAGEMENT?

So, why should you be interested in operations and supply chain management? There are three simple reasons.

1. ***Every organization must make a product or provide a service that someone values.*** Otherwise, why would the organization exist? Think about it. Manufacturers produce physical goods that are used directly by consumers or other businesses. Transportation companies provide valuable services by moving and storing these goods. Design firms use their expertise to create products or even corporate images for customers. Software firms develop apps that consumers use on their smartphones. The need to provide a valuable product or service holds true for not-for-profit organizations as well. Consider the variety of needs met by government agencies, charities, and religious groups, for example.

   The common thread is that each organization has an operations function, or *operations*, for short. The **operations function** is the collection of people, technology, and systems within an organization that has primary responsibility for providing the organization's products or services. Regardless of what career path you might choose, you will need to know something about your organization's operations function.

   Operations function
   Also called *operations*. The collection of people, technology, and systems within an organization that has primary responsibility for providing the organization's products or services.

   As important as the operations function is to a firm, few organizations can—or even want to—do everything themselves. This leads to our second reason for studying operations and supply chain management.

2. ***Most organizations function as part of larger supply chains.*** A **supply chain** is a network of manufacturers and service providers that work together to create products or services needed by end users. These manufacturers and service providers are linked together through physical flows, information flows, and monetary flows. When the primary focus is on physical goods, much of the supply chain activity will revolve around the conversion, storage, and movement of materials and products. In other cases, the focus might be on providing an intangible service. For example, automobile insurance companies like Progressive Insurance depend on cellular phone networks and Internet service providers (ISPs) to support the data flows that allow customers to upload photos of accident damage and receive settlement checks electronically.

   Supply chain
   A network of manufacturers and service providers that work together to create products or services needed by end users. These manufacturers and service providers are linked together through physical flows, information flows, and monetary flows.

   Supply chains link together the operations functions of many different organizations to provide real value to customers. Consider a sporting goods store that sells athletic shoes. Although the store doesn't actually make the shoes, it provides valuable services for its customers—a convenient location and a wide selection of products. Yet, the store is only one link in a much larger supply chain that includes:

   - Plastic and rubber producers that provide raw materials for the shoes.
   - Manufacturers that mold and assemble the shoes.
   - Wholesalers that decide what shoes to buy and when.
   - Transportation firms that move the materials and finished shoes to all parts of the world.
   - Software firms and ISPs that support the information systems that coordinate these physical flows.
   - Financial firms that help distribute funds throughout the supply chain, ensuring that the manufacturers and service firms are rewarded for their efforts.

   So where does this lead us? To our third reason for studying operations and supply chain management—and the premise for this book.

3. ***Organizations must carefully manage their operations and supply chains in order to prosper and, indeed, survive.*** Returning to our example, think about the types of decisions facing a shoe manufacturer. Some fundamental operations decisions that it must make include the following: "How many shoes should we make, and in what styles and sizes?" "What kind of people skills and equipment do we need?" "Should we locate our

Dmitri Ma/Shutterstock

Athletic shoes at a retailer represent the last stage in a supply chain that crosses the globe and involves many different companies.

plants to take advantage of low-cost labor or to minimize shipping cost and time for the finished shoes?"

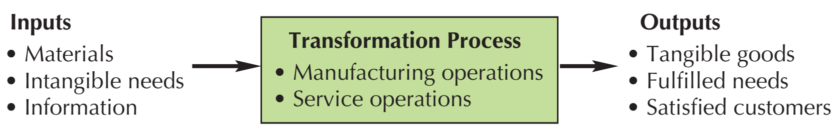
In addition to these operations issues, the shoe manufacturer faces many decisions with regard to its role in the supply chain: "From whom should we buy our materials—the lower-cost supplier or the higher-quality one?" "Which transportation carriers will we use to ship our shoes?" The right choices can lead to higher profitability and increased market share, while the wrong choices can cost the company dearly—or even put it out of business.

Operations Management

Let's begin our detailed discussion of operations and supply chain management by describing operations a little more fully and explaining what we mean by operations management. As we noted earlier, all organizations must make products or provide services that someone values, and the operations function has the primary responsibility for making sure this happens.

One way to think about operations is as a *transformation process* that takes a set of inputs and transforms them in some way to create outputs—either goods or services—that a customer values (Figure 1.1). Consider a plant that makes wood furniture. Even for a product as simple as a chair, the range of activities that must occur to transform raw lumber into a finished chair can be overwhelming at first. Raw lumber arrives as an input to the plant, perhaps by truck or even train car. The wood is then unloaded and moved onto the plant floor. Planing machines cut the

FIGURE 1.1
Viewing Operations as a Transformation Process



Goodluz/Shutterstock

Health care services use highly skilled individuals as well as specialized equipment to provide physiological transformation processes for their patients.

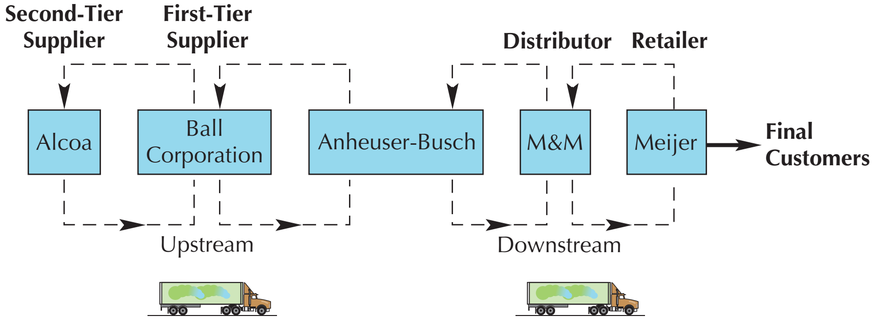
lumber to the right thickness. Lathes shape pieces of wood into legs and back spindles for the chairs. Other machines fabricate wood blanks, shaping them into seats and boring holes for the legs and back spindles.

In addition to the equipment, there are people who run and load the machines, conveyors, and forklifts that move materials around the plant, and there are other people who assemble the chairs. Once the chairs are finished, still more people pack and move the chairs into a finished goods warehouse or onto trucks to be delivered to customers. In the background, supervisors and managers use information systems to plan what activities will take place next.

The operations function can also provide intangible services, as in the case of a law firm. A major input, for example, might be the need for legal advice—hardly something you can put your hands around. The law firm, through the skill and knowledge of its lawyers and other personnel, transforms this input into valuable legal advice, thereby fulfilling the customer's needs. How well the law firm accomplishes this transformation goes a long way in determining its success.

Figure 1.1 makes several other points. First, inputs to operations can come from many places and take many different forms. They can include raw materials, intangible needs, and even information, such as demand forecasts. Also, operations are often highly dependent on the quality and availability of inputs. Consider our furniture plant again. If the lumber delivered to it is of poor quality or arrives late, management might have to shut down production. In contrast, a steady stream of good-quality lumber can ensure high production levels and superior products. Second, nearly all operations activities require coordination with other business functions, including engineering, marketing, and human resources. We will revisit the importance of cross-functional decision making in operations throughout the book. Third, operations management activities are information and decision intensive. You do not have to be able to assemble a product or treat a patient yourself to be a successful operations manager—but you *do* have to make sure the right people and equipment are available to do the job, the right materials arrive when needed, and the product or service is completed on time, at cost, and to specifications!

FIGURE 1.2
A Simplified View of Anheuser-Busch's Supply Chain



Operations management
"The planning, scheduling, and control of the activities that transform inputs into finished goods and services."

Operations management, then, is "the planning, scheduling, and control of the activities that transform inputs into finished goods and services."[1] Operations management decisions can range from long-term, fundamental decisions about what products or services will be offered and what the transformation process will look like to more immediate issues, such as determining the best way to fill a current customer request. Through sound operations management, organizations hope to provide the best value to their customers while making the best use of resources.

Supply Chain Management

Upstream
A term used to describe activities or firms that are positioned *earlier* in the supply chain relative to some other activity or firm of interest. For example, corn harvesting takes place upstream of cereal processing, and cereal processing takes place upstream of cereal packaging.

Downstream
A term used to describe activities or firms that are positioned *later* in the supply chain relative to some other activity or firm of interest. For example, sewing a shirt takes place downstream of weaving the fabric, and weaving the fabric takes place downstream of harvesting the cotton.

First-tier supplier
A supplier that provides products or services directly to a firm.

Second-tier supplier
A supplier that provides products or services to a firm's first-tier supplier.

The traditional view of operations management illustrated in Figure 1.1 still puts most of the emphasis on the activities a particular organization must perform when managing its own operations. But, as important as a company's operations function is, it is not enough for a company to focus on doing the right things within its own four walls. Managers must also understand how the company is linked in with the operations of its suppliers, distributors, and customers—what we refer to as the supply chain.

As we noted earlier, organizations in the supply chain are linked together through physical flows, information flows, and monetary flows. These flows go both up and down the chain. Let's extend our discussion and vocabulary using a product many people are familiar with: a six-pack of beer. Figure 1.2 shows a simplified supply chain for Anheuser-Busch. From Anheuser-Busch's perspective, the firms whose inputs feed into its operations are positioned **upstream,** while those firms who take Anheuser-Busch's products and move them along to the final consumer are positioned **downstream.**

When the typical customer goes to the store to buy a six-pack, he or she probably does not consider all of the steps that must occur beforehand. Take cans, for example. Alcoa extracts the aluminum from the ground and ships it to Ball Corporation, which converts the aluminum into cans for Anheuser-Busch. In the supply chain lexicon, Ball Corporation is a **first-tier supplier** to Anheuser-Busch because it supplies materials directly to the brewer. By the same logic, Alcoa is a **second-tier supplier;** it provides goods to the first-tier supplier.

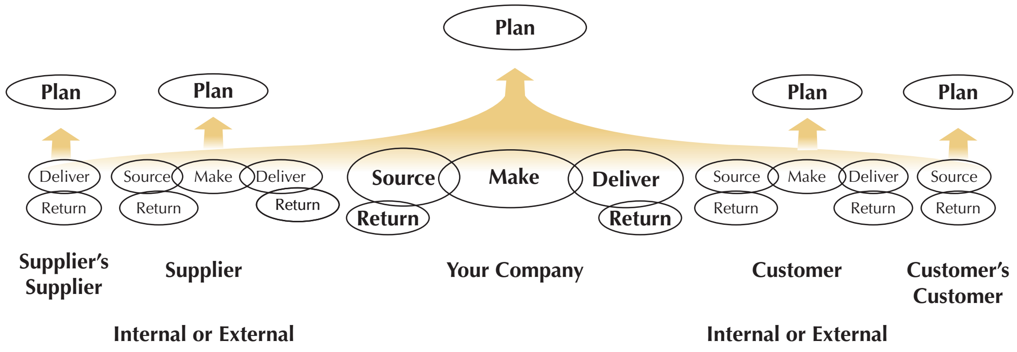
The cans from Ball Corporation are combined with other raw materials, such as cartons, grain, hops, yeast, and water, to produce the packaged beverage. Anheuser-Busch then sells the packaged beverage to M&M, a wholesaler that, in turn, distributes the finished good to Meijer, the retailer. Of course, we cannot forget the role of transportation carriers, which carry the inputs and outputs from one place to the next along the supply chain.

As Figure 1.2 suggests, the flow of goods and information goes both ways. For instance, Ball Corporation might place an order (information) with Alcoa, which, in turn, ships aluminum (product) to Ball. Anheuser-Busch might even return empty pallets or containers to its first-tier suppliers, resulting in a flow of physical goods back *up* the supply chain.

Of course, there are many more participants in the supply chain than the ones shown here; Anheuser-Busch has hundreds of suppliers, and the number of retailers is even higher. We could also diagram the supply chain from the perspective of Alcoa, M&M, or any of the other

[1]J. H. Blackstone, ed., *APICS Dictionary*, 15th ed. (Chicago, IL: APICS, 2016).

FIGURE 1.3
The Supply Chain Operations Reference (SCOR) Model



participants. The point is that most of the participants in a supply chain are both customers and suppliers. Finally, the supply chain must be very efficient, as the final price of the good must cover all of the costs involved plus a profit for each participant in the chain.

While you were reading through the above example, you might have thought to yourself, "Supply chains aren't new"—and you'd be right. Yet most organizations historically performed their activities independently of other firms in the chain, which made for disjointed and often inefficient supply chains. In contrast, **supply chain management** is the *active* management of supply chain activities and relationships in order to maximize customer value and achieve a sustainable competitive advantage. It represents a conscious effort by a firm or group of firms to develop and run supply chains in the most effective and efficient ways possible.

Supply chain management
The *active* management of supply chain activities and relationships in order to maximize customer value and achieve a sustainable competitive advantage. It represents a conscious effort by a firm or group of firms to develop and run supply chains in the most effective and efficient ways possible.

But what exactly *are* these supply chain activities? To answer this, we turn to the **Supply Chain Operations Reference (SCOR) model.** The SCOR model is a framework that seeks to provide standard descriptions of the processes, relationships, and metrics that define supply chain management.[2] We will explore the SCOR model in more detail in Chapter 4, but for now, Figure 1.3 provides a high-level view of the framework. According to the SCOR model, supply chain management covers five broad areas:

Supply Chain Operations Reference (SCOR) model
A framework developed and supported by the Supply Chain Council that seeks to provide standard descriptions of the processes, relationships, and metrics that define supply chain management.

1. *Planning activities,* which seek to balance demand requirements against resources and communicate these plans to the various participants.
2. *Sourcing activities,* which include identifying, developing, and contracting with suppliers and scheduling the delivery of incoming goods and services.
3. *"Make," or production, activities,* which cover the actual production of a good or service.
4. *Delivery activities,* which include everything from entering customer orders and determining delivery dates to storing and moving goods to their final destination.
5. *Return activities,* which include the activities necessary to return and process defective or excess products or materials.

Finally, notice that Figure 1.3 shows the supply chain management task extending from the company's suppliers' suppliers, all the way to the customers' customers. As you can imagine, coordinating the activities of all these parties is challenging.

To illustrate, let's consider Walmart, one of the earliest proponents of supply chain management.[3] What Walmart was doing in the late 1980s and early 1990s was nothing short of revolutionary. Individual stores sent daily sales information to Walmart's suppliers via satellite. These suppliers then used the information to plan production and ship orders to Walmart's warehouses. Walmart used a dedicated fleet of trucks to ship goods from warehouses to stores in less than 48 hours and to replenish store inventories about twice a week. The result was better customer service (because products were nearly always available), lower production and transportation costs (because suppliers made and shipped only what was

[2]SCOR Framework, **www.apics.org/apics-for-business/products-and-services/apics-scc-frameworks/scor.**
[3]G. Stalk, P. Evans, and L. E. Shulman, "Competing on Capabilities: The New Rules of Corporate Strategy," *Harvard Business Review* 70, no. 2 (March–April 1992): 57–69.

Walmart was an early proponent of superior supply chain performance. Other companies have now adopted many of the practices Walmart pioneered in the 1980s.

needed), and better use of retail store space (because stores did not have to hold an excessive amount of inventory).

Walmart has continued to succeed through superior sourcing and delivery, and many of the practices it helped pioneer have taken root throughout the business world. In fact, many retailers now make *multiple* shipments to stores each day, based on *continuous* sales updates. To illustrate how widespread supply chain management thinking has become, consider the example of Panera Bread in the *Supply Chain Connections* feature.

Supply chain management efforts can range from an individual firm taking steps to improve the flow of information between itself and its supply chain partners to a large trade organization looking for ways to standardize transportation and billing practices. In the case of Walmart, a single, very powerful firm took primary responsibility for improving performance across its own supply chain. As an alternative, companies within an industry often form councils or groups to identify and adopt supply chain practices that will benefit all firms in the industry. One such group is the Automotive Industry Action Group (AIAG, **www.aiag.org**), whose members "work collaboratively to streamline industry processes via global standards development & harmonized business practices."[4] The Grocery Manufacturers of America (GMA, **www.gmaonline.org/**) serves a similar function. Other organizations, such as APICS (**www.apics.org/apics-for-business**), seek to improve supply chain performance across many industries.

[4]Automotive Industry Action Group (AIAG), **www.aiag.org/about.**

SUPPLY CHAIN CONNECTIONS

PANERA BREAD: "A LOAF OF BREAD IN EVERY ARM"

If you live in the United States or Canada, there is a good chance that you have either heard of or visited a Panera Bread bakery-cafe. Panera Bread is a specialty food retailer that has built its business on providing consumers with fresh artisan bread products served at strategically located, distinctive bakery-cafes. As of December 2016, Panera Bread had over 2,100 company- and franchise-operated bakery-cafes.[5] Financial results have been equally impressive: for 2015, revenues from $2.68 billion, with an operating profit of over $240 million.[6]

But consider for a moment the upstream supply chain activities that must take place to ensure that these bakery-cafes receive the fresh dough needed to fulfill the company's mission statement, "A loaf of bread in every arm." In the case of Panera Bread, the operations and supply chain team has responded by putting in place a network of 24 fresh dough manufacturing facilities that produce more than 300 million pounds of dough annually. To ensure the freshest product possible, this dough is delivered 7 days a week, 365 days a year, to the bakery-cafes. Panera's operations and supply chain team also controls the distribution system for the retail bakery-cafes and supports the company's baking activities. In effect, the team is responsible for everything that comes through the back doors of Panera Bread bakery-cafes.

Even in this short description, we can see how Panera Bread's supply chain activities cover everything from sourcing to production to delivery. It's a safe bet that Panera Bread's interest in effective supply chain management will continue to "rise" along with its products.

Judith Collins/Alamy Stock Photo

[5]Reuters, Profile: Panera Bread (PNRA.O), **www.reuters.com/finance/stocks/companyProfile?symbol=PNRA.O**, April 6, 2017.

[6]Panera Bread Company, 2015 Annual Report to Stockholders, **www.panerabread.com/content/dam/panerabread/documents/financial/2016/pbc-annual-report-2015.pdf.**

1.2 IMPORTANT TRENDS

As we shall see, operations management and supply chain management are as much philosophical approaches to business as they are bodies of tools and techniques, and thus they require a great deal of interaction and trust between companies. For right now, however, let's talk about three enduring trends that will continue to attract the attention of operations and supply chain management professionals for the foreseeable future:

- Agility
- Information technologies
- People

Agility

Agility
The ability to recalculate plans in the face of market, demand, and supply volatility and deliver the same or comparable cost, quality, and customer service.

As customers become more demanding and globalization expands the number of competitors in any marketplace, many businesses have found it increasingly important to develop agile operations and supply chains. *Supply Chain Insights* defines **agility** as "the ability to recalculate plans in the face of market, demand and supply volatility and deliver the same or comparable cost, quality and customer service."[7]

For example, in the past it might have taken *months* for a manufacturer to increase or decrease production levels in response to market demands. This is no longer a viable option—today's customers will not wait months for products when demand is going up, and investors will not tolerate excess inventories when demand is going down.

Of course, quickly adjusting production levels is just one example of agility. Agility can also include the ability to quickly respond to interruptions in the supply chain, reconfigure the supply chain to include new partners, or even the ability to launch new products and services based on changing market conditions, all while simultaneously minimizing negative impacts on operational and financial performance. Agility depends in large part on sophisticated information technologies that give a firm "visibility" into how operations and supply chains are performing, as well as supply chain professionals who know how to use these systems, two trends we discuss next.

Information Technologies

Electronic commerce
Also called *e-commerce*. "The use of computer and telecommunications technologies to conduct business via electronic transfer of data and documents."

Over the past 25 years, no area has had a greater impact on business than information technology, most notably the Internet and electronic commerce. **Electronic commerce,** or e-commerce for short, refers to "the use of computer and telecommunications technologies to conduct business via electronic transfer of data and documents."[8] Progressive Insurance, which we mentioned earlier, is just one example of a company that has built its business around e-commerce. Another is Netflix, which first used the Internet and advanced software applications to help subscribers order DVDs but now uses the Internet to stream content to its customers.

As you will see in the chapters that follow, information technology affects everything from the execution of day-to-day operations activities to the development of long-term plans. For example, in the opening case study for Chapter 5, we discuss how Delta Air Lines is using radio frequency identification (RFID) to precisely track the location of millions of bags in real time. At the other extreme, companies are using sophisticated decision support systems to develop long-term business plans. We explore the operations and supply chain impacts of information technology—including such topics as cloud computing and the Internet of Things (IoT)—in more detail in the Chapter 12 supplement.

People

The last trend concerns people; specifically, the current shortage of talented operations and supply chain professionals and the importance of relationship management. With regard to the talent shortage, Sue Doerfler from *Inside Supply Management* puts it this way, "Unlike agility with its growth potential, the talent shortage presents more of a dilemma going forward for the supply management profession. There is a diminishing senior leadership labor pool as baby boomers reach retirement. Conjointly, a new talent shortage predicament is emerging as the profession becomes more technological."[9]

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[7]Supply Chain Insights LLC Research Report, "How S&OP Drives Agility," March–April 2012, **http://supplychaininsights.com/research-reports/agility-report/.**

[8]Blackstone, *APICS Dictionary*.

[9]S. Doerfler, "Now Trending!," *Inside Supply Management*, November–December 2016, 16–19, **http://magazine.ism.ws/wp-content/uploads/2016/12/16-19-now-trending.**

But agility, information technology, and a talented pool of professionals are not enough to guarantee a firm's success. Any efforts to improve operations and supply chain performance are likely to be inconsequential without the cooperation of other firms. As a result, more companies are putting an emphasis on relationship management.

Of all the activities operations and supply chain personnel perform, relationship management is perhaps the most difficult and therefore the most susceptible to breakdown. Poor relationships within any link of the supply chain can have disastrous consequences for all other supply chain members. For example, an unreliable supplier can "starve" a plant, leading to inflated lead times and resulting in problems across the chain, all the way to the final customer.

To avoid such problems, organizations must manage the relationships with their upstream suppliers as well as their downstream customers. This can be quite difficult when supply chain partners are geographically distant or when there are cultural differences. In the case of high-tech firms, many components can be purchased only from foreign suppliers who are proprietary owners of the required technology. In such environments, it becomes more important to choose a few, select suppliers, thereby paving the way for informal interaction and information sharing. We will discuss the challenges of relationship management more in Chapter 7.

1.3 OPERATIONS AND SUPPLY CHAIN MANAGEMENT AND YOU

At this point, you might be asking yourself, "If I choose to work in operations or supply chain management, where am I likely to end up?" The answer: Anywhere you like! As the Professional Profiles for Mandy Althoff and Stuart Williams show, operations and supply chain professionals are found in virtually every business sector.

Salaries and placement opportunities for operations and supply chain personnel also tend to be highly competitive, reflecting the important and challenging nature of the work, as well as the relative scarcity of qualified individuals. In fact, each year the Institute for Supply Management (ISM) publishes a salary survey broken down by job position, work experience, and education level.[10]

You also might be asking yourself, "What would my career path look like?" Many operations and supply chain managers find that over their career, they work in many different areas. Table 1.1 lists just a few of the possibilities.

TABLE 1.1
Potential Career Paths in Operations and Supply Chain Management

Analyst	Uses analytical and quantitative methods to understand, predict, and improve processes within the supply chain.
Production manager	Plans and controls production in a manufacturing setting. Responsible for a wide range of personnel.
Service manager	Plans and directs customer service teams to meet the needs of customers and support company operations.
Sourcing manager	Identifies global sources of materials, selects suppliers, arranges contracts, and manages ongoing relationships.
Commodity manager	Acquires knowledge in a specific market in which the organization purchases significant quantities of materials and services. Helps formulate long-term commodity strategies and manage long-term relationships with selected suppliers.
Supplier development manager	Measures supplier performance, identifies suppliers requiring improvement, and facilitates efforts to improve suppliers' processes.
International logistics manager	Works closely with manufacturing, marketing, and purchasing to create timely, cost-effective import/export supply chains.
Transportation manager	Manages private, third-party, and contract carriage systems to ensure timely and cost-efficient transportation of all incoming and outgoing shipments.

[10]ISM's 2016 Salary Survey, **http://magazine.ism.ws/wp-content/uploads/2016/12/16-23-Salary-Survey-May16.pdf.**

PROFESSIONAL PROFILE

MANDY ALTHOFF, METLIFE

MetLife is a well-respected financial services company that provides life insurance, annuities, employee benefits, and asset management services. Whenever MetLife issues an insurance policy, it takes on some financial risk in exchange for the premiums paid by the customer. Sound business practice and regulatory requirements dictate that MetLife keep enough cash reserves to pay off expected claims by the customers. In some instances, it makes good business sense for MetLife to outsource bundles of existing policies to another insurance company who "reinsures" the policies and takes the financial risk, while MetLife, in some cases, continues to provide service support to the customers.

Reaching an outsourcing agreement that is a win-win-win for MetLife, the reinsurer, and the final customer is a complicated task. While actuaries and underwriters perform much of the financial analysis, someone has to help manage the actual negotiation process (see Chapter 7). Enter Mandy Althoff, a Senior Sourcing Consultant at MetLife. As Mandy puts it, "The idea of having someone from sourcing involved in helping arrange these outsourcing agreements is relatively new—these agreements used to be purely finance driven." Mandy continues: "The business leadership team has been open to my creative approach to negotiation, allowing me a unique seat at the table. It all goes back to my undergraduate sourcing class."

Photo courtesy of Mandy Althoff

Professional Organizations

If you decide to pursue a career in operations or supply chain management, you will find a number of professional organizations willing to help you. These organizations have certification programs that establish an individual as a professional within his or her particular area. Most organizations also have regular meetings at the local level, as well as national and international meetings once or twice a year. We highlight some of these organizations here.

APICS—APICS (**www.apics.org**) describes itself as "The Association for Operations Management." It is a widely recognized professional society for persons interested in operations and supply chain management. APICS currently has more than 67,000 members and 250 chapters throughout the United States and its territories.

ISM—The Institute for Supply Management (ISM, **www.ism.ws**) provides national and international leadership in purchasing and materials management, particularly in

PROFESSIONAL PROFILE

STUART WILLIAMS, MARSH FURNITURE COMPANY

Stuart Williams has had an interesting career path. After graduating with an undergraduate degree in Education, Stuart went back to school and received his MBA in Finance and Supply Chain Management. After working for Carquest, where he honed his inventory management skills, Stuart took a job as Supply Chain Manager for Marsh Furniture Company, a 110-year-old manufacturer of kitchen cabinets located in High Point, North Carolina.

As Stuart puts it, "The immediate reaction of many people is, 'How hard can it be to manufacture kitchen cabinets?' But there are quality specifications and manufacturing tolerances to consider, a wide variety of sizes and styles, and material flows and production levels that must be planned and coordinated. The level of complexity is higher than you might think."

When Stuart arrived at Marsh Furniture Company in 2013, one of his first jobs was to get a better handle on the flow of parts and raw materials coming into the assembly plant. This included working closely with key suppliers and improving inventory accuracy. Stuart also worked with others in the company to move from a batch style manufacturing process to a paced production line process (see Chapter 3) and to put advanced planning and control information systems in place (Chapter 12). Thanks to these efforts, Marsh has improved cash flows and is positioned for another one hundred years of success.

Photo courtesy of Stuart Williams

When asked what advice he would give students entering the workforce, Stuart says, "Do the task on hand. Immerse yourself in details." He also suggests that students take the advice of Cal Newport, a Computer Science professor at Georgetown University—"Be so good they can't ignore you."

the areas of education, research, and standards of excellence. Established in 1915, ISM has grown to more than 40,000 members.

CSCMP—The Council of Supply Chain Management Professionals (CSCMP, **www.cscmp.org**) seeks to be the preeminent professional association providing worldwide leadership for the evolving logistics profession through the development, dissemination, and advancement of logistics knowledge.

ASQ—The American Society for Quality (ASQ, **www.asq.org**) is a leader in education and all aspects of quality improvement, including the Baldrige Award, ISO 9000, and continuous improvement activities.

If you are a student, it is not too early to start thinking of joining one of these organizations. In fact, many of them provide scholarships for college education and can help defray education costs.

Cross-Functional and Interorganizational Linkages

Even if you decide that a career in operations and supply chain management is not for you, chances are you will still find yourself working with people in these areas. This is because *none* of the major operations and supply chain activities takes place in a vacuum. Rather, these activities require the input and feedback of other functions within a firm, as well as suppliers and

TABLE 1.2
Major Operations and Supply Chain Activities

OPERATIONS AND SUPPLY CHAIN ACTIVITY	PURPOSE	KEY INTERFUNCTIONAL PARTICIPANTS	KEY INTERORGANIZATIONAL PARTICIPANTS
Process selection	Design and implement the transformation processes that best meet the needs of the customer and the firm	Engineering Marketing Finance Human resources IT	Customers
Forecasting	Develop the planning numbers needed for effective decision making.	Marketing Finance Accounting	Suppliers Customers
Capacity planning	Establish strategic capacity levels ("bricks and mortar") and tactical capacity levels (workforce, inventory).	Finance Accounting Marketing Human resources	Suppliers Customers
Inventory management	Manage the amount and placement of inventory within the company and the supply chain.	IT Finance	Suppliers Customers
Planning and control	Schedule and manage the flow of work through an organization and the supply chain; match customer demand to supply chain activities.	Marketing IT	Suppliers Customers
Purchasing	Identify and qualify suppliers of goods and services; manage the ongoing buyer–supplier relationships.	Engineering Finance Marketing	Suppliers
Logistics	Manage the movement of physical goods throughout the supply chain.	Marketing Engineering	Suppliers Customers

customers. Table 1.2 lists some major operations and supply chain activities, as well as some of the key outside participants. Look, for example, at process selection. Engineering and IT personnel help identify and develop the technologies needed, while human resources personnel identify the people skills and training programs necessary to make the system work. Involving marketing personnel and customers will ensure that the process meets the customers' needs. Finally, finance personnel will need to be involved if the process requires a substantial investment in resources.

1.4 EMPLOYABILITY SKILLS

Throughout this book, we will cover many skills that hiring managers identify as important to success in any variety of business settings, including small and large firms, nonprofit organizations, and public service. These skills are important, even if your career path takes you outside the operations and supply chain discipline.

Critical Thinking

Critical thinking involves purposeful and goal-directed thinking used to define and solve problems, make decisions, or form judgments related to a particular situation or set of circumstances. As you will see, this book is filled with dozens of useful frameworks that managers regularly use to support problem solving, including the Six Sigma methodology (Chapter 4), decision tree analysis (Chapter 6), sourcing portfolio analysis (Chapter 7), and project management tools

(Chapter 14). It is not an exaggeration to say that critical thinking and fact-based decision making are built into the DNA of the operations and supply chain discipline.

Collaboration

As we showed in Table 1.2, many key operations and supply chain activities require close collaboration with participants from other areas, such as marketing, engineering, and finance. Throughout this book, we will emphasize the importance of cross-functional collaboration as well as collaboration with outside supply chain partners. Forecasting (Chapter 9) and inventory management (Chapter 11) are just two areas in which collaboration is essential for the process to work. Chapter 10, in fact, is devoted to sales and operations planning, an approach to planning that depends entirely on collaboration and negotiation between operations, marketing, finance, and human resources in order to succeed.

Knowledge Application and Analysis

Knowledge application and analysis is defined as the ability to learn a concept and then apply that knowledge in another setting to achieve a higher level of understanding. Put another way, understanding is more than just memorizing formulas and cranking out answers. As such, this book seeks to move you "beyond the formulas" by illustrating how the concepts can be applied in a wide range of settings, using both extended examples and in-chapter case studies.

Information Technology Application and Computing Skills

Finally, information technology application and computing skills are defined as the ability to select and use appropriate technology to accomplish a given task. This book covers this skill set in a couple different ways. First, the book includes numerous, detailed examples of how Microsoft Excel can be used to carry out the various calculations covered in the text. Second, we have devoted the Chapter 12 supplement to understanding supply chain information system needs and reviewing recent trends in the area.

1.5 PURPOSE AND ORGANIZATION OF THIS BOOK

Now that we have defined operations and supply chain management, it's time to discuss the purpose and organization of this book. Simply put, the purpose of this book is to give you a solid foundation in the topics and tools of *both* operations management and supply chain management. This is a significant departure from most other operations management textbooks, which are dominated by internal operations issues and treat supply chain management as a subdiscipline. Our decision to emphasize both areas is based on two observations. First, organizations are demanding students who have been exposed to traditional supply chain areas such as purchasing and logistics, as well as more traditional operations topics. Students who have had a course only in operations management are seen as not fully prepared. Second, our years of experience in industry, education, and consulting tell us that supply chain management is here to stay. While a strong internal operations function is vital to a firm's survival, it is not sufficient. Firms must also understand how they link with their supply chain partners. With this in mind, we have organized the book into five main parts (Table 1.3).

Part I, *Creating Value through Operations and Supply Chains*, introduces some basic concepts and definitions that lay the groundwork for future chapters. Chapter 2 deals with the topic of operations and supply chain strategies, including what they are, how they support the organization's overall strategy, and how they help a firm provide value to the customer.

Part II, *Establishing the Operations Environment*, deals with fundamental choices that define an organization's internal operations environment. Chapter 3 deals with the manufacturing and service processes that firms put in place to provide products or services. Chapter 4 is devoted to the topic of business processes, which can be thought of as the "molecules" that make up all operations and supply chain flows. Chapter 4 will also introduce you to some of the approaches companies use to design and improve their business processes, including the Six Sigma

TABLE 1.3 Organization of the Book

I. Creating Value through Operations and Supply Chains
Chapter 1: Introduction to Operations and Supply Chain Management
Chapter 2: Operations and Supply Chain Strategies
II. Establishing the Operations Environment
Chapter 3: Process Choice and Layout Decisions in Manufacturing and Services
Chapter 4: Business Processes
Chapter 5: Managing Quality
Chapter 6: Managing Capacity
III. Establishing Supply Chain Linkages
Chapter 7: Supply Management
Chapter 8: Logistics
IV. Planning and Controlling Operations and Supply Chains
Chapter 9: Forecasting
Chapter 10: Sales and Operations Planning (Aggregate Planning)
Chapter 11: Managing Inventory throughout the Supply Chain
Chapter 12: Managing Production across the Supply Chain
Chapter 13: JIT/Lean Production
V. Project Management and Product/Service Development
Chapter 14: Managing Projects
Chapter 15: Developing Products and Services

methodology. Quality control is a particularly important part of process management, and so we devote Chapter 5 to the topic. In Chapter 6, we discuss the concept of capacity: How much and what types of capacity will an organization need? In the supplement to Chapter 6, we also offer a more advanced discussion of capacity from a process perspective. The topics covered here—including queuing theory and simulation modeling—are particularly relevant in service environments where capacity decisions can have a direct impact on customer waiting and processing times. Chapters 3 through 6 together set clear boundaries on what an organization can do and how the operations function will be managed. As such, we address them early in the book.

Part III, *Establishing Supply Chain Linkages*, turns the spotlight away from the internal operations function to how organizations link with their supply chain partners. Through sourcing decisions and purchasing activities, organizations establish supply chain relationships with other firms. In fact, nearly all firms play the role of upstream supplier or downstream customer at one time or another. Chapter 7 describes the broad set of activities carried out by organizations to analyze sourcing opportunities, develop sourcing strategies, select suppliers, and carry out all the activities required to procure goods and services, while Chapter 8 deals with the physical flow of goods throughout the supply chain and covers such areas as transportation, warehousing, and logistics decision models.

Part IV, *Planning and Controlling Operations and Supply Chains*, focuses on core topics in planning and control. These topics can be found in any basic operations management book. But in contrast to more traditional books, we have deliberately extended the focus of each chapter to address the implications for supply chain management. Forecasting, covered in Chapter 9, is a prime example. By forecasting downstream customer demand and sharing it with upstream suppliers, organizations can do a better job of planning for and controlling the flow of goods and services through the supply chain. In Chapter 10, we discuss not only how firms can develop tactical sales and operations plans, but also how they can link these plans with supply chain partners. In Chapter 11, we don't just cover basic inventory models; we discuss *where* inventory should be located in the supply chain; *how* transportation, packaging, and material-handling issues affect inventory decisions; and *how* inventory decisions by one firm affect its supply chain partners. Similarly, in Chapters 12 and 13, we don't just cover basic production planning topics; we show how such techniques as distribution requirements planning (DRP) and kanban can be used to synchronize the flow of goods between supply chain partners.

The last part of the book, Part V, *Project Management and Product/Service Development*, covers two topics that, while not generally considered part of the day-to-day operational activity of a firm, are nevertheless important to operations and supply chain managers. Chapter 14 describes how organizations manage projects, such as new product development efforts or capacity expansions. Chapter 15 addresses the product and service development process, with an emphasis on how these decisions directly affect choices in operations and supply chain management.

The chapters in Part I provide the foundation knowledge, while Part II deals with fundamental choices that serve to define the capabilities of a firm's operations area. Sourcing and logistics—the topics of Part III—establish linkages between a firm and its supply chain partners. Finally, through the planning and control activities described in Part IV, firms and their partners manage the flows of goods and information across the supply chain.

CHAPTER SUMMARY

Operations and supply chains are pervasive in business. *Every* organization must provide a product or service that someone values. This is the primary responsibility of the operations function. Furthermore, most organizations do not function independently but find that their activities are linked with those of other organizations through supply chains. Careful management of operations and supply chains is, therefore, vital to the long-term health of nearly every organization.

Because operations and supply chain activities cover everything from planning and control activities to sourcing and logistics, there are numerous career opportunities for students interested in the area. Trends in e-commerce and global competition, as well as the growing importance of maintaining good relationships with other supply chain partners, will only increase these opportunities. Fortunately, there are many professional organizations, including APICS, CSCMP, and ISM, that cater to the career development of professionals in operations and supply chain management.

KEY TERMS

Agility 10
Downstream 6
Electronic commerce 10
First-tier supplier 6
Operations function 3
Operations management 6
Second-tier supplier 6
Supply chain 3
Supply chain management 7
Supply Chain Operations Reference (SCOR) model 7
Upstream 6

DISCUSSION QUESTIONS

1. Consider the simplified Anheuser-Busch supply chain shown in Figure 1.2. Is Alcoa really the first entity in the supply chain? What other suppliers would Anheuser-Busch have? What information should be shared among companies in the supply chain?
2. One of your friends states that "operations management and supply chain management are primarily of interest to *manufacturing* firms." Is this true or false? Give some examples to support your answer.
3. In this chapter, we defined a supply chain as a network of manufacturers and service providers that work together to create products or services needed by end users. What are some of the different supply chains that support a product such as the Apple iPhone? How does Apple manage the supply chain that allows users to download various software apps to their iPhones?
4. Early in the chapter, we argued that "every organization must make a product or provide a service that someone values." Can you think of an example in which poor operations or supply chain management undercut a business?

PROBLEMS

Problem for Section 1.1: Why Study Operations and Supply Chain Management?

1. Draw out the transformation process similar to Figure 1.1 for a simple operations function, such as a health clinic or a car repair shop. What are the inputs? The outputs?

Problems for Section 1.3: Operations and Supply Chain Management and You

2. Visit the Web sites for the professional organizations listed in this chapter. Who are their target audiences? Are some more focused on purchasing professionals or logistics professionals? Which of the careers listed at these Web sites are mentioned in the chapter? Which ones sound appealing to you?

CASE STUDY

Supply Chain Challenges at LeapFrog

Introduction

A supply chain consists of a network of companies linked together by physical, information, and monetary flows. When supply chain partners work together, they are able to accomplish things that an individual firm would find difficult, if not impossible, to do. Few cases illustrate this better than the situation faced by LeapFrog in August 2003.[11,12]

LeapFrog, which describes itself as a "leading designer, developer and marketer of innovative, technology-based educational products and related proprietary content,"[13] had just introduced a new educational product called the LittleTouch LeapPad. The distinguishing feature of the LeapPad, whose target market was toddlers, was that it combined high-tech materials and sophisticated electronics to create an interactive "book" that made appropriate sounds when a child touched certain words or pictures.

While LeapFrog was confident the toy would be popular, no one—including the retailers, LeapFrog, and Capable Toys, the Chinese manufacturer who had primary responsibility for producing the LeapPads—knew for sure what actual consumer demand would be. Such uncertainty, which is typical for the toy industry, can be particularly problematic because the demand for toys is concentrated around the November and December holiday season, giving supply chain partners little time to react. Furthermore, toy companies planning for holiday sales have traditionally had to place orders many months in advance—in February or March—to allow enough time for products to work their way through the supply chain and to retailers' shelves. In effect, toy companies had *one chance* to get it right. If a toy company ordered too few copies of a particular toy in February or March, customers in November and December went away disappointed, and the toy company lost significant revenues; if a toy company ordered too many, the result was leftover toys that had to be sold at a steep discount or loss.

By 2003, however, LeapFrog had developed a new approach that used sophisticated forecasting systems, fast information flows and cooperation between supply chain partners, and a flexible manufacturing base to improve the responsiveness of the toy supply chain. Here's how it happened.

E-commerce, Relationship Management, and Forecasting

The first inkling that the LittleTouch LeapPad was a hit came in early August 2003, when major retailers such as Target and Toys "R" Us showed sales of 360 units during the introductory weekend. In previous years, these retailers might have hesitated to share such detailed sales information with a toy company. By 2003, however, retailers realized that sharing sales information in real time with LeapFrog would increase the toy company's odds of meeting surging market demand. The result was that by the Monday following the introductory weekend, LeapFrog knew about the weekend sales figures.

While 360 units might not seem like a lot, LeapFrog's forecasting models indicated that if the trend continued, holiday demand for LeapPads would be approximately 700,000, more than double what LeapFrog had requested be produced by Capable Toys. LeapFrog and its manufacturing and logistics supply chain partners would have to find a way to produce another 350,000 LeapPads and move them to retail stores, all within a few months.

Supply Chain Constraints

Within days of developing the revamped demand forecast, LeapFrog started to work with Capable Toys to identify what steps would need to be taken to increase production levels. They found that several constraints had to be resolved:

- **Production molding constraints.** To manufacture the required plastic parts used in the LeapPad, Capable Toys had designed and built two sets of mold tools capable of producing the equivalent of 3,500 LeapPads each day. If these mold tools were run for 60 days, they could produce only $3{,}500 \times 60 = 210{,}000$ additional units—far short of the quantity needed.
- **Material constraints.** Capable Toys and LeapFrog faced a limited supply of key components, including custom-designed electronics and Tyvek, a special water- (i.e., drool-) proof paper.
- **Logistics constraints.** Even if Capable Toys was able to produce the additional toys required, LeapFrog had to consider how best to get those units from China to U.S. retail shelves. Traditionally, toys produced in China traveled by ship. Although this option was relatively slow, it kept down costs. But with production creeping into September and October, LeapFrog had to consider other, more expensive, options.

How did LeapFrog and its supply chain partners resolve these constraints? First, Capable Toys put its in-house engineers to work designing two additional mold sets. The third mold set, which went online in October and improved on the design of the earlier two sets, allowed Capable Toys to increase its production of LeapPads from 3,500 to 6,300 units per day, an 80% increase.

At the same time, Capable Toys called on its first-tier suppliers to help identify additional sources for the specialized chips, membranes, and other electronics used in the LeapPads. Finding a source for the Tyvek paper was a little bit trickier; to gain access to this key material, LeapFrog had to contract with a U.S. company for the printing. While this added to the product's costs, LeapFrog management felt this was a better alternative than running out of units and alienating retailers and their customers.

With the production capacity and material constraints resolved, LeapFrog had one final problem—getting the units

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[11]UPS, *Maximizing Your Adaptability—Surviving and Winning the High Tech Supply Chain Challenge,* 2005, **www.ups-scs.com/solutions/white_papers/wp_maximizing_adaptability.pdf.**

[12]G. A. Fowler and J. Pereira, "Christmas Sprees: Behind Hit Toy, a Race to Tap Seasonal Surge," *Wall Street Journal*, December 18, 2003.

[13]LeapFrog Enterprises, Inc., *About Us,* **www.leapfrog.com/en/home/about_us.html.**

to the stores in time for the holiday season. Because of the short lead time, LeapFrog was forced to use air shipping and special fast shipping, which added $10 to $15 to the cost of each LeapPad. These additional costs ate into the profit of the LeapPad, which sold for $35, but as with the Tyvek paper, LeapFrog management felt that the long-term satisfaction of retailers and customers outweighed the additional costs.

In the end, the decisions LeapFrog made to respond to the surging demand for LeapPads turned out to be the right one. While LeapFrog struggled financially in recent years, in 2013 the company made $84 million on sales of $553 million.[14] And the company has used its success with the LeapPad product line (discontinued in 2008) to launch a wider range of educational toys that incorporate even more sophisticated electronics.

Questions

1. Draw a map of the supply chain for LeapFrog, including the retailers, Capable Toys, and suppliers of key materials (i.e., Tyvek). Which supply chain partners are upstream of LeapFrog? Which are downstream? Which partners are first-tier suppliers? Second-tier suppliers?
2. What data ultimately led to LeapFrog's decision to increase production levels of the LittleTouch LeapPads? Where did these data come from? How long after interpreting these data did LeapFrog start talking with Capable Toys about increasing production levels—was it days, weeks, or months?
3. What part of the production process limited output levels at Capable Toys? How did Capable respond to the challenge?
4. What were some of the material sourcing challenges LeapFrog and Capable Toys faced? How did they resolve these problems?
5. What type of logistics solutions did LeapFrog use to get the toys to the stores on time? What are the strengths and weaknesses of these solutions? If it had been August rather than December, what other options might LeapFrog have used?
6. In the chapter, we described agility as an enduring trend in operations and supply chain management. In your opinion, did LeapFrog and Capable Toys demonstrate agility in responding to the new market demands?

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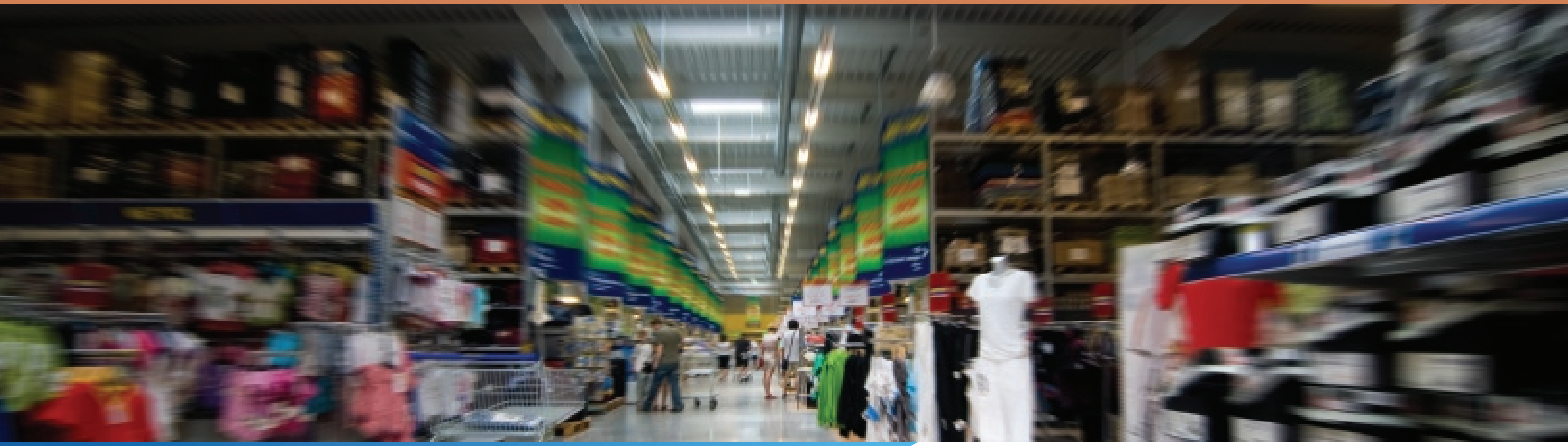

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CHAPTER
two

Operations and Supply Chain Strategies

CHAPTER OBJECTIVES

By the end of this chapter, you will be able to:

- Explain the relationship between business strategies and functional strategies and the difference between structural and infrastructural elements of the business.
- Describe the main operations and supply chain decision categories.
- Explain the concept of customer value and calculate a value index score.
- Differentiate between order winners and qualifiers and explain why this difference is important to developing the operations and supply chain strategy for a firm.
- Discuss the concept of trade-offs and give an example.
- Define *core competencies* and give an example of how core competencies in the operations and supply chain areas can be used for competitive advantage.
- Explain the importance of strategic alignment and describe the four stages of alignment between the operations and supply chain strategy and the business strategy.

TESLA MOTORS

Since Tesla Motors introduced its first roadster in 2006, the company has followed a business strategy designed to ultimately position it as one of the leading manufacturers of electric-powered vehicles. Tesla has purposefully moved toward more affordable models, including the Model S, which was launched in early 2012 and topped 100,000 in total sales by the end of 2015. Tesla's newest offering is the "entry-level" Model 3, which will sell for $35,000, and is scheduled for delivery to customers by the middle of 2017. Yet Tesla's future is far from certain.[1] To succeed, Tesla will need an operations and supply chain strategy that matches its business strategy. Here's how it intends to do it:

Ink Drop/Shutterstock

Manufacturing and After-Sales Service Strategy

Tesla Motors currently assembles its vehicles in Fremont, California, at a site originally opened by General Motors (GM) in the 1960s. From the start, Tesla management understood that while a few early adopters would buy the cars simply to have access to the "latest" technology, the company would need to build high-quality, reliable vehicles and provide top-notch customer service in order to sway customers that might otherwise buy a vehicle from a more-established make. So far, Tesla has met the challenge, achieving high marks for build quality and after-sales service.[2]

Upstream Sourcing Strategy

While its electric drivetrain is radically different from traditional gas-powered vehicles, the Tesla shares many components, such as brakes, suspension, and steering systems, with other vehicles. This helps hold down costs and provides Tesla with access to the best technologies available. Nevertheless, the availability, quality, and performance characteristics of the battery packs, which power the cars, are critical to Tesla's long-term success. Tesla therefore made the decision to build the batteries it needs rather than outsource them. In 2014 Tesla broke ground on its futuristic battery plant, known as Gigafactory 1, near Sparks, Nevada. By 2017, the plant was producing the battery cells needed to support Tesla's assembly operations.[3,4] Tesla ultimately expects the plant to "be able to turn out more lithium-ion batteries than all the battery factories in the world today."[5] By developing a *core competency* in battery manufacturing, Tesla hopes to simultaneously improve battery performance (i.e., more miles per charge) while driving down costs.

Downstream Strategy

Finally, Tesla could build the best electric vehicle in the world but still fail. Why? Simply put, many consumers are hesitant to buy a vehicle whose top range is 265 miles, even though the vast majority of car trips are under 30 miles. To address this concern, Tesla is building a network of supercharger stations in the United States that will allow owners to charge their vehicles in as little as 20 minutes. As of April 2017, Tesla had put in place over 800 supercharger stations with more than 5,000 superchargers.[6]

But will it all work? As one expert noted, "I don't see how they can reduce the [battery] cost more than 20%. . . . We are already reaching the limit on the energy density you can get in the lithium-ion battery. Next-generation battery chemistries, such as lithium air, are another 25 years away from commercialization."[7] And Tesla's competitors are not holding still: Toyota, for example, is pushing hydrogen-cell technology.[8] A more serious threat in the near-term are hybrid vehicles, which combine the benefits of an electric vehicle and the convenience of a backup gas-powered engine. But one thing is certain: If Tesla *does* succeed, it will be because it made investments in manufacturing, after-sales service and technology that are consistent with its goal of being a leading manufacturer of electric-powered vehicles.

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[1]M. Pento, "Tesla Is a Hot Mess–There Is No Path to Profitability," CNBC, May 3, 2016, **www.investopedia.com/news/will-tesla-make-profit-2017-tsla/.**

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[6]Tesla Motors, **www.teslamotors.com/supercharger.**

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INTRODUCTION

Discussing operations or supply chain management without someone mentioning the word *strategy* is almost impossible. But what does that term really mean? What constitutes an operations or supply chain strategy, and how does it support a firm's overall efforts? In this chapter, we will describe how businesses actually create strategies and how operations and supply chain strategies fit within the larger process.

The second half of the chapter is devoted exclusively to the topic of operations and supply chain strategy. We will discuss the three main objectives of operations and supply chain strategy and consider some of the decisions managers face in developing and implementing their strategies. Throughout this discussion, we will stress the key role operations and supply chains play in creating value for the customer.

2.1 ELEMENTS OF THE BUSINESS

Structural element
One of two major decision categories addressed by a strategy. Includes tangible resources, such as buildings, equipment, and computer systems.

Infrastructural element
One of two major decision categories addressed by a strategy. Includes the policies, people, decision rules, and organizational structure choices made by a firm.

Before we begin our main discussion, let's take a moment to consider the business elements that, together, define a business. These elements include structural and infrastructural elements. **Structural elements** are tangible resources, such as buildings, equipment, and information technology. These resources typically require large capital investments that are difficult to reverse. Because of their cost and inflexibility, such elements are changed infrequently and only after much deliberation. An excellent example would be the new battery plant for Tesla. In contrast, **infrastructural elements** are the people, policies, decision rules, and organizational structure choices made by the firm. These elements are, by definition, not as visible as structural elements, but they are just as important. In Chapter 4, for instance, we will discuss the Six Sigma approach to improving business processes. As we will see, the success of Six Sigma depends on highly skilled people, top management support, and a disciplined approach to problem solving. Organizations that adopt Six Sigma will probably make very different infrastructural choices than will firms that don't follow such an approach.

To make these ideas more concrete, think about the business elements at a typical university. Structural elements might include the classrooms, laboratories, dormitories, and athletic facilities. On the infrastructure side, there are people who handle everything from feeding and housing students, assigning parking spaces, and building and maintaining facilities to performing basic research (not to mention teaching). Another part of the infrastrucure are the university's policies and procedures that guide admissions and hiring decisions, tenure reviews, the assignment of grades, and the administration of scholarships and research grants. Some schools even have policies and procedures that guide how students get tickets to football and basketball games.

For a business to compete successfully, all these elements must work together. Because some of these elements can take years and millions of dollars to develop, businesses need to ensure that their decisions are appropriate and consistent with one another. This is why strategy is necessary.

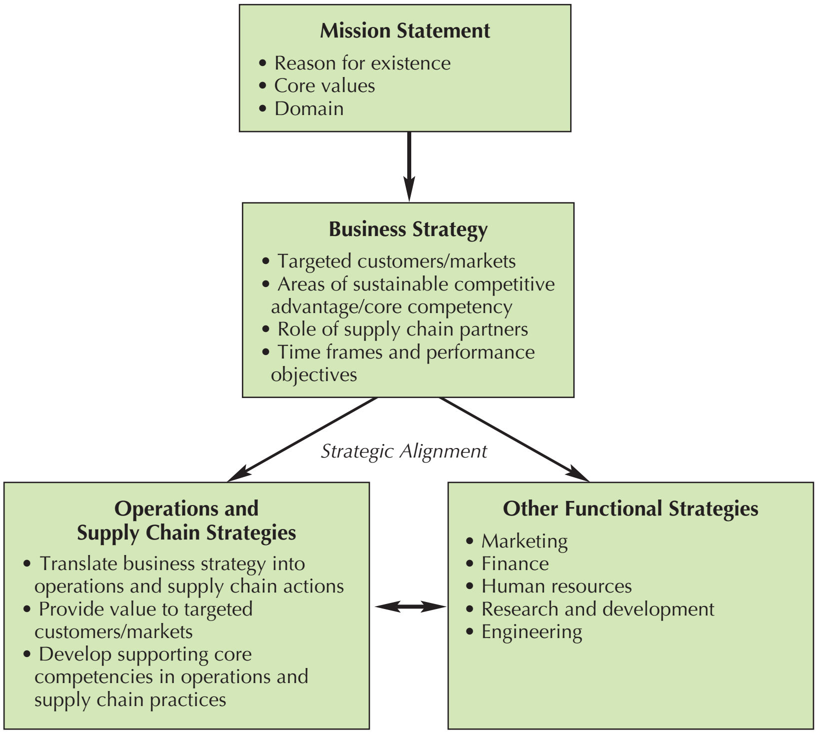
2.2 STRATEGY

Strategy
A mechanism by which a business coordinates its decisions regarding structural and infrastructural elements.

Strategies are the mechanisms by which businesses coordinate their decisions regarding their structural and infrastructural elements. As Harvard Business School professor Michael Porter puts it, "Strategy is creating fit among the company's activities. The success of a strategy depends on doing many things well—not just a few—and integrating among them."[9] Strategies can be thought of as long-term game plans. What is considered *long-term* can differ from one industry to another, but generally the phrase covers several years or more.

[9]M. Porter, "What Is Strategy?," *Harvard Business Review* 74, no. 6 (November–December 1996): 61–78.

FIGURE 2.1
A Top-Down Model of Strategy



Mission statement
A statement that explains why an organization exists. It describes what is important to the organization, called its core values, and identifies the organization's domain.

Business strategy
The strategy that identifies a firm's targeted customers and sets time frames and performance objectives for the business.

Core competency
An organizational strength or ability, developed over a long period, that customers find valuable and competitors find difficult or even impossible to copy.

Functional strategy
A strategy that translates a business strategy into specific actions for functional areas such as marketing, human resources, and finance. Functional strategies should align with the overall business strategy and with each other.

As Figure 2.1 suggests, most organizations have more than one level of strategy, from upper-level business strategies to more detailed, functional-level strategies. (When organizations have *multiple* distinct businesses, they often distinguish between an overall *corporate* strategy and individual *business unit* strategies.) The **mission statement** explains why an organization exists. It describes what is important to the organization, called its *core values*, and identifies the organization's domain.

Much has been written on what a business strategy should accomplish. To keep things simple, we will focus on the parts of a business strategy that are directly relevant to the development of successful operations and supply chain strategies. In this vein, the **business strategy** must:

- Clearly identify the firm's targeted customers and broadly indicate what the operations and supply chain functions need to do to provide value to these customers.
- Set time frames and performance objectives that managers can use to track the firm's progress toward fulfilling its business strategy.
- Identify and support the development of core competencies in the operations and supply chain areas.

The concept of core competencies deserves special attention because of the implications for operations and supply chain strategies. **Core competencies** are organizational strengths or abilities, developed over a long period of time, that customers find valuable and competitors find difficult or even impossible to copy. Honda, for example, is recognized for having core competencies in the engineering and manufacture of small gas-powered engines. Those core competencies have helped Honda conquer numerous markets, including the markets for motorcycles, cars, lawnmowers, jet skis, and home generators.

Core competencies can take many forms and even shift over time. IBM used to be known as a computer hardware company. Today, IBM's core competency is arguably its ability to provide customers with integrated information solutions and the consulting services needed to make them work. In some cases, the ability of a firm to manage its supply chain partners may in itself be considered a core competency (see *Supply Chain Connections: Apple iPod*).

Functional strategies translate a business strategy into specific actions for functional areas, such as marketing, human resources, and finance. An operations and supply chain strategy might address the manufacturing or service processes needed to make a specific product, how suppliers will be evaluated and selected, and how the products will be distributed.

SUPPLY CHAIN CONNECTIONS

APPLE iPOD

A firm's ability to manage its supply chain partners may in itself be a core competency. This has certainly been true for Apple. Consider Apple's iPod, which at one time dominated the market for portable media players. Figure 2.2 shows the sales history for the iPod.[10] As the numbers suggest, iPod demand consistently showed large seasonal "bumps" in the fall of each year. These bumps can be attributed to the introduction of new generations of products combined with the holiday shopping season.

As the iPod comes to the end of its life cycle, it is fair to say that not only has the iPod been a marketing success, it's been a supply chain success. This is because Apple put in place a supply chain strategy that addressed both physical flows and information flows. Consider:

- On the upstream side, Apple partnered with suppliers capable of providing both the *quantity* and *quality* of components Apple needs to assemble the iPod. These suppliers are located around the globe and include Samsung, Wolfson Microelectronics, SigmaTel, and Hitachi. Having suppliers that can respond quickly to new requirements is crucial for products with short life cycles and variable demand levels, such as the iPod.
- On the downstream side, Apple worked with a wide range of logistics service providers and retailers, including Walmart and Best Buy, to get iPods into the hands of consumers. Accomplishing this task without incurring excessive transportation costs, excessive inventories, or shortages is quite a challenge. This is especially true when you consider that demand can be highly seasonal and the life cycle for earlier iPod generations was around one year. (Who wanted last year's model once the new one came out?)

Vicki Beaver/Alamy Stock Photo

- Finally, in addition to managing the physical flow of iPods to consumers, Apple established an *information* supply chain that allows users to download music and videos for a fee. In some ways, this is arguably the most important element behind the iPod's success. The iPod replaced the old physical supply chain of burning, packaging, and shipping CDs to warehouses or stores with a virtual one that allows the user to buy and instantly receive only the music and videos he or she wants.

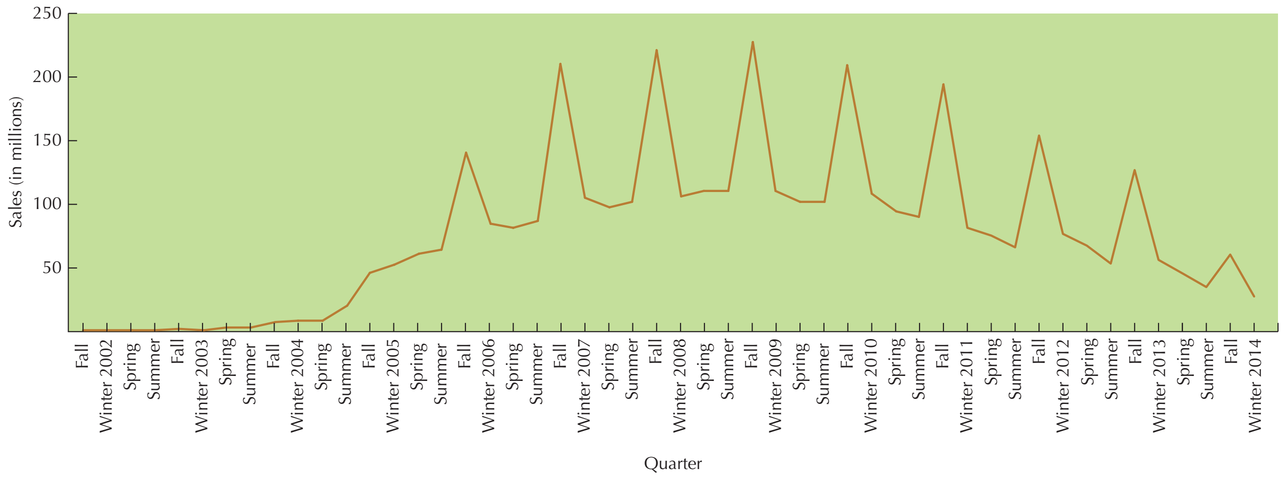


FIGURE 2.2 iPod Sales History

[10]Apple Inc. quarterly results, 2002–2014.

The model in Figure 2.1 shows how the mission statement, business strategy, and functional strategies are related to one another. Managers should be able to pick any specific strategic action at the functional level (e.g., "Develop a European source for raw material X") and trace it back to the business strategy ("Increase our European business presence") and, ultimately, to the firm's mission statement ("Become a world-class competitor in our industry"). When the different levels of the strategic planning process fit together well, an organization is said to have good strategic alignment.

A firm's strategies should also be aligned *across* the functional areas. Continuing with the above example, operations and supply chain efforts aimed at developing a European supply base should be matched by marketing, finance, and human resource efforts aimed at expanding the firm's global presence. Indeed, many so-called functional-level strategies—such as new product development and information technology—are really better described as *cross*-functional, as the responsibility, authority, and resources for these activities often reside in multiple areas.

2.3 OPERATIONS AND SUPPLY CHAIN STRATEGIES

Operations and supply chain strategy
A functional strategy that indicates how structural and infrastructural elements within the operations and supply chain areas will be acquired and developed to support the overall business strategy.

Now that we have some understanding of the relationship between business strategies and functional strategies, let's turn our attention to operations and supply chain strategies in particular. The **operations and supply chain strategy** is a functional strategy that indicates how structural and infrastructural elements within the operations and supply chain areas will be acquired and developed to support the overall business strategy. Table 2.1 lists some of the major structural and infrastructural decisions that must be addressed by an operations and supply chain strategy, as well as where they are discussed in this book. From this table, you can easily see how pervasive infrastructural decisions are in the operations and supply chain strategy. This list of decisions is by no means exhaustive, and it would be much longer and more detailed for an actual business. However, the point is this: Executing successful operations and supply chain strategies means choosing and implementing the right mix of structural and infrastructural elements.

TABLE 2.1
Operations and Supply Chain Decision Categories

STRUCTURAL DECISION CATEGORIES	INFRASTRUCTURAL DECISION CATEGORIES
Capacity (Chapter 6) • Amount of capacity • Type of capacity • Timing of capacity changes (lead, lag, or match market demands)	*Organization* • Structure—centralization/decentralization • Control/reward systems • Workforce decisions
Facilities (Chapters 3, 6, and 8) • Service facilities • Manufacturing plants • Warehouses • Distribution hubs • Size, location, degree of specialization	*Sourcing decisions and purchasing process (Chapter 7)* • Sourcing strategies • Supplier selection • Supplier performance measurement
Technology (Chapters 3, 8, and 12) • Manufacturing processes • Services processes • Material handling equipment • Transportation equipment • Information systems	*Planning and control (Chapters 9–13)* • Forecasting • Tactical planning • Inventory management • Production planning and control
	Business processes and quality management (Chapters 4 and 5) • Six Sigma • Continuous improvement • Statistical quality control
	Product and service development (Chapter 15) • The development process • Organizational and supplier roles

Source: Based on R. Hayes and S. Wheelwright, *Restoring Our Competitive Edge* (New York: John Wiley, 1984).

What constitutes the best mix of structural and infrastructural elements is a subject of ongoing debate among business and academic experts. Nevertheless, we can identify three primary objectives of an operations and supply chain strategy:

1. Help management choose the right mix of structural and infrastructural elements, based on a clear understanding of the performance dimensions valued by customers and the trade-offs involved.
2. Ensure that the firm's structural and infrastructural choices are strategically aligned with the firm's business strategy.
3. Support the development of core competencies in the firm's operations and supply chains.

These three objectives bring up a whole list of concepts: performance dimensions and customer value, trade-offs, strategic alignment, and core competencies in the operations and supply chain areas. In the remainder of this chapter, we describe these concepts more fully.

Customer Value

As we noted in Chapter 1, operations and supply chains help firms provide products or services that someone values. But how should we define *value*? To begin, most customers evaluate products and services based on multiple performance dimensions, such as performance quality, delivery speed, after-sales support, and cost. The organization that provides the best mix of these dimensions will be seen as providing the highest value. Example 2.1 shows how one might assess the value of a product or service.

EXAMPLE 2.1

Calculating a Value Index for Two Competing Products

John wants to buy a tablet PC to use for his school assignments. John decides to evaluate the choices on four dimensions:

1. **Performance quality.** How many programs come loaded on the tablet? How fast is the processor? What is the screen resolution and graphics capability of the tablet?
2. **Delivery speed.** How quickly can John receive the tablet?
3. **After-sales support.** Will the provider help John resolve any technical problems? Will John be able to get help 24 hours a day or just at certain times?
4. **Cost.** What is the total cost to own the tablet?

John rates the importance of each of these dimensions on a scale from 1 ("completely unimportant") to 5 ("critical") and comes up with the following values:

DIMENSION	IMPORTANCE
Performance quality	3
Delivery speed	1
After-sales support	2
Cost	4

The campus store carries two different tablet PCs: one made by WolfByte Computers and the other by Dole Microsystems. WolfByte's tablet has a relatively fast processor and a high-resolution screen, can be delivered in a week, includes around-the-clock technical support for a full year, and costs $800. The Dole Microsystems tablet is a little slower and has lower screen resolution. However, it is available immediately, comes with a month of technical support, and costs $500. John uses this information to rate the performance of each offering with regard to the four dimensions on a scale from 1 ("poor") to 5 ("excellent"):

DIMENSION	IMPORTANCE	WOLFBYTE PERFORMANCE	DOLE MICROSYSTEMS PERFORMANCE
Performance quality	3	4	3
Delivery speed	1	3	5
After-sales support	2	4	2
Cost	4	2	4

Value index
A measure that uses the performance and importance scores for various dimensions of performance for an item or a service to calculate a score that indicates the overall value of an item or a service to a customer.

To find which tablet provides the greater value, John calculates a value index for each. A **value index** is a measure that uses the performance and importance scores for various dimensions of performance for an item or a service to calculate a score that indicates the overall value of an item or a service to a customer. The formula for the value index is:

$$V = \sum_{i=1}^{n} I_n P_n \tag{2.1}$$

where:

V = Value index for product or service
I_n = Importance of dimension n
P_n = Performance with regard to dimension n

For WolfByte, the value index equals $(3 \times 4 + 1 \times 3 + 2 \times 4 + 4 \times 2 = 31)$; for Dole Microsystems, it is $(3 \times 3 + 1 \times 5 + 2 \times 2 + 4 \times 4 = 34)$. So even though the Dole tablet has less performance quality and after-sales support, its lower cost makes it a better value for John.

Four Performance Dimensions

Quality
The characteristics of a product or service that bear on its ability to satisfy stated or implied needs.

Performance quality
A subdimension of quality that addresses the basic operating characteristics of a product or service.

Conformance quality
A subdimension of quality that addresses whether a product was made or a service performed to specifications.

Reliability quality
A subdimension of quality that addresses whether a product will work for a long time without failing or requiring maintenance.

Delivery speed
A performance dimension that refers to how quickly the operations or supply chain function can fulfill a need once it has been identified.

Operations and supply chains can have an enormous impact on business performance. Experience suggests that four generic performance dimensions are particularly relevant to operations and supply chain activities:

1. Quality
2. Time
3. Flexibility
4. Cost

Let's look at each of these performance dimensions in depth.

Quality. **Quality** is defined as the characteristics of a product or service that bear on its ability to satisfy stated or implied needs.[11] The concept of quality is broad, with a number of subdimensions, including **performance quality** (What are the basic operating characteristics of the product or service?), **conformance quality** (Was the product made or the service performed to specifications?), and **reliability quality** (Will a product work for a long time without failing or requiring maintenance? Does a service operation perform its tasks consistently over time?). Chapter 5 provides a comprehensive list of the various quality dimensions and discusses them in detail. The relative importance of these quality dimensions will differ from one customer to the next. One buyer may be more interested in performance, another in reliability. To compete on the basis of quality, a firm's operations and supply chain must consistently meet or exceed customer expectations or requirements on the most critical quality dimensions.

Time. Time has two basic characteristics: speed and reliability. **Delivery speed** generally refers to how quickly the operations or supply chain function can fulfill a need once it has been identified.

[11]American Society for Quality, **http://asq.org/glossary/q.html**.

Justin Kase z03z/Alamy Stock Photo

Delivery reliability and delivery speed are critical performance dimensions for perishable goods such as fruits and vegetables.

Delivery reliability
A performance dimension that refers to the ability to deliver products or services when promised.

Delivery reliability refers to the ability to deliver products or services when promised. Note that a firm can have long lead times yet still maintain a high degree of delivery reliability. Typical measures of delivery reliability include the percentage of orders that are delivered by the promised time and the average tardiness of late orders.

Delivery reliability is especially important to companies that are linked together in a supply chain. Consider the relationship between a fish wholesaler and its major customer, a fish processing facility. If the fish arrive too late, the processing facility may be forced to shut down. On the other hand, fish that arrive too early may go bad before they can be processed. Obviously, these two supply chain partners must coordinate their efforts so that the fish will arrive within a specific **delivery window,** which is defined as the acceptable time range in which deliveries can be made. One automobile manufacturer charges suppliers a penalty fee of $10,000 for every minute a delivery is late. That practice may seem extreme until one considers that late deliveries may shut down an entire production line.

Delivery window
The acceptable time range in which deliveries can be made.

Another measure of delivery reliability is the accuracy of the quantity shipped. For example, Sam's Club demands 95% accuracy in stock deliveries from suppliers. If suppliers ship more than the quantity ordered, they are still considered to be in error. Some firms will consider a partial shipment to be on time if it arrives by the promised date, but others will accept only complete shipments, delivered within the scheduled window.

Flexibility
A performance dimension that considers how quickly operations and supply chains can respond to the unique needs of customers.

Mix flexibility
The ability to produce a wide range of products or services.

Changeover flexibility
The ability to provide a new product with minimal delay.

Volume flexibility
The ability to produce whatever volume the customer needs.

Flexibility. Many operations and supply chains compete by responding to the unique needs of different customers. Both manufacturing and service firms can demonstrate **flexibility.** A full-service law firm, for instance, will handle any legal issue a client faces. (Some law firms specialize in only real estate transactions or divorce settlements.) A full-service hotel will go to great lengths to fulfill a guest's every need. For example, a staff member at the Ritz-Carlton in Dearborn, Michigan, once noticed a guest standing outside the gift shop, waiting for it to open. The employee found out what the guest wanted, picked it up when the shop opened, and waited outside a conference hall to deliver it to the guest. Many firms distinguish among several types of flexibility, including **mix flexibility** (the ability to produce a wide range of products or services), **changeover flexibility** (the ability to provide a new product with minimal delay), and **volume flexibility** (the ability to produce whatever volume the customer needs).

Consider the case of Flex Ltd., a company that buys components and manufactures goods for many original equipment manufacturers (OEMs) in the electronics industry.[12] Because the

[12]Flex Ltd., *Wall Street Journal*, **http://quotes.wsj.com/FLEX/company-people.**

electronics industry is notorious for short product life cycles and unpredictable demand, Flex must be able to quickly adjust the mix and volume of the products it produces. Flex's supply chain partners must be equally flexible. For instance, Flex might order 10,000 units of Part A on Friday for delivery on Monday and then call back on Monday and ask the supplier to take back the 10,000 units and deliver 8,000 units of Part B instead.

Flexibility has become particularly valuable in new product development. Some firms compete by developing new products or services faster than their competitors, a competitive posture that requires operations and supply chain partners who are both flexible and willing to work closely with designers, engineers, and marketing personnel. Chapter 15 includes a detailed discussion of how operations and supply chains can support new product development.

Cost. Cost is always a concern, even for companies that compete primarily on some other dimension. However, "cost" covers such a wide range of activities that companies commonly categorize costs in order to focus their cost management efforts. Some typical cost categories include:

- Labor costs
- Material costs
- Engineering costs
- Quality-related costs (including failure costs, appraisal costs, and prevention costs)

This is just the tip of the iceberg: Firms have developed literally thousands of different cost categories, many of which are specific to the issues facing a particular firm. The point is that operations and supply chain activities are natural targets for cost management efforts because they typically account for much of an organization's costs. In fact, cost is such an important performance dimension we will return to it frequently throughout this book.

Trade-Offs among Performance Dimensions

Take a moment to think about the differences between a world-class sprinter and a marathon runner. The sprinter has trained for explosive speed off the line, while the marathon runner has trained for paced distance running. Both athletes are in peak condition, yet neither would dream of competing in both events.

The same is true in business. In a competitive marketplace, no firm can sustain an advantage on *all* performance dimensions indefinitely. Excellence in some dimensions might conflict with excellence in others, preventing any one firm from becoming the best in all. In such cases, firms must make **trade-offs,** or decisions to emphasize some dimensions at the expense of others. Nearly all operations and supply chain decisions require such trade-offs. To make logical and consistent decisions, operations and supply chain managers must understand which performance dimensions are most valued by the firm's targeted customers and act accordingly.

Trade-off
A decision by a firm to emphasize one performance dimension over another, based on the recognition that excellence on some dimensions may conflict with excellence on others.

Consider some of the trade-offs Delta Air Lines might face in scheduling flights between Raleigh and Orlando. More flights mean greater flexibility for customers but higher costs. Similarly, larger, more comfortable seats improve the quality of the service but also raise costs and reduce the number of passengers a plane can carry. Delta managers know that business flyers will pay a premium for flexibility and comfortable seats, but casual flyers (such as families on their way to Disney World) will be more price-sensitive.

Now suppose a competitor of Delta's decides to offer flights between Raleigh and Orlando. Given this move, Delta's flight schedule and seat design take on added importance. If managers choose frequent flights and larger seats, costs may climb higher than the competitor's; if they choose fewer flights and smaller seats, flexibility and quality may suffer. Delta's managers must decide whose needs—those of business flyers or those of casual flyers—will guide their operational decisions.

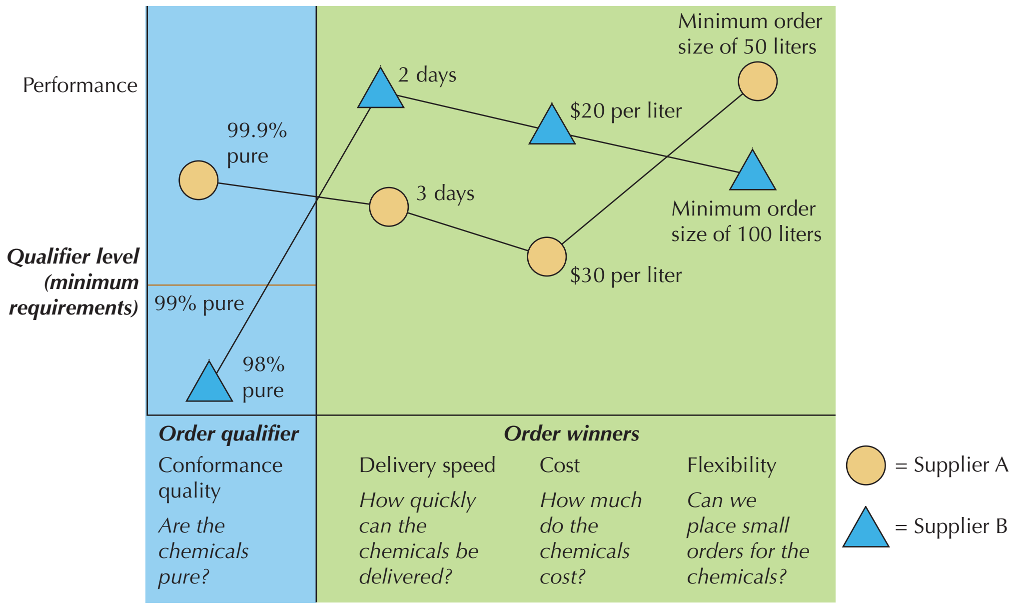
Order Winners and Order Qualifiers

Order winner
A performance dimension that differentiates a company's products and services from its competitors. Firms win a customer's business by providing superior levels of performance on order winners.

Some managers use the concepts of order winners and order qualifiers to highlight the relative importance of different performance dimensions.[13] **Order winners** are performance

[13]T. Hill, *Manufacturing Strategy: Text and Cases* (Boston: Irwin McGraw-Hill, 2000).

FIGURE 2.3
Performance of Two Chemical Suppliers vis-à-vis Customers' Order Winners and Qualifiers



Order qualifier
A performance dimension on which customers expect a minimum level of performance. Superior performance on an order qualifier will not, by itself, give a company a competitive advantage.

dimensions that differentiate a company's products and services from those of its competitors. A firm wins a customer's business by providing superior levels of performance on order winners. **Order qualifiers** are performance dimensions on which customers expect a minimum level of performance. Superior performance on an order qualifier will not, by itself, give a company a competitive advantage.

The industrial chemical market offers an example to illustrate the difference between order winners and order qualifiers. Buyers of industrial chemicals expect a certain level of purity (i.e., conformance quality) before they will even consider purchasing a chemical from a particular source. Because all potential sources must meet this minimum requirement, purity is incredibly important. Once the purity requirement has been satisfied, however, other performance dimensions—such as cost, delivery speed, and flexibility—will be used to determine the best source. From the supplier's perspective, product quality is the order qualifier; cost, delivery speed, and flexibility are order winners.

Now suppose we have two suppliers, A and B, who are competing head-to-head in this industry. Figure 2.3 illustrates how the order winner/qualifier logic can be used to evaluate the two suppliers. Supplier A meets the minimum requirements on quality but falls below Supplier B on all but one of the remaining dimensions (volume flexibility). Supplier B, however, has purity levels below the minimum requirement. So even though Supplier B is superior to A on two performance dimensions, Supplier B will be dropped from consideration because it fails to qualify on one of the dimensions.

Understanding what the relevant order qualifiers and order winners are helps operations and supply chain managers formulate strategy in three ways. First, it helps identify potential problem areas, as well as strengths. Second, it clarifies the issues surrounding decisions on trade-offs. Finally, it helps managers prioritize their efforts.

Take a look again at Supplier B. Supplier B must immediately address its quality problems if it wants to compete at all. After that, the company might look for ways to protect or even increase its delivery and cost advantages. Furthermore, if improving purity involves increasing costs (e.g., buying new equipment), Supplier B should understand what the appropriate trade-off is.

Stages of Alignment with the Business Strategy

The ultimate goal of any firm is to develop an operations and supply chain strategy that supports its business strategy. Management should be able to state how each operations and supply chain structural or infrastructural choice supports the customers' order winners and qualifiers and what trade-offs had to be considered when making these choices. However, as Bob Hayes and Steven Wheelwright recognized years ago,[14] at any point in time some organizations are further along toward achieving this than are others. They described four stages of alignment, and although the stages originally referred to manufacturing, their descriptions apply equally well to the operations and supply chain areas today. The four stages are as follows:

Stage 1—Internally neutral. In this stage, management seeks only to minimize any negative potential in the operations and supply chain areas. There is no effort made to link these areas with the business strategy.

Stage 2—Externally neutral. Here industry practice is followed, based on the assumption that what works for competitors will work for the company. Still, there is no effort made to link the operations and supply chain areas with the overall business strategy.

Stage 3—Internally supportive. At this stage, the operations and supply chain areas participate in the strategic debate. Management recognizes that the operations and supply chain structural and infrastructural elements must be aligned with the business strategy.

Stage 4—Externally supportive. At this stage, the operations and supply areas do more than just support the business strategy: The business strategy actively seeks to exploit the core competencies found within these areas.

To illustrate how a firm's operations and supply chain strategies might achieve Stage 3 alignment, let's revisit Dole Microsystems and WolfByte Computers. Suppose that as part of its business strategy, Dole decides to target price-sensitive buyers who need adequate, but not exceptional, performance, delivery, and after-sales support. In contrast, WolfByte decides to focus on buyers who want excellent performance, delivery, and after-sales support. Table 2.2 shows how managers might begin to align their operations and supply chain strategies with the business strategies of these two distinctive companies.

Notice how the operations and supply chain decisions outlined in Table 2.2 seem to naturally flow from the different business strategies. Table 2.2 vividly illustrates how operations and supply chain decisions that are appropriate in one case may be inappropriate in another. Purchasing low-cost components, for example, would make sense for Dole, given its business strategy, but would run counter to WolfByte's emphasis on performance.

TABLE 2.2
Aligning Business and Operations and Supply Chain Strategies

	DOLE MICROSYSTEMS	WOLFBYTE COMPUTERS
Business strategy	Assemble, sell, and support tablet PCs targeted at price-sensitive buyers who require adequate, but not exceptional, performance, delivery, and support.	Assemble, sell, and support tablet PCs targeted at buyers who are willing to pay extra for exceptional performance, delivery, and customer service.
Operations and supply chain strategy	• Buy components from the *lowest-cost* suppliers who meet minimum quality and delivery requirements. • Keep minimum levels of inventory in factories to *hold down inventory costs.* • Hire and train support staff to provide *acceptable* customer service. • Use three-day ground shipment to *keep costs low.*	• Buy components from *state-of-the-art* suppliers. Price is important but not the critical factor. • Keep enough inventory in factories to *meet rush orders* and *shorten lead times*. • Hire and train support staff to provide *superior* customer service. • Use overnight air freight to *minimize lead time* to the customer.

[14]R. Hayes and S. Wheelwright, *Restoring Our Competitive Edge* (New York: John Wiley, 1984).

Worldpics/Shutterstock

Many companies use cross-docking systems to simultaneously lower transportation and inventory costs. Such systems illustrate how supply chain management can provide a competitive advantage.

Core Competencies in Operations and Supply Chains

Before firms can think about progressing to the fourth stage of alignment (externally supportive), they must develop core competencies within the operations and supply chain areas. Consider the example of Lowe's, a national hardware retailer headquartered in North Carolina. Lowe's uses large regional distribution centers (RDCs) to coordinate shipments between suppliers and retail stores. The RDCs receive large truckload shipments from suppliers, a strategy that allows Lowe's to save on item costs as well as transportation costs. Employees at the RDCs then remix the incoming goods and deliver them to individual stores, as often as twice a day. To give you an appreciation of the scale of these operations, the typical RDC covers about *one million* square feet of space and serves up to *200* Lowe's stores.

But that isn't all. The RDCs use computer-based information systems to closely coordinate incoming shipments from suppliers with outgoing shipments to individual stores. In fact, more than half the goods that come off suppliers' trucks are immediately put onto other trucks bound for individual stores, a method known as *cross-docking*. The result is that both the RDCs and the retail stores hold minimal amounts of inventory, yet Lowe's receives the cost breaks associated with large shipments from suppliers (see Figure 2.4).

FIGURE 2.4
Building Core Competencies at the Operations and Supply Chain Level: Lowe's Distribution System

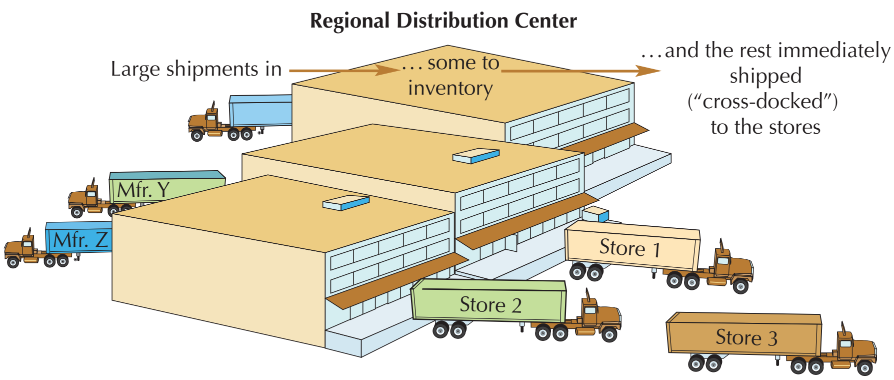
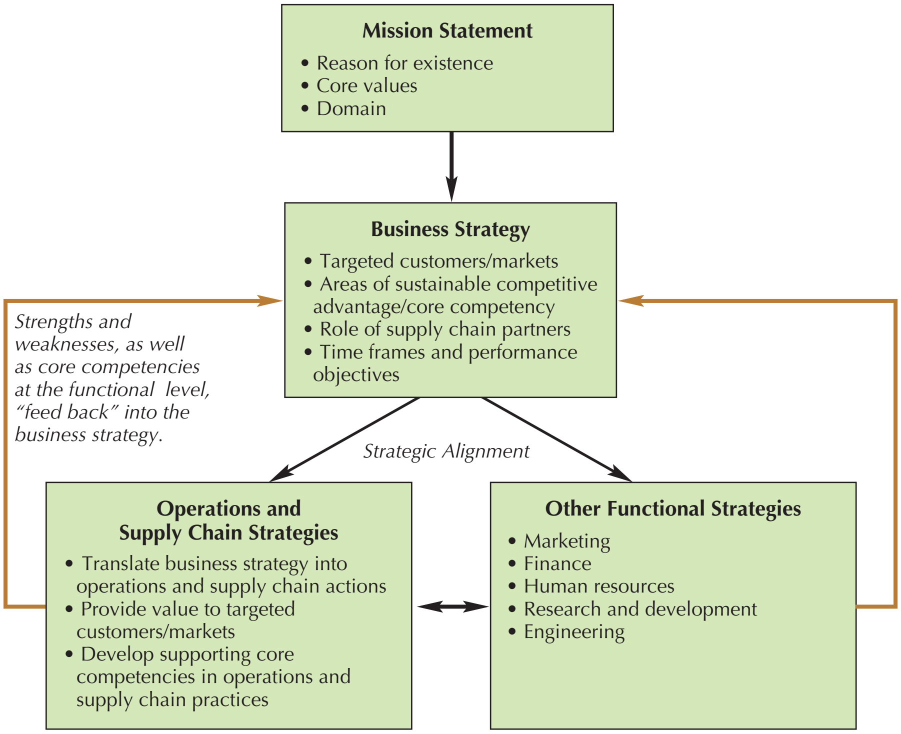


FIGURE 2.5
Closing the Loop between Business Strategy and Functional Area Strategies



Why did Lowe's spend millions of dollars and many years developing this distribution system? One reason is that it helps keep costs low and the availability of goods high—performance dimensions that its targeted customers value highly. Just as importantly, the Lowe's distribution system has emerged as a core competency that will serve the company well even as the marketplace changes.

Finally, we mentioned earlier in the chapter that core competencies at the functional level can feed back into the business strategy. This is exactly what Hayes and Wheelwright meant by the fourth stage of alignment. Some experts also refer to this as *closing the loop*. Figure 2.5 illustrates the idea. Firms such as Amazon, Honda, Lowe's, and others have developed significant core competencies at the functional level. It makes sense, then, for top managers to look for ways to exploit these strengths. More generally, by closing the loop, top managers ensure that the business strategy adequately considers the current capabilities—both positive and negative—within the functional areas.

CHAPTER SUMMARY

The operations and supply chain areas are important providers of value in any organization. To ensure that managers make sound operations and supply chain decisions, firms must develop strategies for these functions that are tied to the overall business strategy. This chapter has presented a top-down model of the strategic planning process, with particular attention to the concepts of value, competitive advantage, and core competency.

In the second half of the chapter, we defined the major operations and supply chain decision variables, outlined the four generic performance dimensions (quality, time, flexibility, and cost), and discussed the need to make trade-offs between these key dimensions. We showed how order winner and order qualifier information can help managers understand exactly what their customers demand, so they can make trade-offs in a logical fashion. We ended the chapter with a discussion of the four stages of alignment in operations and supply chain strategy, showing how firms can exploit core competencies in the operations and supply chain areas.

KEY FORMULA

Value index (page 27):

$$V = \sum_{i=1}^{n} I_n P_n \qquad (2.1)$$

where:

V = Value index for product or service
I_n = Importance of dimension n
P_n = Performance with regard to dimension n

KEY TERMS

Business strategy 23
Changeover flexibility 28
Conformance quality 27
Core competency 23
Delivery reliability 28
Delivery speed 27
Delivery window 28
Flexibility 28
Functional strategy 23
Infrastructural element 22
Mission statement 23
Mix flexibility 28
Operations and supply chain strategy 25
Order qualifier 30
Order winner 29
Performance quality 27
Quality 27
Reliability quality 27
Strategy 22
Structural element 22
Trade-off 29
Value index 27
Volume flexibility 28

SOLVED PROBLEM

PROBLEM

Calculating Value Indices at WarsingWare

WarsingWare produces specialized shipping containers for food products. The shipping containers help protect the food and keep it from spoiling. In addition, the shipping containers have security devices to ensure that the food is not tampered with. WarsingWare is not the fastest or the cheapest; however, the company prides itself on its ability to provide a wide range of styles to its customers, its strong conformance quality, and its ability to ship products on time. WarsingWare management has rated the firm's performance as shown in Table 2.3.

TABLE 2.3 Performance Dimension Ratings for WarsingWare

DIMENSION	PERFORMANCE (1 = "POOR" TO 5 = "EXCELLENT")
Performance quality	4
Conformance quality	5
Delivery speed	2
Delivery reliability	4
Mix flexibility	5
Cost	2
Volume flexibility	3

WarsingWare has two main customers, Sonco Foods and Gregg Groceries. The relative importance (1 = "completely unimportant" to 5 = "critical") each of these customers' places on the dimensions is shown in Table 2.4.

TABLE 2.4 Importance Ratings for Two Major Customers

DIMENSION	SONCO FOODS	GREGG GROCERIES
Performance quality	4	1
Conformance quality	5	4
Delivery speed	1	5
Delivery reliability	4	3
Mix flexibility	3	2
Cost	4	4
Volume flexibility	4	1

1. According to the value index, which customer—Sonco Foods or Gregg Groceries—currently gets more value out of WarsingWare's products?
2. Suppose WarsingWare decides to reduce its costs by offering fewer design variations. Cost performance will rise to 4, and mix flexibility will fall to 2. Will the customers be more satisfied? Explain.

Solution

Table 2.5 shows the value indices for Sonco Foods and Gregg. Sonco is currently receiving greater value from WarsingWare than Gregg is. This is due in part to the fact that Sonco places a fairly high degree of importance on the dimensions that WarsingWare is particularly good at—performance quality, conformance quality, delivery reliability, and mix flexibility. On the other hand, Gregg does not value any of these four dimensions as highly as Sonco.

TABLE 2.5 Value Indices for Two Major Customers

	IMPORTANCE			*VALUE INDEX*	
	PERFORMANCE	SONCO FOODS	GREGG	SONCO FOODS	GREGG
Performance quality	4	4	1	16	4
Conformance quality	5	5	4	25	20
Delivery speed	2	1	5	2	10
Delivery reliability	4	4	3	16	12
Mix flexibility	5	3	2	15	10
Cost	2	4	4	8	8
Volume flexibility	3	4	1	12	3
Totals:				**94**	**67**

Now suppose WarsingWare improves its costs but does this by reducing its mix flexibility. The *new* value indices are shown in Table 2.6.

TABLE 2.6 New Value Indices for Two Major Customers

	IMPORTANCE			*VALUE INDEX*	
	PERFORMANCE	SONCO FOODS	GREGG	SONCO FOODS	GREGG
Performance quality	4	4	1	16	4
Conformance quality	5	5	4	25	20
Delivery speed	2	1	5	2	10
Delivery reliability	4	4	3	16	12
Mix flexibility	**2**	3	2	6	4
Cost	**4**	4	4	16	16
Volume flexibility	3	4	1	12	3
Totals:				**93**	**69**

According to Table 2.6, the value index for Gregg rises to 69, but Sonco's value index actually falls to 93. Whether or not this is an acceptable trade-off will depend on the relative importance of these two customers to WarsingWare, and WarsingWare's position vis-à-vis competitors.

DISCUSSION QUESTIONS

1. Consider the sales history for the iPod, shown in Figure 2.2. In the early days of the iPod, Apple's business strategy was to introduce a new iPod generation around October, just in time for the holiday season. What were the advantages of doing this? From a supply chain perspective, what were the challenges? How might Apple's business strategy have affected the level of emphasis Apple placed on delivery speed and volume flexibility when choosing suppliers?

2. Go to the Web and see if you can find the mission statement for a business or school you are familiar with. Is it a useful mission statement? Why or why not? From what you can tell, are the operations and supply chain strategies consistent with the mission statement?

3. We have talked about how operations and supply chain strategies should be based on the business strategy. But can strategy flow the other way? That is, can operations and supply chain capabilities drive the business strategy? Can you think of any examples in industry?

4. Is it enough to just write down the business strategy of a firm? Why or why not? Conversely, what are the limitations of not writing down the strategy but rather depending on the firm's actions to define the strategy?

5. Chances are you are a college student taking a course in operations or supply chain management. What were the order winners and qualifiers you used in choosing a school? A degree program?

6. Different customers can perceive the value of the same product or service very differently. Explain how this can occur. What are the implications for developing successful operations and supply chain strategies?

7. Go back and look at Hayes and Wheelwright's four stages of alignment. Do firms actually have to develop and then exploit core competencies in the operations and supply chain areas in order to be successful? That is, do all firms need to reach Stage 4?

PROBLEMS

Additional homework problems are available at www.pearsonhighered.com/bozarth. These problems use Excel to generate customized problems for different class sections or even different students.

(* = easy; ** = moderate; *** = advanced)

Problems for Section 2.3: Operations and Supply Chain Strategies

1. (*) You have just graduated from college and are looking to buy your first car. Money is tight right now, so you are concerned with initial cost as well as ongoing expenses. At the same time, you don't want to drive a slow, outdated car like your parents do. You have narrowed your choices to two vehicles: a Honda Enigma and a Bizzarrini Booster. Based on the following numbers, calculate the value index for each car. Which car provides you with the greatest value?

DIMENSION	IMPORTANCE TO YOU	HONDA ENIGMA	BIZZARRINI BOOSTER
Fuel economy	3	5	2
Reliability	5	5	2
Speed and handling	4	2	5
Aesthetics	4	2	5
After-sales support	2	4	4
Purchase price	4	4	1

2. A Chicago-based manufacturer is looking for someone to handle its shipments to the West Coast. In order to evaluate potential transportation providers, the manufacturer has developed the following criteria.

At a minimum, a shipper must be able to:

a. Pick up shipments in less than eight hours from the time it is notified. (The manufacturer doesn't have enough space for shipments to sit around at the dock.)

b. Deliver shipments in 72 hours or less.

Beyond this, shippers will be evaluated according to cost and the percentage of shipments that arrive undamaged.

Three shippers—McAdoo, Klooless, and Big Al—have put in bids for the business. The relevant performance information for the shippers is shown in the following chart:

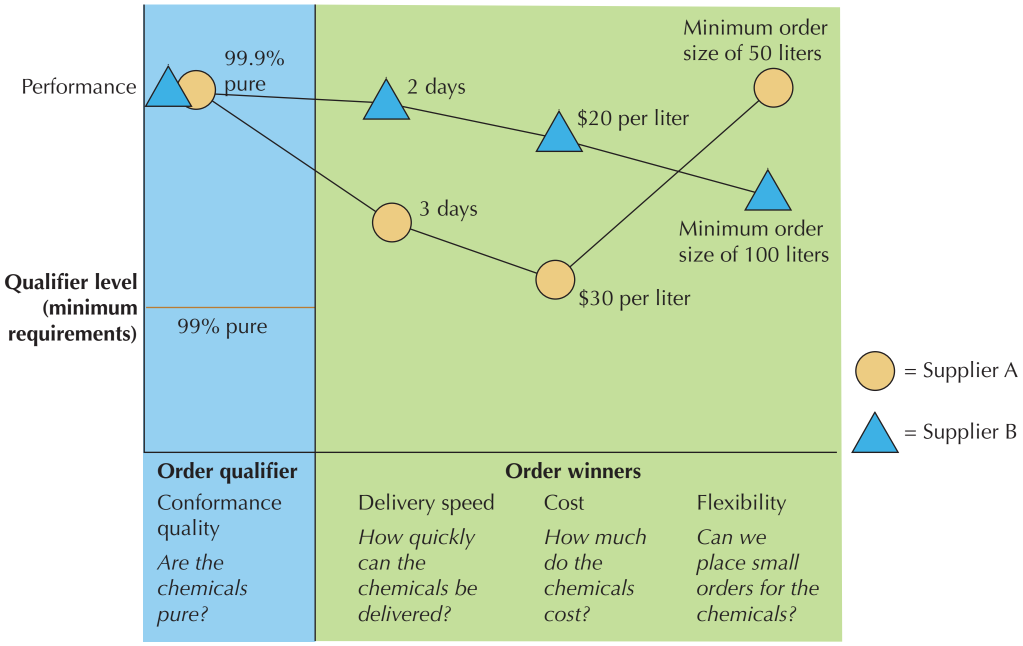
	McADOO	KLOOLESS	BIG AL
Pickup time	6 hours	8 hours	9 hours
Shipping time	48 hours	72 hours	36 hours
Cost per 100 lb. shipped	$20	$30	$15
% of shipments that arrive undamaged	98%	95%	99%

a. (**) Using Figure 2.3 as a guide, graph how well each of the shippers performs with regard to the order winners and order qualifiers.

b. (**) Who is most likely to win the business? Why?

c. (**) What's going on with Big Al? What does Big Al need to do in order to compete successfully for the business?

d. (**) Comment on Klooless's competitive position. Does it meet the minimum requirements? Is it very competitive? Why or why not?



3. Reconsider Figure 2.3. Suppose Supplier B improves its conformance quality so that the chemicals it produces are now 99.9% pure. The chart at the top of this page shows the new competitive situation:

a. (*) Will this be enough to make Supplier B competitive? Which supplier do you think will win the business?

b. (**) Managers at Supplier A have determined that if they increase the minimum order size to 80 liters, they can decrease their costs to $18 per liter. Should they do it? Explain your logic. (*Hint:* There is no single right answer to this problem.)

4. (***) (*Microsoft Excel problem*) The following figure shows an Excel spreadsheet that calculates the value index for each of two alternative suppliers. Re-create this spreadsheet in Excel. You should develop the spreadsheet so that the results will be recalculated if any of the values in the highlighted cells are changed. Your formatting does not have to be exactly the same, but the numbers should be. (As a test, see what happens if you change all of the importance scores to 3. Your new value indices for Supplier 1 and Supplier 2 should be 72 and 63, respectively.)

	A	B	C	D	E	F	G
1	**Calculating the Value Index for Two Alternative Suppliers**						
2							
3	Performance: 1 = “poor” to 5 = “excellent”						
4	Importance: 1 = “completely unimportant” to 5 = “critical”						
5							
6				Performance		Value Index	
7			Importance	Supplier 1	Supplier 2	Supplier 1	Supplier 2
8	Performance quality		5	4	3	20	15
9	Conformance quality		4	5	4	20	16
10	Delivery reliability		2	5	4	10	8
11	Delivery speed		3	1	3	3	9
12	Cost		2	3	5	6	10
13	Mix flexibility		2	2	1	4	2
14	Volume flexibility		3	4	1	12	3
15					**Totals:**	**75**	**63**

CASE STUDY

Netflix

NETFLIX, now 20 years old, has more than 94 million subscribers worldwide and is the most popular subscription media business in the United States.[15] In the fourth quarter of 2016 alone, Netflix had estimated total revenue of nearly $2.4 billion.[16] But the road has not always been so smooth for Netflix. In 2011, Netflix dramatically changed its business strategy from one based on the physical distribution of DVDs and Blu-ray discs, to one based predominantly on the direct streaming of entertainment content across the Internet. This case study looks at the impact on Netflix's supply chain strategy.

Netflix's Supply Chain Strategy, before 2011

Before 2011, Netflix's supply chain strategy mixed information technology and physical logistics to replace traditional brick-and-mortar stores, such as Blockbuster. The Netflix Web site not only served as a virtual storefront but also used customized software to track its subscribers' preferences and make recommendations based on an individual's viewing habits. Enough subscribers responded to these recommendations that Netflix could keep many of its older DVD titles circulating and continuing to earn revenue, while lowering demand somewhat for the "latest" releases.

The second major piece of Netflix's supply chain, its distribution system, was just as critical to the firm's success. By operating several distribution centers around the United States right from the start, the company was able to accept, inspect, and clean DVDs quickly and ship them out just as fast, so customers experienced very short wait times between placing their orders and receiving their DVDs. By 2011, Netflix had about 60 distribution centers in operation.

For the most part, Netflix's traditional supply chain, with its one-day delivery and same-day processing, was effective. Its inventory system not only automatically tracked incoming DVDs that customers had returned, it also emailed each customer a confirmation of receipt and alerted the appropriate shipping center to send the next title on that customer's list or queue. It also ensured that subscribers weren't sent more DVDs than they had paid for (customers were limited to a certain number of DVDs per month). However, a number of factors affected which DVDs a subscriber got and when they got them. If there weren't many copies in the system, the company would ship one from a center that was far from where a subscriber lived. Another was the popularity of the movies. Often there were fewer copies of a newly released film than there were people who wanted to see it. And the shipping process, which involved multiple handling steps, sometimes resulted in damage to the DVDs.

Netflix's Supply Chain Strategy, Today

In retrospect, all the problems listed earlier stemmed from the fact that Netflix's traditional supply chain tied the delivery of an *intangible* service (information content) to a *tangible* item (a DVD or Blu-ray disc). With this in mind, starting in 2007 Netflix made a conscious effort to take advantage of advances in information technology and move to a truly *virtual* supply chain that uses the Internet to both manage subscribers' accounts and stream content directly to them. Such a supply chain has numerous advantages, including:

- Subscribers can receive content immediately.
- Netflix no longer needs to manage an expensive network of distribution centers. In addition to cutting costs, this also allows Netflix to quickly expand into any market that has Internet access.
- Netflix no longer needs to make decisions regarding how many DVDs or Blu-ray discs to order or where to stock them.

But this new supply chain solution is not without its risks:

- **Upstream supplier risks.** Netflix depends on entertainment companies to provide the content subscribers want, yet many of these companies have concerns about having their content—particularly newer shows and movies—delivered in electronic format.[17] If entertainment companies refuse to license their products or provide only limited access to their "best" content, this could undermine the quality and range of Netflix's offerings.
- **Downstream distributor risks.** Instead of having the U.S. Postal Service deliver discs, Netflix's new supply chain strategy depends on Internet service providers (ISPs), such as cable companies and satellite network providers, to deliver the content. Many of these providers have been arguing that Netflix or its subscribers should pay higher fees due to the higher levels of traffic they generate. And even if these issues are resolved, higher traffic levels could result in overloaded networks and service interruptions.
- **Competitive risks.** Today, Netflix faces a new set of competitors, including Amazon, Google, and Hulu, and possibly new companies that have not yet entered the market.[18]

Nevertheless, Netflix provides an excellent example of how supply chain strategies can provide firms with a distinctive competitive advantage and how these strategies need to adapt to changes in technology and the marketplace.

[15] T. Team, "Netflix Subscriber Growth Continues Unabated, As Margins Improve," *Forbes*, January 19, 2017, **www.forbes.com/sites/greatspeculations/2017/01/19/netflix-subscriber-growth-continues-unabated-as-margins-improve/#5579d8fc52dd.**

[16] Netflix letter to shareholders, January 18, 2017, **http://files.shareholder.com/downloads/NFLX/4178437955x0x924415/A5ACACF9-9C17-44E6-B74A-628CE049C1B0/Q416ShareholderLetter.pdf.**

[17] B. Stelter, "In Setback for Netflix, Starz Won't Renew Distribution Deal," *The New York Times*, September 2, 2011, p. B2.

[18] Investopedia, "Analyzing Netflix's Degree of Rivalry among Competitors," **www.investopedia.com/.university/netflix-porters-5-forces-analysis/analyzing-netflixs-degree-rivalry-among-competitors.asp.**

Questions

1. What were some of the key structural and infrastructural elements that defined Netflix's supply chain strategy before 2011? Today?
2. How have the customers' order winners for Netflix's customers changed over time? Would today's customer be satisfied by the delivery performance or selection of Netflix's "old" supply chain?
3. As of early 2017, Netflix still supported customers who want to rent DVDs, although the number of subscribers has fallen to around 4.1 million (vs. 94 million online subscribers)[19]. Should Netflix abandon its physical distribution system altogether? Why or why not?

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CHAPTER three

CHAPTER OUTLINE

Process Choice and Layout Decisions in Manufacturing and Services

CHAPTER OBJECTIVES

By the end of this chapter, you will be able to:

- Describe the characteristics of the five classic types of manufacturing processes.
- Discuss how different manufacturing process choices support different market requirements.
- Explain how different manufacturing processes can be linked together via the supply chain.
- Describe the critical role of customization in manufacturing, including the degree and point of customization, as well as upstream versus downstream activities.
- Discuss the three dimensions that differentiate services from one another—the service package, customization, and customer contact—and explain the different managerial challenges driven by these dimensions.
- Position a service on a conceptual model and explain the underlying managerial challenges.
- Explain how different service processes support different market requirements.
- Develop a product-based layout, using line balancing, and calculate basic performance measures for the line.
- Develop a functional layout based on total distance traveled.

SCHARFFEN BERGER CHOCOLATE

David McNew/Getty Images

FROM its start in a small Berkeley, California, plant in 1996, Scharffen Berger Chocolate has grown to become one of America's leading manufacturers of premium dark chocolate. In fact, chocolate connoisseurs view the company's products as more than candy—as chocolate meant to be savored.

Scharffen Berger's chocolate is produced using a *low-volume batch manufacturing process* carefully designed to ensure that the finished product continues to meet connoisseurs' expectations.[1] Scharffen Berger purchases premium beans months in advance and roasts the beans in 250-kg batches, using its own roasters. Once the company has removed the beans from their shells, it grinds them into a fine paste, using a melangeur (Scharffen Berger's first melangeur was built in Dresden, Germany, in the 1920s) and mixes them with other premium ingredients in specialized processes. The company then forms chocolate bars using tempering and molding processes to ensure that the finished product has just the right look and feel, as well as the right "snap" when it is broken. At each step in the process, skilled operators use their eyes and taste buds—as well as other more high-tech measuring devices—to ensure that the product meets Scharffen Berger's high-quality standards.

In 2005, Hershey Company, one of the world's largest producers of confectionaries, purchased Scharffen Berger. Four years later, the original Scharffen Berger plant in Berkeley, California, was closed, and all manufacturing operations moved to Robinson, Illinois, where Hershey already produced Payday, Whoppers, and Milk Duds candies using *large-volume, continuous flow processes*. But Sharffen Berger fans need not worry: Hershey management clearly understands that Scharffen Berger products are different and has maintained a separate manufacturing process for its premium product line.

[1]D. Snow, S. Wheelwright, and A. Wagonfeld, "Scharffen Berger Chocolate Maker," Case 6-606-043, Harvard Business School, 2007.

INTRODUCTION

Manufacturing and service process decisions are very important to firms for at least two reasons. First, they tend to be expensive and far reaching. The decision to put in a production line, for example, dictates the types of workers and equipment that are needed, the types of products that can be made, and the kinds of information systems that are required to run the business. Because of the financial commitment, it is not a decision that can be easily reversed.

Second, process decisions deserve extra attention because different processes have different strengths and weaknesses. Some processes are particularly good at supporting a wide variety of goods or services, while others are better at providing standardized products or services at the lowest possible cost. But no process is best at everything. Managers must therefore carefully consider the strengths and weaknesses of different processes and make sure that the process they choose best supports their overall business strategy and, in particular, the needs of their targeted customers.

We start this chapter by describing manufacturing processes. We first review the five classic types and then discuss the concepts of hybrid and linked manufacturing processes. We pay particular attention to the roles that product standardization, production volumes, and customization play in determining the best process choice.

In the second half of the chapter, we turn our attention to service processes. How do they differ from one another? What are the key managerial challenges and capabilities of the different service process types? How can service firms position themselves for strategic advantage? The special role services play in supply chains will also be discussed.

We end the chapter by introducing two approaches that firms use to develop layouts. As you will see, the approach used differs dramatically, depending on the type of layout involved.

3.1 MANUFACTURING PROCESSES

Managers face a plethora of choices when deciding on a specific manufacturing process. Scharffen Berger Chocolate is a case in point: The choices it made were aligned with the company's business strategy of making a premium chocolate in relatively low volumes. Here are a few general principles to keep in mind when selecting and implementing a manufacturing process:

1. Selecting an effective manufacturing process means much more than just choosing the right equipment. Manufacturing processes also include people, facilities and physical layouts, and information systems. These pieces must work together for the manufacturing process to be effective.
2. Different manufacturing processes have different strengths and weaknesses. Some are best suited to making small numbers of customized products, while others excel at producing large volumes of standard items. Companies must make sure that their manufacturing processes support the overall business strategy.
3. The manufacture of a particular item might require many different types of manufacturing processes, spread over multiple sites and organizations in the supply chain. Effective operations and supply chain managers understand how important it is for these processes to work well together.

Much has changed in manufacturing over the past 20 years. High quality is no longer a way for manufacturers to differentiate themselves from competitors but rather a basic requirement of doing business. At the same time, many customers are demanding smaller quantities, more frequent shipments, and shorter lead times—not to mention lower prices. Add to this list of challenges the increasingly important role of information technologies (Chapter 12), and you can see that the hallmark of manufacturing in the twenty-first century will be *change*.

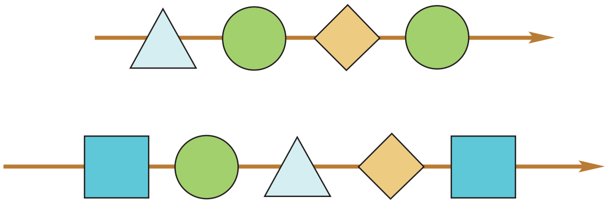
Despite the many changes in manufacturing, there is a basic truth that will not change: *No manufacturing process can be best at everything*. The choice of one manufacturing process over another will always bring trade-offs. **Flexible manufacturing systems (FMSs),** for instance, are highly automated batch processes (discussed later) that can reduce the cost of making groups of similar products. But as efficient as FMSs are, a production line dedicated to a smaller set of standard products will still be cheaper, if not as flexible. Similarly, today's high-volume line processes might be more flexible than their counterparts of just a few years ago, but they are still not as flexible as skilled laborers with general-purpose tools and equipment.

Flexible manufacturing systems (FMSs)
Highly automated batch processes that can reduce the cost of making groups of similar products.

Obviously, the selection of a manufacturing system is a complex process. However, experienced managers find that several questions crop up regularly in the selection process:

- What are the physical requirements of the company's product?
- How similar to one another are the products the company makes?
- What are the company's production volumes?
- Where in the value chain does customization take place (if at all)?

FIGURE 3.1
Production Line and Continuous Flow Processes



- Product-based layout: Equipment and people are highly specialized and arranged sequentially according to the steps required to make a product or product family.
- Production is often "paced."
- Best suited to high-volume production of standardized products.

We will use these criteria to describe five classic manufacturing processes: production lines, continuous flow processes, job shops, batch manufacturing, and fixed-position layout.

Production Lines and Continuous Flow Manufacturing

Production line
A type of manufacturing process used to produce a narrow range of standard items with identical or highly similar designs.

Product-based layout
A type of layout where resources are arranged sequentially, according to the steps required to make a product.

Cycle time
For a line process, the actual time between completions of successive units on a production line.

Continuous flow process
A type of manufacturing process that closely resembles a production line process. The main difference is the form of the product, which usually *cannot* be broken into discrete units. Examples include yarns and fabric, food products, and chemical products such as oil or gas.

When most people think about manufacturing, they think about production lines. A **production line** is a type of manufacturing process used to produce a narrow range of standard items with identical or highly similar designs.[2] Production lines have several distinct characteristics. First, they follow a **product-based layout** (Figure 3.1), where resources are arranged sequentially according to the steps required to make a product. The various steps are usually linked by some system that moves the items from one step to the next, such as a conveyor belt. A production line for battery-powered hand tools might divide the assembly into three steps—mounting the motor inside the right half of the casing, putting the left and right halves together, and putting a safety warning sticker on the outside of the casing. All three steps are done continuously, so as one hand tool is having its motor mounted, another is having its safety warning sticker put on.

Second, items typically move through the production line at a predetermined pace. A line might, for example, complete 60 units an hour, or 1 every minute. The time between completions of successive units is known as the **cycle time** of the line. At each step in the process, equipment or people have a set amount of time to finish each task. By dividing the manufacturing process into a series of discrete, carefully timed steps, production lines achieve high degrees of equipment and worker specialization, as well as consistent quality and high efficiency.

Production lines are ideally suited to the high-volume production of a single product or of products characterized by similar design attributes, such as size, material, or manufacturing steps. An auto assembly line can handle the same model car with different transmissions, different engines, and even different interiors, one right after the other, because the line was designed to fit all possible options of the car model it produces.

Production lines have two drawbacks, however. First, high volumes are required to justify the required investment in specialized equipment and labor. Second, lines are inflexible with regard to products that do not fit the design characteristics of the production line. When production volumes are low or product variety is high, other solutions are needed.

Continuous flow processes closely resemble production line processes in that they produce highly standardized products using a tightly linked, paced sequence of steps. The main difference is the *form* of the product, which usually *cannot* be broken into discrete units until the very end of the process. Examples include food processing, chemicals, and fiber formation processes. In many ways, a continuous flow process is even less flexible than a production line. The nature of the product tends to make shutdowns and start-ups expensive, which discourages flexibility and encourages product standardization. And the highly technical nature of many continuous flow processes means that specialists are needed to control operations. The only responsibilities of direct laborers might be to load and unload materials and monitor the process. Continuous flow processes also tend to be highly capital-intensive and very inflexible with respect to changes in output levels.

[2] J. H. Blackstone, ed., *APICS Dictionary*, 15th ed. (Chicago, IL: APICS, 2016).

Mark Yuill/Shutterstock

Products moving rapidly through an automated production line at a modern dairy factory.

Job Shops

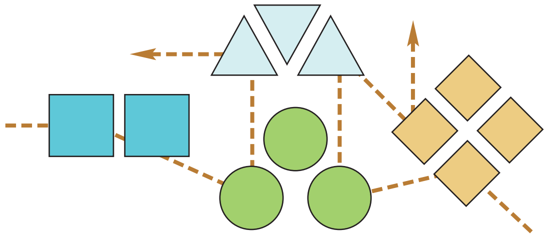
Job shop
A type of manufacturing process used to make a wide variety of highly customized products in quantities as small as one. Job shops are characterized by general-purpose equipment and workers who are broadly skilled.

In contrast to production line and continuous flow processes, a **job shop** is a type of manufacturing process used to make a wide variety of highly customized products in quantities as small as one. Job shops are characterized by general-purpose equipment and broadly skilled workers. The main emphasis in a job shop is meeting a customer's unique requirements, whatever they may be. Products made in job shops include custom furniture, specialized machine tools used by manufacturers, and restoration and refurbishing work. In a job shop, the product design is *not* standardized. In fact, the shop may need to work closely with the customer to identify just what the product's characteristics should be, and these characteristics may even change once manufacturing starts. Obviously, estimating the time, cost, and specific production requirements for such products is not easy!

Courtesy of Cecil Bozarth

Even though this 1937 Lincoln-Zephyr was originally produced on an assembly line, its restoration took place in a job shop characterized by broadly skilled workers and general-purpose tools.

FIGURE 3.2
Job Shop Processes



- General-purpose equipment and broadly skilled people.
- Functional layout: Work areas are arranged by function.
- Requirements can change dramatically from one job to the next.
- Best suited to low-volume production of one-of-a-kind products.
- Highly flexible, but not very efficient.

Job shops depend on highly flexible equipment and personnel to accomplish their tasks. Personnel in job shops commonly handle several stages of production. Job shops typically follow a **functional layout,** where resources are physically grouped by function (molding, welding, painting, etc.). This makes sense because the process steps required can change dramatically from one job to the next (Figure 3.2). Finally, job shops must be very flexible in their planning. While the manager of a paced assembly line might have clear expectations of what the output level should be (e.g., 200 ovens an hour), the manager of a job shop does not have that luxury. Manufacturing requirements can change dramatically from one job to the next. And the lack of a clear, predictable product flow means that some areas of a job shop can be idle while other areas are backed up.

Functional layout
A type of layout where resources are physically grouped by function.

Batch Manufacturing

Batch manufacturing
A type of manufacturing process where items are moved through the different manufacturing steps in groups, or batches.

Batch manufacturing gets its name from the fact that items are moved through the different manufacturing steps in groups, or batches. This process fits somewhere between job shops and lines in terms of production volumes and flexibility. Batch manufacturing covers a wide range of environments and is probably the most common type of manufacturing process.

As an example of a typical batch process, consider a manufacturer of golf and turf mowers, such as John Deere. Management might decide to make a batch of 50 engines of a particular model. Workers might then run the engines through one machine, stacking the semifinished engines on a pallet. After all 50 engines have completed this step, the entire batch will be moved to the next machine, where the 50 engines will wait their turn to be processed. This sequence of processing, moving, and waiting will continue throughout the production process.

While production volumes are higher in a batch process than in a job shop, the sequence of steps is not so tightly linked that units are automatically passed, one at a time, from one process step to the next, as they are on a production line. Thus, batch manufacturing strikes a *balance* between the flexibility of a job shop and the efficiency of a line.

Fixed-Position Layout

Fixed-position layout
A type of manufacturing process in which the position of the product is fixed. Materials, equipment, and workers are transported to and from the product.

The final classic manufacturing process type is known as **fixed-position layout.** The distinguishing characteristic here is that the position of the product, due to size or other constraints, is fixed. Materials, equipment, and workers are transported to and from the product. Fixed-position layouts are used in industries where the products are very bulky, massive, or heavy and movement is problematic.[3] Examples include shipbuilding, construction projects, and traditional home building.

Hybrid manufacturing process
A general term referring to a manufacturing process that seeks to combine the characteristics, and hence advantages, of more than one of the classic processes. Examples include flexible manufacturing systems, machining centers, and group technology.

Hybrid Manufacturing Processes

Not all manufacturing processes fall cleanly into the above categories. **Hybrid manufacturing processes** seek to combine the characteristics, and hence advantages, of more than one of the

[3] Ibid.

Machining center
A type of manufacturing process that completes several manufacturing steps without removing an item from the process.

Group technology
A type of manufacturing process that seeks to achieve the efficiencies of a line process in a batch environment by dedicating equipment and personnel to the manufacture of products with similar manufacturing characteristics.

Cellular layout
A type of layout typically used in group technology settings in which resources are physically arranged according to the dominant flow of activities for the product family.

Product family
In group technology, a set of products with very similar manufacturing requirements.

3D printing
An additive manufacturing process that creates a physical object from a digital design.

classic processes. We already mentioned flexible manufacturing systems earlier in the chapter. Flexible manufacturing systems are highly automated (like line processes) but are able to handle a wider range of products (like batch processes).

While there are literally hundreds of hybrid manufacturing processes out there, we will illustrate the point by discussing two common types: machining centers and group technology. **Machining centers** are typically found in batch manufacturing environments. What makes them different, however, is that a machining center will complete several manufacturing steps without removing an item from the process. By combining steps, a machining center tries to achieve some of the efficiencies of a production line while still maintaining the flexibility of a batch process.

Similarly, **group technology** is a type of manufacturing process that seeks to achieve the efficiencies of a line process in a batch environment by dedicating equipment and personnel to the manufacture of products with very similar manufacturing characteristics. Group technology cells typically follow a **cellular layout,** in which the resources are physically arranged according to the dominant flow of activities for the product family. To illustrate, a batch manufacturer might find that, while it makes 3,000 different items, 25% of them are products with very similar manufacturing requirements. These products might, therefore, be grouped together into a **product family.** Because of the relatively high percentage of production accounted for by the product family, management might find it worthwhile to dedicate specific equipment and personnel to just these products. The resulting group technology work cell should be able to improve its efficiencies, but at the expense of lower flexibility (Figure 3.3).

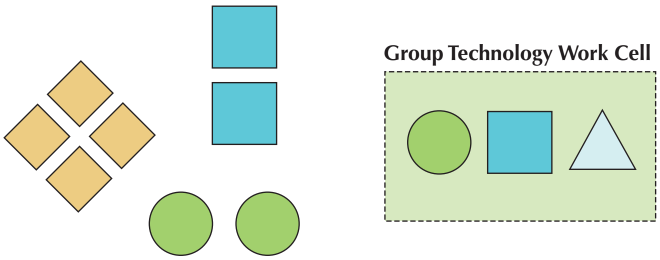
3D Printing

One of the most interesting developments in manufacturing in recent years is **3D printing,** also known as additive manufacturing. As 3D Hubs explains it:

> 3D printing is an additive manufacturing process that creates a physical object from a digital design. There are different 3D printing technologies and materials you can print with, but all are based on the same principle: a digital model is turned into a solid three-dimensional physical object by adding material layer by layer.[4]

While 3D printing is still limited with regard to the types of materials it uses and the products it can make, there are situations in which it has advantages over traditional manufacturing. Specifically, 3D printing allows manufacturing to occur *when* and *where* the item is needed. This can be a real advantage when time is of the essence or when shipping an item from a plant to its final destination is difficult. For instance, the U.S. Navy is considering putting 3D printers on its warships so that critical spare parts can be created when needed—"In many cases, the waiting time for [a replacement] order could be reduced from months or weeks to days or hours."[5]

FIGURE 3.3
Group Technology Work Cell

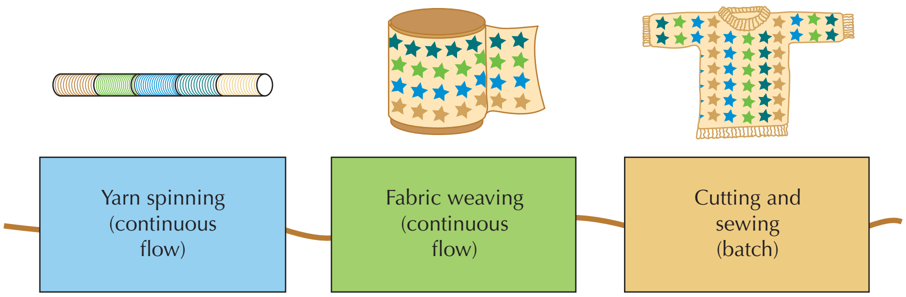


- Equipment and personnel are dedicated to the production of a product family.
- Cellular layout: Resources are physically arranged according to the dominant flow of activities for the product family.

[4]3D Hubs, "What Is 3D Printing?: The Definitive Guide to 3D Manufacturing," **www.3dhubs.com/what-is-3d-printing.**

[5]J. Joyce, "Navy Officials: 3-D Printing to Impact Future Fleet with 'On Demand' Manufacturing Capability," *America's Navy,* May 19, 2016, **www.navy.mil/submit/display.asp?story_id=94769/.**

FIGURE 3.4
Linking Processes Together to Make a Sweater



Linking Manufacturing Processes across the Supply Chain

A manufacturing system may actually consist of several different types of processes linked across multiple supply chain partners. Consider the sequence of manufacturing processes needed to produce a sweater. Yarn production has all the characteristics of a continuous flow process: It is capital intensive, turns out a standardized product at a predetermined pace, and requires little or no user interaction. The finished yarn is then fed into a loom that weaves the yarn into fabric, also a continuous flow process. At this point, the rolls of woven fabric might be sent to another facility, where the fabric is cut into patterns and sewn into sweaters. The final sewing operation is highly labor intensive, requiring a classic batch process, in which individual workers are responsible for completing a lot of 50 or more garments. When the garments are finished, they might move on to another station for additional processing, followed by a packing operation. Figure 3.4 illustrates this idea.

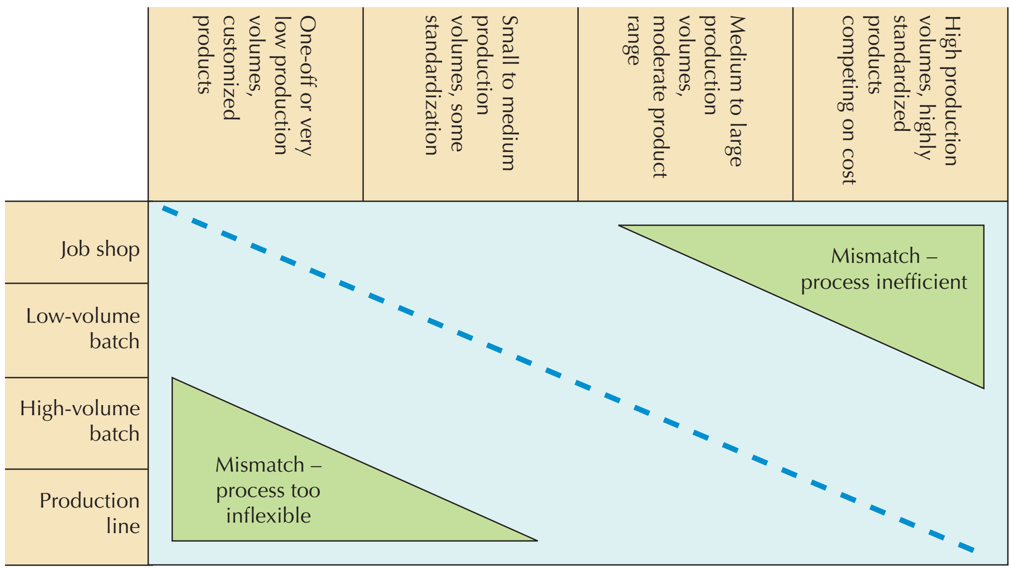
Selecting a Manufacturing Process

With the exception of fixed-position layouts and continuous flow manufacturing (which are essentially dictated by the physical characteristics of the product), managers face several choices when selecting a manufacturing process. Job shops have a clear advantage when production volumes are low, customization levels are high, and the manufacturer is not competing on the basis of cost. Production lines excel when production volumes are high, products are standard rather than customized, and cost is important. Batch systems tend to fall somewhere between these extremes.

The Product-Process Matrix

The product-process matrix (Figure 3.5) makes the preceding points graphically. When the characteristics of a company's manufacturing processes line up with the products' characteristics, as shown by the points on the diagonal line, there is a strategic match. But consider the two shaded areas labeled as mismatches. The area in the top-right corner occurs when a job shop

FIGURE 3.5
The Product-Process Matrix
Source: Based on R. Hayes and S. Wheelwright, *Restoring Our Competitive Edge: Competing through Manufacturing* (New York: Wiley, 1984), p. 209.



tries to support high-volume, standardized products. Although such products *could* be built in a job shop, it would be an unwise use of resources, and the job shop could never hope to compete on a cost basis with production lines.

In contrast, the shaded area in the bottom-left corner suggests an organization trying to produce low-volume or one-of-a-kind products using a high-volume batch or production line process. Once again, there is a strategic mismatch: These processes can't possibly meet the flexibility or broad skill requirements needed here. The point is that a company must choose the right manufacturing process, given its markets and product requirements.

3.2 PRODUCT CUSTOMIZATION WITHIN THE SUPPLY CHAIN

A word commonly heard in discussions of manufacturing is *customization*. But what does this term mean? True customization requires *customer-specific* input at some point in the supply chain. For instance, manufacturers of specialized industrial equipment often start with an *individual customer's* specifications, which drive subsequent design, purchasing, and manufacturing efforts. And hardware stores mix ready-made paints to match a customer's particular color sample. In both cases, the product is customized. However, the *degree* and *point* of customization differ radically between the two.

Four Levels of Customization

Manufacturers typically talk about four levels of product customization. From least to greatest customization, these are:

- Make-to-stock (MTS) products
- Assemble-to-order (ATO) or finish-to-order products
- Make-to-order (MTO) products
- Engineer-to-order (ETO) products

Make-to-stock (MTS) products
Products that require no customization. They are typically generic products and are produced in large enough volumes to justify keeping a finished goods inventory.

Assemble-to-order (ATO) or finish-to-order products
Products that are customized only at the very end of the manufacturing process.

Make-to-order (MTO) products
Products that use standard components but have customer-specific final *configuration* of those components.

Engineer-to-order (ETO) products
Products that are designed and produced from the start to meet unusual customer needs or requirements. They represent the highest level of customization.

Make-to-stock (MTS) products involve no customization. They are typically generic products and are produced in large enough volumes to justify keeping a finished goods inventory. Customers typically buy these products "off the shelf." Examples include basic tools (e.g., hammers, screwdrivers), consumer products sold in retail stores, and many raw materials.

Assemble-to-order (ATO) or finish-to-order products are products that are customized only at the very end of the manufacturing process. Even then, the customization is typically limited in nature. A T-shirt with a customer's name airbrushed on it is a simple example. The T-shirt itself is generic until the very last step. Many automobiles are also ATO products because the final set of options—deluxe or standard interior, navigation systems, and so on—is not determined until the very last stage, based on the dealer's or customer's order.

Like ATO products, **make-to-order (MTO) products** use standard components, but the final *configuration* of those components is customer specific. To illustrate, Balley Engineered Structures builds an endless variety of customized walk-in industrial coolers or refrigerators from a standard set of panels.[6] MTO products push the customization further back into the manufacturing process than ATO products do.

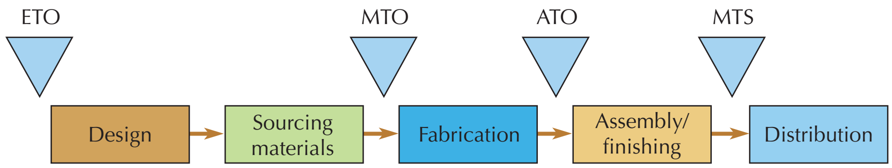
The most highly customized products are **engineer-to-order (ETO) products.** These products are designed and produced from the start to meet unusual customer needs or requirements. While these products might include standard components, at least some of these components are specifically designed with the help of the customer. One can imagine, for example, that some major components that go into the rockets made by SpaceX would fit into this category.

The Customization Point

To manufacturing personnel, the key difference between these four product types is not so much the degree of customization but the *point at which* it occurs. That is, *when and where* do a customer's specific requirements affect operations and supply chain activities? Consider Figure 3.6.

[6] B. J. Pine II, *Mass Customization: The New Frontier in Business Competition* (Boston: Harvard Business School Press, 1993).

FIGURE 3.6
Where Does Customization Occur in the Supply Chain?



For ETO products, the customer's needs become apparent at the design stage (at the far left in Figure 3.6). The exact content and timing of all subsequent activities, from design through distribution, are determined only after the customer's order arrives. Not surprisingly, ETO products are often found in job shop environments. In contrast, MTS products (at the far right in Figure 3.6) move along from the design stage to finished goods inventory, the warehouse, or even the retail outlet, without direct input from the final customer. The timing and volume of production activities for MTS products are more likely to be driven by internal efficiency or capacity utilization goals. As a result, production lines or even high-volume batch processes are usually the best choice for MTS products.

Upstream activities
In the context of manufacturing customization, activities that occur prior to the point of customization.

Downstream activities
In the context of manufacturing customization, activities that occur at or after the point of customization.

Law of variability
According to Roger Schmenner and Morgan Swink, "The greater the random variability either demanded of the process or inherent in the process itself or in the items processed, the less productive the process is." This law is relevant to customization because completing upstream activities offline helps isolate these activities from the variability caused by either the timing or the unique requirements of individual customers.

Drawing attention to the point at which customization occurs allows us to make crucial distinctions between manufacturing activities that occur on either side of the customization point. We refer to activities that take place prior to the customization point as **upstream activities,** while those that occur at or after the customization point are called **downstream activities.**

By definition, upstream activities are not affected by the particular nuances of an individual customer order. Thus, they can be completed offline, or prior to the arrival of a customer order. Completing activities offline has two advantages. First, it reduces lead time to the customer, as only the downstream activities remain to be completed. This can be particularly important in competitive situations where delivery speed is critical. At Dell Computer, all value chain activities in the manufacturing system except final assembly and shipping, which are downstream activities, take place before the customer order arrives. Upstream activities include the ordering, manufacturing, shipping, and stocking of standardized components. The result is two- to three-day lead times for the customer.[7]

A second advantage has to do with the **law of variability,** described by Roger Schmenner and Morgan Swink (1998). According to the authors, "the greater the random variability either demanded of the process or inherent in the process itself or in the items processed, the less productive the process is."[8] Completing upstream activities offline helps isolate these activities from the variability caused by either the timing or the unique requirements of individual customers.

But in ETO, MTO, and ATO environments, some activities *must* be completed on-line, once the customer's needs are known. This tends to increase lead times to the customer. The *Supply Chain Connections* feature describes how TimberEdge Cabinets changed from an MTO manufacturer to an ATO manufacturer. The change had dramatic implications for the efficiency of its manufacturing processes and TimberEdge's ability to meet customer needs in a timely manner.

To summarize, when customization occurs *early* in the supply chain:

- Flexibility in response to unique customer needs will be greater.
- Lead times to the customer will tend to be longer.
- Products will tend to be more costly.

When customization occurs *late* in the supply chain:

- Flexibility in response to unique customer needs will be limited.
- Lead times to the customer will tend to be shorter.
- Products will tend to be less costly.

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[7]J. Magretta, "The Power of Virtual Integration: An Interview with Dell Computer's Michael Dell," *Harvard Business Review* 76, no. 2 (March–April 1998): 73–84.
[8]R. Schmenner and M. Swink, "On Theory in Operations Management," *Journal of Operations Management* 17, no. 1 (1998): 101.

SUPPLY CHAIN CONNECTIONS

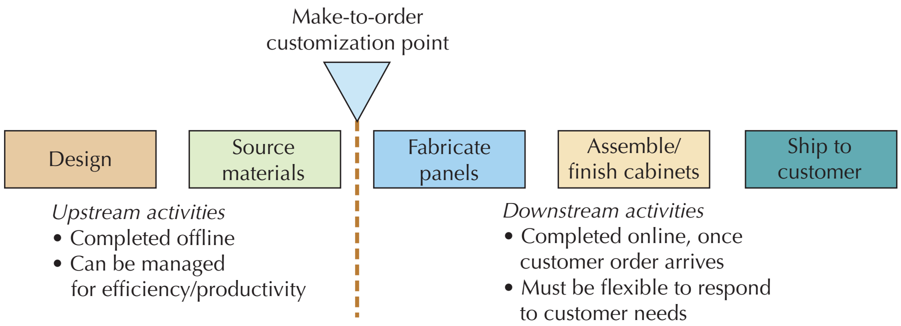


FIGURE 3.7 TimberEdge Cabinets Before: Make-to-Order Manufacturing

TIMBEREDGE CABINETS

TimberEdge Cabinets[9] illustrates what can happen when a manufacturing organization changes its customization point. Originally, TimberEdge manufactured custom-fit cabinets for home kitchens and bathrooms. Manufacturing was make-to-order (MTO). Specifically, the customization point occurred in TimberEdge's fabrication area, where the cabinet sides and back and front panels were actually cut to a customer's exact specifications (Figure 3.7).

While the make-to-order system provided considerable flexibility, it also created several problems. First, lead times to the customer often ran several weeks or more because cabinet panels could not be fabricated in advance. The long lead times also made it more difficult to coordinate the completion of cabinets with the construction schedules of new homes. In addition, the slight dimensional differences from one job to the next forced TimberEdge to use highly flexible, albeit less efficient, equipment and labor in the fabrication area.

Management concluded that a selection of standard-sized panels (sized in two-inch increments) would provide enough product range to satisfy customers' needs. As a result, management transformed the product into an assemble-to-order (ATO) one (Figure 3.8). Under this arrangement, the fabrication area now became an *upstream* activity. New manufacturing equipment was used in the fabrication area to produce large batches of standard-sized panels *before* the customer orders arrived. Customization now took place in the assembly and finishing steps, which were organized around a job shop style of manufacturing process.

The results were impressive. The switch from MTO to ATO allowed greater efficiency in the fabrication area. Because fabrication—the longest and most labor-intensive value chain activity—was now offline, lead times to the customer shrank from weeks to days. Inventory levels were cut in half, and the workforce was decreased by 25%. Quality actually increased due to the focus on standard-sized panels.

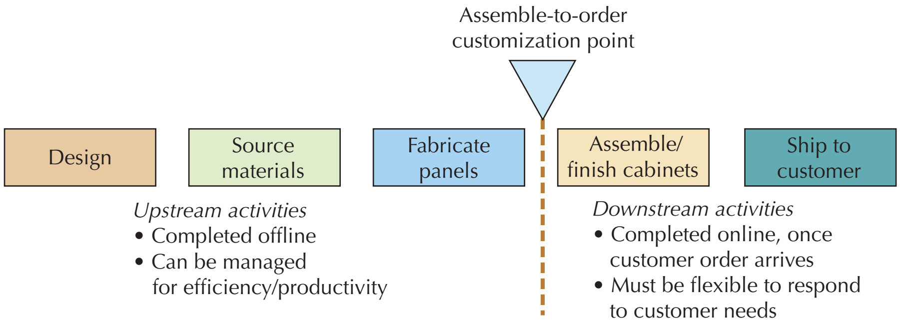


FIGURE 3.8 TimberEdge Cabinets After: Assemble-to-Order Manufacturing

[9] The company name has been changed to protect the company's confidentiality.

SUPPLY CHAIN CONNECTIONS

CUSTOMER-INTRODUCED VARIABILITY IN SERVICES

In her article "Breaking the Trade-off between Efficiency and Service," Professor Frances Frei of the Harvard Business School poses an interesting question:

> *What if a manufacturer had to deal with customers waltzing around its shop floor? What if they showed up, intermittently and unannounced, and proceeded to muck up the manufacturer's carefully designed processes left and right? For most service businesses, that's business as usual. In a restaurant or a rental car agency or most of the other service companies that make up the bulk of mature economies today, customers aren't simply the open wallets at the end of an efficient supply chain. They're directly involved in ongoing operations. The fact that they introduce tremendous variability—but complain about any lack of consistency—is an everyday reality.*[10]

In fact, Professor Frei suggests that there are five distinct forms of customer-introduced variability:

1. **Arrival variability.** Customers arrive when they desire service. In some cases, this can be controlled (e.g., a hotel reservation system). In other cases, it cannot (e.g., emergency medical services).
2. **Request variability.** Customers demand and expect different services outcomes, even from the same service provider. One customer might want a restaurant to make a menu substitution, while another might want the restaurant to serve her after closing time.
3. **Capability variability.** Some customers are capable of performing many service tasks themselves, while others require substantial hand-holding.
4. **Effort variability.** Even if they are capable of performing certain tasks, customers can differ from one another with regard to the amount of effort they are willing to apply to these tasks. For example, some customers at a grocery checkout will bag their own groceries; others will wait for the cashier or someone else to do it.
5. **Subjective preference.** Different customers can perceive the same service outcome differently. What one customer might interpret as a "quick and efficient" answer to a question might strike another customer as a "cold, unsympathetic" response.

Professor Frei goes on to identify different strategies service organizations can use to manage these different forms of variability. For example, services can use targeted marketing to attract customers with very similar needs and capabilities, thereby reducing request and capability variability. In addition, services can use well-designed automation systems and low-cost labor to take over some of the "hand-holding" that might otherwise be done by more expensive skilled labor.

[10]F. Frei, "Breaking the Trade-off between Efficiency and Service," *Harvard Business Review* 84, no. 11 (November 2006): 92–101.

3.3 SERVICE PROCESSES

Business textbooks have traditionally differentiated between manufacturing and service operations. The reason for this distinction was that manufacturers produce tangible, physical products, while service operations provide intangible value. Unfortunately, this distinction has led some readers to assume that service operations are somehow "softer," or more difficult to pin down, than manufacturing operations.

In reality, service operations are more diverse than manufacturing operations. Some service operations even have more in common with manufacturing than they do with other services. Consider package sorting at a UPS center. Packages are sorted using highly specialized sorting and reading equipment. This activity occurs "behind the scenes," out of the customer's view. Furthermore, the equipment is arranged sequentially, following a product-based layout. One can readily see that package sorting has more in common with batch manufacturing than it does with other services, such as consulting or teaching. On the other hand, services frequently have to deal directly with customers, who introduce considerable variability into the service process (see the *Supply Chain Connections* feature).

To begin our discussion of services, then, let's consider three dimensions on which services can *differ*: the nature of the service package, the degree of customization, and the level of customer contact.[11] These dimensions have a great deal to do with how different services are organized and managed.

[11]Our discussion and model of service processes is derived from the work of Roger Schmenner and, in particular, from R. Schmenner, "How Can Service Businesses Survive and Prosper?," *Sloan Management Review* 27, no. 3 (Spring 1986): 21–32.

TABLE 3.1
Sample Activities in Two Distinct Service Packages

SERVICE	INTANGIBLE ACTIVITIES	PHYSICAL ACTIVITIES
University	Teaching Conducting research Performing service and outreach	Supporting the "physical plant" Providing transportation services Providing dining services
Logistics services provider	Finding the best transportation solution for the customer Handling government customs issues	Moving goods Storing goods

Service Packages

Service package
A package that includes all the value-added *physical* and *intangible* activities that a service organization provides to the customer.

A **service package** includes all the value-added *physical* and *intangible* activities that a service organization provides to the customer. For some service operations, the primary sources of value are physical activities, such as the storage, display, or transportation of goods or people. Airlines move passengers from one city to another; hotels provide travelers with rooms and meeting facilities. Retailers add value by providing customers with convenient access to a wide range of products at a fair price. Many of the same rules and techniques that are used to manage physical goods in a manufacturing setting apply equally well to these services, even though airlines, hotels, and retail stores do not actually "make" products.

For other services, the service package consists primarily of intangible activities. A lawyer or an editor, for example, creates value primarily through the knowledge he or she provides. The fact that this knowledge might be captured on paper or electronically is secondary.

Most service packages include a mix of physical and intangible value-adding activities. Table 3.1 lists some of the activities in the service packages offered by a university and a logistics services provider.

While the primary source of value that logistics companies provide might be the movement and storage of goods, such companies also routinely determine the best transportation options for customers and handle customs paperwork. Airlines are another example of a mix of physical and intangible services. In addition to providing physical transportation, airlines help travelers plan their itineraries and track their frequent flier miles.

The greater the emphasis on physical activities, the more management's attention will be directed to capital expenditures (buildings, planes, and trucks), material costs, and other tangible assets. Retailers, for instance, frequently spend more than 60 cents of every sales dollar on products. These products must be moved, stored, displayed, and in some cases returned. Hotel and airline executives also spend a great deal of time managing expensive tangible assets.

The greater the emphasis on intangible activities, the more critical are the training and retention of skilled employees and the development and maintenance of the firm's knowledge assets. Labor cost tends to be quite a high percentage of total cost in such environments. In some intellectually intensive services, such as consulting, labor costs may far outstrip expenditures on buildings and other physical assets.

Knowledge assets generally refer to the intellectual capital of the firm, which may be embedded in the people, the information systems, or the copyrights and patents owned by a firm. For example, Oracle spends an enormous amount of time developing, refining, and protecting its software offerings. Oracle's market intelligence about competitors' products and customer needs can also be viewed as a key knowledge asset.

Service Customization

Customization has an enormous impact on how services are designed and managed. *As the degree of customization decreases,* the service package becomes more standardized. To deliver a standardized service, managers can hire workers with more narrow skills and employ special-purpose technology. Within the same business sector, for instance, one law firm might specialize in divorce or traffic cases, while another might offer a full range of legal services, depending on the customer's needs. Law firms that specialize in divorces can use special software packages designed to help clients reach a quick and equitable settlement.

Controlling the degree of customization also allows better measurement and closer control over the service process. In some cases, managers might draw up a precise, step-by-step process map of the service and establish standard times for performing each step. Many fast-food restaurants follow such an approach.

Not surprisingly, businesses that offer less-customized services have more opportunity to focus on cost and productivity. A classic example is an automotive shop dedicated only to oil changes. Employees in this type of business do not need to be master mechanics or skilled electricians, nor do they need a broad range of expensive equipment and tools. Furthermore, customers can be handled at a predictable and relatively fast rate. The standardized nature of the service allows many such shops to guarantee that a customer's car will be serviced within some precise period, usually an hour or less.

As the degree of customization increases, the service package becomes less predictable and more variable. Efficiency and productivity, while they are important, become much more difficult to measure and control, as each customer may have unique needs. Organizations that offer customized services tend to compete less on cost and more on their ability to provide customers with exactly what they need.

Consider, for example, a general hospital that offers a full range of health care services, from pediatrics to surgery. On any given day, the mix of patients and ailments the hospital must treat is only partially predictable. The breadth and depth of skills required to deal with any and every eventuality are high, and labor costs are, therefore, high as well. Such a hospital also needs to invest in a wide range of technologies, some of which might be quite expensive.

Customer Contact

A third consideration in managing service processes is the level of customer contact. Contact is *not* the same as customization. A fast-food restaurant provides a high degree of customer contact but little customization. On the other hand, a health clinic provides a high degree of contact *and* customization: Physicians may need to see patients frequently to make diagnoses, prescribe treatments, and monitor the effectiveness of treatments.

Front room
The physical or virtual point where the customer interfaces directly with the service organization.

The degree of customer contact determines the relative importance of front-room and back-room operations in a service process. The **front room** in a service organization is the point (either physical or virtual) where the customer interfaces directly with the service organization. It may be the sales floor in a retail store, the help desk for a software provider, or the Web page for a company. The front-room operations of an airline include the reservation desk, baggage check-in, and terminal gate, as well as the planes themselves. As a rule, *as the degree of customer contact increases*, more of the service package is provided by front-room operations.

In designing front-room operations, managers must consider how the customer interfaces with the service. Layout, location, and convenience become key. The physical layout must be comfortable, safe, and attractive, and the location must be convenient. In addition, front-room service must be available when the customer needs it. FedEx Kinko's is an example of a high-contact service: Its copying services are available 24 hours a day at locations convenient to colleges and universities.

Back room
The part of a service operation that is completed without direct customer contact.

As the degree of customer contact decreases, more of the service package is provided by back-room operations. The **back room** refers to the part of a service operation that is completed without direct customer contact. The back room is often hidden from the customer's view. Package sorting at FedEx or UPS is a classic example of a back-room operation, as is the testing of medical samples. Such services can be located to reduce transportation costs and laid out to improve productivity. Because back-room personnel do not deal directly with customers, the hours of operation are not as crucial as they are in front-room operations, and employees do not have to be skilled in dealing with customers. FedEx and UPS personnel sort packages in the middle of the night, while customers are sleeping. As you might expect, back-room service operations are usually easier to manage than front-room operations.

Table 3.2 summarizes the different managerial challenges faced by services, depending on the nature of the service package, the degree of customization, and the degree of customer contact.

Service blueprinting is a specialized form of business process mapping (Chapter 4) that allows the user to better visualize the degree of customer contact.[12] The service blueprint does

[12]M. J. Bitner, "Managing the Evidence of Service," in E. E. Scheuing and W. F. Christopher, eds., *The Service Quarterly Handbook* (New York: AMACOM, 1993).

TABLE 3.2
Managerial Challenges in Service Environments

Nature of the service package	**Primarily physical activities -->** Greater emphasis on managing physical assets (airline, trucking firm).	**Primarily intangible activities -->** Greater emphasis on managing people and knowledge assets (law firm, software developer).
Degree of customization	**Lower customization -->** Greater emphasis on closely controlling the process and improving productivity (quick-change oil shop).	**Higher customization -->** Greater emphasis on being flexible and responsive to customers' needs (full-service car repair shop).
Degree of customer contact	**Lower contact -->** More of the service package can be performed in the back room. Service layout, location, and hours will be based more on cost and productivity concerns (mail sorting).	**Higher contact -->** More of the service package must be performed in the front room. Service layout, location, and hours must be designed with customer convenience in mind (physical therapist).

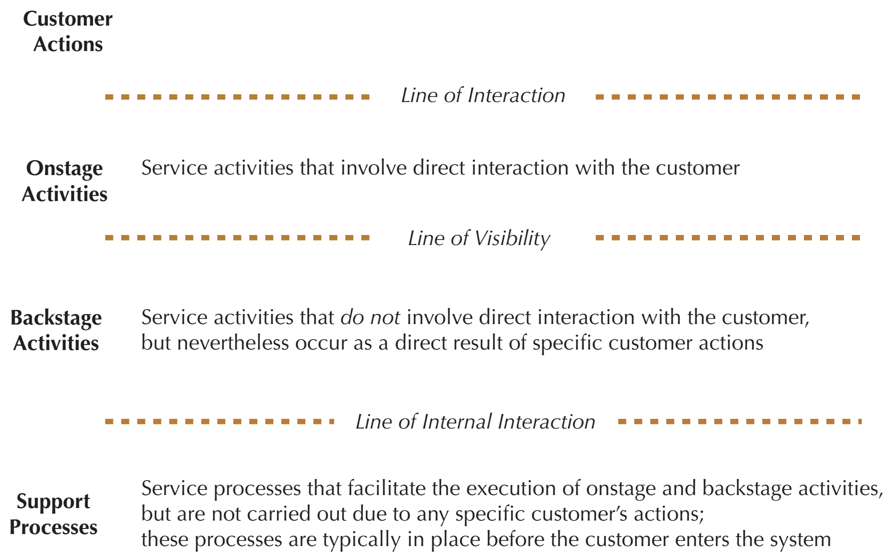
this in two ways. First, it lays out the service process from the viewpoint of the customer. It then parses out the organization's service actions based on (1) the extent to which an action involves direct interaction with the customer and (2) whether an action takes place as a direct response to a customer's needs.

Figure 3.9 provides a template for the service blueprint. The blueprint has four layers. The first layer represents specific *customer actions*, such as placing an order, calling up a service support hotline, or entering a service facility, such as a doctor's office or a retail store. The second layer represents *onstage actions* carried out by the service provider. Onstage actions provide a point of direct interaction with the customer. Some proponents of service blueprinting reserve this layer for activities that involve direct *face-to-face* interaction with the customer. Others argue that any form of direct interaction, whether it is a phone call or a visit to a Web site, would appear here. In this sense, onstage activities are synonymous with front-room operations. Because onstage actions involve direct interaction with the customer, they cross the *line of interaction* and occur above the *line of visibility*.

The third layer of the service blueprint consists of *backstage actions*. These actions take place in direct response to a customer action, but the customer does not "see" these activities carried out. They therefore take place below the line of visibility and are analogous to back-room operations. An example would be the activities required to pick, pack, and ship books and videos you order from Amazon.com. You don't see these activities take place, but nevertheless they occur as a direct result of your placing an order.

The fourth layer of the service blueprint contains *support processes*. Unlike onstage and backstage actions, these processes do not occur as a result of any particular customer's actions.

FIGURE 3.9
Service Blueprinting Template



Peter Bernik/Shutterstock

Most of a personal trainer's activities occur onstage—that is, in direct interaction with the customer. Other activities, such as scheduling and billing, occur backstage or even as support activities.

Rather, these processes facilitate the execution of onstage and backstage actions. In the language of service blueprinting, they do this by crossing the *line of internal interaction*. Continuing with our example, Amazon's Web site development and inventory management processes ensure that there is a Web site that can take your order (and credit card information!) and that the products you want are in stock.

EXAMPLE 3.1

Service Blueprinting at the Bluebird Café

Katie Favre, owner of the Bluebird Café, has developed a simple process map of all the steps that occur when a customer visits her café. This process map is shown in Figure 3.10.

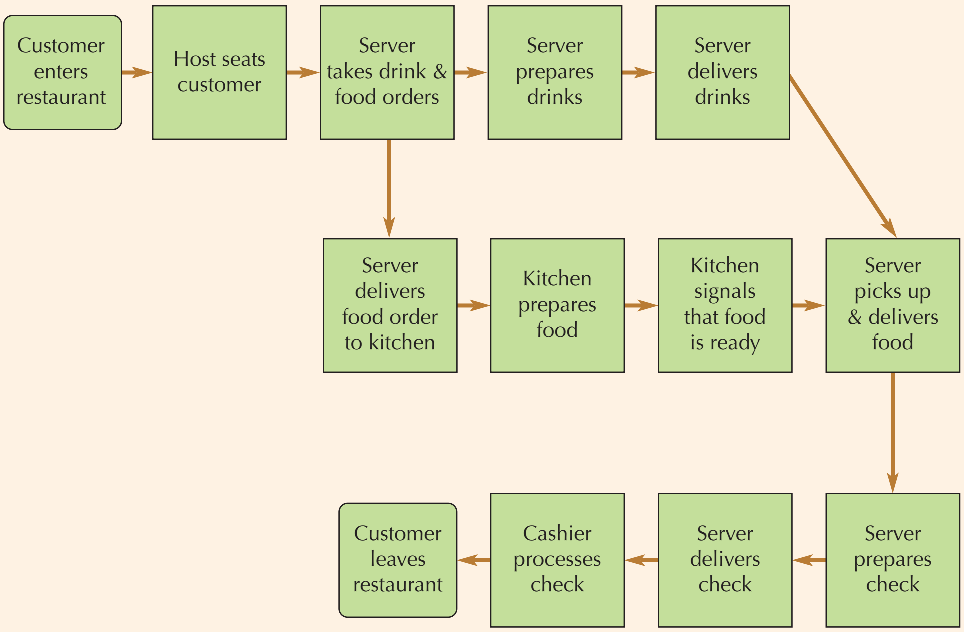


FIGURE 3.10 Process Map for the Bluebird Café

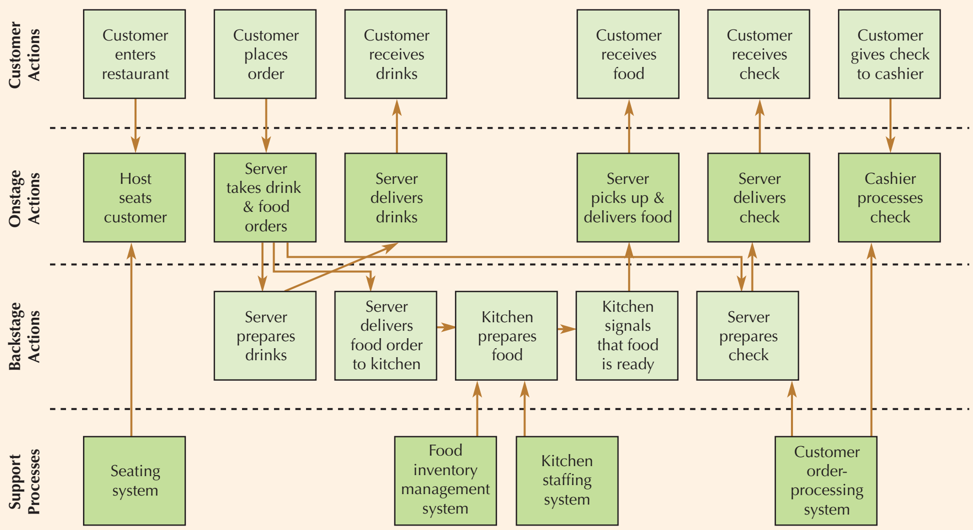


FIGURE 3.11 **Service Blueprint for the Bluebird Café**

Katie feels that it would be valuable to remap this process using service blueprinting so that she can better see how the customer interacts with her staff. Furthermore, Katie would like to understand what support processes are critical to carrying out the onstage and backstage actions. Figure 3.11 presents the resulting service blueprint.

Looking at the service blueprint provides Katie with new insights into her business. First, Katie notes that there are six points at which the customer directly interacts with her staff. Furthermore, four of these six interactions occur between the server and the customer. Katie has usually had her friendliest and most efficient people serve as hosts or cashiers, but the service blueprint makes her wonder about the wisdom of this policy.

Katie also observes that the ability of the kitchen to prepare food (a backstage activity) depends in part on two support processes: the food management inventory system, which makes sure that the right quantities of food are on hand and properly stored; and the kitchen staffing system, which makes sure the proper number and mix of personnel are available.

Katie has heard grumblings in the past about the kitchen staffing system (really just an informal sign-up sheet). She had dismissed this as a problem for the kitchen management staff to resolve, but now she begins to think about how this "invisible," indirect support process might potentially undermine key backstage and onstage actions.

Service Positioning

Service operations compete and position themselves in the marketplace based on the three dimensions—nature of the service package, degree of customization, and degree of customer contact—that were just discussed. Figure 3.12 shows a conceptual model of service processes containing these three dimensions. The three dimensions of the cube represent the nature of the service package, the degree of customization, and the level of contact with the customer.

To illustrate how positioning works, consider the case of public hospitals. Such community-sponsored hospitals are typically chartered to provide a wide selection of health services to the local population. These hospitals are characterized by:

- High levels of service customization.
- High levels of customer contact.
- A mix of physical and intangible service activities.

These characteristics make community hospitals very expensive to run and very challenging to manage. The position of such service operations is shown graphically in Figure 3.13.

FIGURE 3.12
A Conceptual Model of Service Process

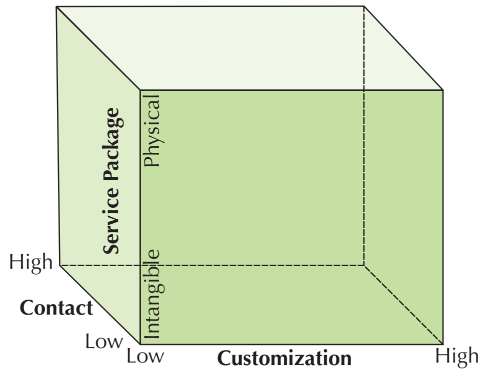


FIGURE 3.13
Positioning a Typical Community Hospital

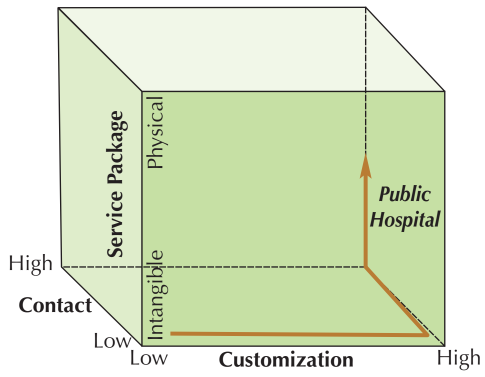
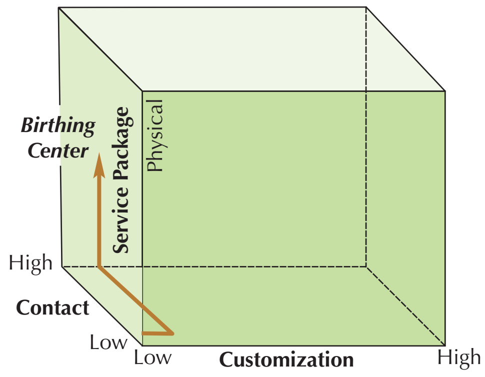


FIGURE 3.14
Positioning a Birthing Center



Now compare this to a birthing center that specializes in low-risk births (Figure 3.14). All the center's personnel and equipment are focused on a single activity. While customer contact is high, customization of the service package is relatively low.

A birthing center competes by staking out a position quite different from that of the traditional public hospital. As a result, the birthing center and the hospital face different managerial challenges and meet different customer needs. While the typical birthing center competes by offering greater efficiency and a more "family-friendly" atmosphere than the typical public hospital, it cannot meet the broad range of health care needs found in a community hospital. A birthing center may "steal" some business from the local hospital, but it cannot replace it.

Services within the Supply Chain

Many people view supply chains as being dominated by manufacturers. However, take a moment to look back at the beginning of Chapter 1, which starts with descriptions of four companies: Walmart, FedEx, Flex Ltd., and SAP. Note that two of these companies, Walmart and FedEx, are service firms that provide both physical and intangible activities. SAP is a service firm that provides software for the management of supply chains. All three companies, in fact, are deeply

Brian Branch-Price/AP Images

Birthing centers have a high degree of customer contact and represent a mix of physical and intangible activities. But because they focus on one particular health care need, the degree of customization is low.

involved with supply chain management issues. Large retailers like Walmart "pull" products through the supply chain, companies like FedEx make sure products and materials arrive in a timely and cost-effective manner, and companies like SAP provide the "smarts" needed to run supply chains as effectively as possible.

The point is that services are an integral part of any supply chain. Of course, some services have very little to do with supply chains, due to the nature of the service package. But for others, supply chains are a source of both products and business opportunities.

3.4 LAYOUT DECISION MODELS

An important part of process choice is deciding how the various resources will be logically grouped and physically arranged. We have already described four types of layouts in this chapter: product-based, functional, cellular, and fixed-position layouts. For a fixed-position layout, there is really little discretion regarding how the process is laid out because the productive resources have to be moved to where the product is being made or the service is being provided.

For the remaining three, however, managers face choices regarding how the processes are laid out. A product-based layout arranges resources sequentially, according to the steps required to make a product or provide a service. The security check-in at an airport is an example of a service process that follows a product-based layout (where the "product" is the passenger). Such an arrangement makes sense when the sequence of activities does not change from one period to the next. In contrast, a functional layout physically groups resources by function. A functional layout is better suited to environments where the process steps can change dramatically from one job or customer to the next. An example of this would be a full-service auto repair facility, with inspections done in one area, alignments in another, and major repairs in a third area. Finally, a cellular layout is similar in many ways to a product-based layout. The primary difference is that the cellular layout is used in a group technology cell, where the production resources have been dedicated to a subset of products with similar requirements, known as a product family.

In the remainder of this section, we introduce two approaches that managers use to develop effective product-based and functional layouts: line balancing and assigning department locations in functional layouts.

Line Balancing

Line balancing is a technique used in developing product-based layouts, as would be found in a production line or group technology work cell. The technique works by assigning tasks to a series of linked workstations in a manner that minimizes the number of workstations and minimizes the total amount of idle time at all stations for a given output level.[13] When the amount of work assigned to each workstation is identical, we say the line is perfectly balanced. In reality, most lines are unbalanced, as the actual amount of work varies from one workstation to the next. The six basic steps of line balancing are as follows:

Takt time
In a production line setting, the available production time divided by the required output rate. Takt time sets the maximum allowable cycle time for a line.

1. Identify all the process steps required, including the time for each task, the immediate predecessor for each task, and the total time for all tasks.
2. Draw a precedence diagram based on the information gathered in step 1. This diagram is used when assigning individual tasks to workstations.
3. Determine the takt time for the line. **Takt time** is computed as the available production time divided by the required output rate:

$$\text{Takt time} = \frac{\text{available production time}}{\text{required output rate}} \tag{3.1}$$

   Simply put, takt time tells us the maximum allowable time between completions of successive units on the line. As we noted earlier, the actual time between completions is referred to as the *cycle time* of a line.
4. Compute the theoretical minimum number of workstations needed. The theoretical minimum number of workstations is defined as:

$$W_{Min} = \frac{\sum_{i=1}^{I} T_i}{\text{takt time}} \tag{3.2}$$

   where:

   T_i = time required for the ith task

   $\sum_{i=1}^{I} T_i$ = total time for all I tasks

   As you can see, the shorter the required takt time is, the more workstations we will require. This is because the tasks will need to be divided across more workstations to ensure that cycle time, which is determined by the total amount of work time in the largest workstation, remains below the takt time.
5. Working on one workstation at a time, use a decision rule to assign tasks to the workstation. Start with the first workstation and add tasks until you reach the point at which no more tasks can be assigned without exceeding the takt time. If you reach this point and all the tasks have not been assigned yet, close the workstation to any more tasks and open up a new workstation. Repeat the process until all tasks have been assigned.

   Be sure not to assign a task to a workstation unless all direct predecessors (if any) have been assigned. Common decision rules for determining which task to assign next are to (1) assign the largest eligible task that will still fit within the workstation without exceeding the takt time, (2) assign the eligible task with the most tasks directly dependent on it, or (3) assign based on some combination of the two.
6. Evaluate the performance of the proposed line by calculating some basic performance measures, including:

$$\text{Cycle time} = CT = \text{maximum amount of time spent in any one workstation} \tag{3.3}$$

$$\text{Idle time} = IT = W_{Actual}CT - \sum_{i=1}^{I} T_i \tag{3.4}$$

   where:

   W_{Actual} = actual number of workstations

---
[13]Blackstone, *APICS Dictionary*.

$$\text{Percent idle time} = PI = 100\%\left[\frac{IT}{W_{Actual}C}\right] \tag{3.5}$$

$$\text{Efficiency delay} = ED = 100\% - PI \tag{3.6}$$

In general, solutions with low idle times and high efficiency delay values are considered superior. It's important to realize that the decision rules mentioned above will not always generate the best solution; good decision makers, therefore, look for ways to improve the solution.

EXAMPLE 3.2

Line Balancing at Blackhurst Engineering

Blackhurst Engineering, a small contract manufacturer, has just signed a contract to assemble, test, and package products for another company. The contract states that Blackhurst must produce 500 units per eight-hour day. The list of tasks, including time requirements and immediate predecessors, is as follows:

TASK	TIME (IN SECONDS)	IMMEDIATE PREDECESSOR(S)
A	15	None
B	26	A
C	15	A
D	32	B, C
E	25	D
F	15	E
G	18	E
H	10	E
I	22	F, G, H
J	24	I
Total	**202**	

Now that Blackhurst has won the business, Griffin Blackhurst, founder of the company, has decided to set up a line process to make the units. He knows that he will have to staff each workstation with one of his employees. Therefore, Griffin does not want to have any more workstations than necessary, and he would like to keep their idle time down to a minimum. As a first step, Griffin draws out the precedence diagram for the various tasks (Figure 3.15). Each task is represented by a box, and precedence relationships are shown with arrows.

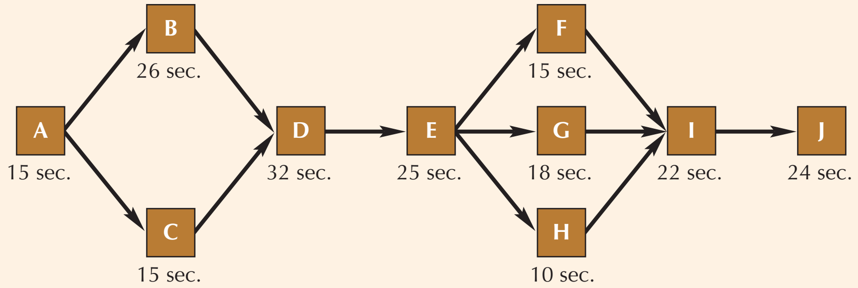


FIGURE 3.15 **Precedence Diagram for Blackhurst Engineering**

Next, Griffin calculates the maximum allowable cycle time, or takt time, for the proposed line. Because there are 28,800 seconds in an 8-hour shift:

$$\text{Takt time} = \frac{\text{available production time}}{\text{required output rate}} = \frac{28{,}800 \text{ seconds}}{500 \text{ units per day}} = 57.6 \text{ seconds}$$

With this information, Griffin calculates the theoretical minimum number of workstations:

$$W_{Min} = \frac{\sum_{i=1}^{I} T_i}{\text{takt time}} = \frac{202 \text{ seconds}}{57.6 \text{ seconds}} = 3.51, \text{ or } 4 \text{ workstations}$$

Griffin rounds up when determining W_{Min} because there is no such thing as a fractional workstation, and anything less than the calculated value would not be enough. Now that Griffin knows the takt time and the theoretical minimum number of workstations that will be needed, he begins to assign tasks to the workstations. He has decided to use the following decision rules:

1. Assign the largest eligible task that can be added to the workstation without exceeding the takt time.
2. If there is a tie, assign the eligible task with the most tasks directly dependent on it.
3. If there is still a tie, randomly choose among any of the tasks that meet the above two criteria.

Following these rules, Griffin begins assigning tasks to the first workstation. He assigns task **A** first, followed by task **B** and task **C**. At this point, the first workstation has a total workload of 56 seconds:

WORKSTATION 1	
Task **A**	15 seconds
Task **B**	26 seconds
Task **C**	15 seconds
Total	56 seconds

Because there are no more tasks that can be added to workstation 1 without exceeding the takt time of 57.6 seconds, Griffin closes workstation 1 to any further assignments and starts assigning tasks to workstation 2. Ultimately, Griffin ends up with the following assignments to the four workstations:

WORKSTATION 1	
Task **A**	15 seconds
Task **B**	26 seconds
Task **C**	15 seconds
Total	56 seconds

WORKSTATION 2	
Task **D**	32 seconds
Task **E**	25 seconds
Total	57 seconds

WORKSTATION 3	
Task **G**	18 seconds
Task **F**	15 seconds
Task **H**	10 seconds
Total	43 seconds

WORKSTATION 4	
Task **I**	22 seconds
Task **J**	24 seconds
Total	46 seconds

Figure 3.16 shows the workstation assignments.

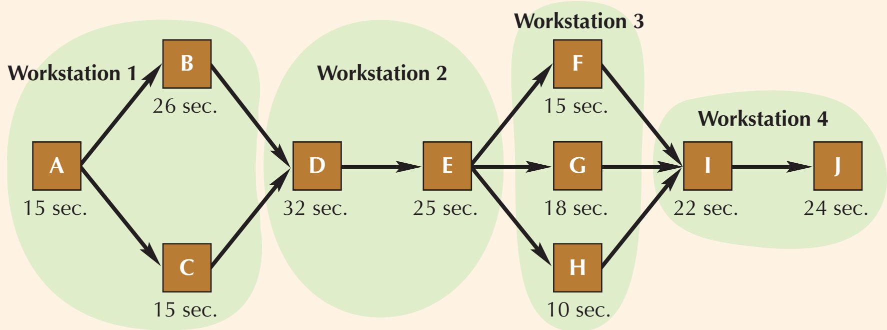


FIGURE 3.16 Workstation Assignments at Blackhurst Engineering

At 57 seconds, workstation 2 has the most task time of any workstation. Because units must be passed from one workstation to the next, units cannot move through the line any faster than the slowest workstation. Workstation 2 effectively dictates that the cycle time for the entire line will be 57 seconds.

The actual number of workstations (W_{Actual}) is the same as the theoretical minimum number (W_{Min}), which makes Griffin think he has developed a good solution. Nevertheless, he calculates the idle time, percent idle time, and efficiency delay for the proposed line:

$$\text{Idle time} = IT = W_{Actual}CT - \sum_{i=1}^{I} T_i = 4(57 \text{ seconds}) - 202 = 26 \text{ seconds}$$

$$\text{Percent idle time} = PI = 100\%\left[\frac{IT}{W_{Actual}CT}\right] = 100\%\left(\frac{26 \text{ seconds}}{228 \text{ seconds}}\right) = 11.4\%$$

$$\text{Efficiency delay} = ED = 100\% - PI = 88.6\%$$

Interpreting the numbers, the line has an idle time of 26 seconds because not all of the workstations have workloads equal to the cycle time of 57 seconds. In fact, the idle times for the four workstations are as follows:

WORKSTATION	CYCLE TIME – ACTUAL TIME = IDLE TIME
1	57 − 56 = 1 second
2	57 − 57 = 0 seconds
3	57 − 43 = 14 seconds
4	57 − 46 = 11 seconds
Total	26 seconds of idle time

Looking at the idle times for each workstation, Griffin realizes that the resulting line is not perfectly balanced. He will probably need to rotate his employees across the workstations to make sure no one feels slighted. The idle time and efficiency delay numbers tell us that a unit going through the process is idle 11.4% of the time. Conversely, the efficiency delay tells us that a unit going through the line is being worked on 88.6% of the time.

Assigning Department Locations in Functional Layouts

Because there is no clearly defined flow of tasks for functional layouts, a different approach to developing layouts is needed. In general, the objective here is to arrange the different functional areas, or *departments*, in such a way that departments that should be close to one another (such as packaging and shipping) are, while departments that don't need to be or shouldn't be near one another aren't.

While this may sound simple, developing functional layouts can actually be quite complex, especially when there is a large number of departments and the criteria for assigning locations are unclear. Experts have developed a variety of approaches to developing functional layouts. Under one approach, decision makers develop closeness ratings for each possible pairing of departments. These closeness ratings, which can be qualitative ("undesirable," "desirable," "critical," etc.) or quantitative (1, 2, 3, etc.), are then used to guide the layout decision.

Another approach, which we describe here, is to locate departments in such a way as to *minimize the total distance traveled*, given a certain number of interdepartmental trips per time period. The logic is that not only will this cut down on unproductive travel time, but also companies can gain natural synergies by locating highly interactive departments next to one another. As with line balancing, the process can be divided into several basic steps:

1. Identify the potential department locations and distances between the various locations.
2. For each department, identify the expected number of trips between the department and all other departments (interdepartmental trips).
3. Attempt to assign department locations in such a way as to minimize the total distance traveled. Several heuristics can be used when making these assignments:
   a. If a particular department can be assigned only to a certain location, do this first. For example, a firm may decide that the client waiting room must be located next to the building entrance. Making such assignments up front reduces the number of potential arrangements to consider.
   b. Rank order department pairings by number of interdepartmental trips and attempt to locate departments with the most interdepartmental trips next to one another.
   c. Centrally locate departments that have significant interactions with multiple departments. (This will help increase the likelihood that other departments can be located adjacent to it.)
   d. See if the solution can be improved by swapping pairs of departments.

In a practical sense, the only way to ensure that one has identified the optimal solution (i.e., the one that minimizes total distance traveled) is to evaluate all possible arrangements. However, this can be prohibitive, as there are $N!$ ways of assigning N departments to N locations. This means that for just five departments, there are $5! = 5 \times 4 \times 3 \times 2 \times 1 = 120$ possible combinations to consider. If there are 10 departments that must be assigned, the possible number of arrangements is a staggering $10! = 3{,}628{,}800$. Therefore, most decision makers seek to identify a viable, if not optimal, solution.

EXAMPLE 3.3

Assigning Departments at Blackhurst Engineering

Blackhurst Engineering has been so successful that its founder, Griffin Blackhurst, has decided to relocate the company to a new facility. Griffin has five departments that must be located within the facility: Accounting, Marketing, Engineering, Production, and Shipping & Receiving (S&R).

Figure 3.17 shows the layout of the new facility. The facility has five different areas, any of which is large enough to house the various departments. Because Shipping & Receiving needs access to the bay doors, Griffin has already assigned this department to area E. In addition, Griffin has determined that Production will need to be in either area C or area D due to the significant flow of materials between Production and Shipping & Receiving. Beyond this, however, Griffin has not decided where to place the four unassigned departments.

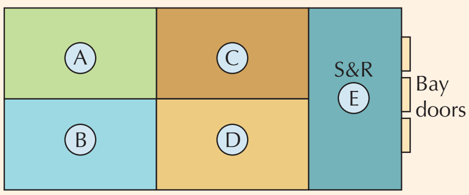


FIGURE 3.17 Layout of New Facility for Blackhurst Engineering

Because material flow will be addressed by locating Production next to Shipping & Receiving, Griffin has decided to base the final layout on the number of trips personnel make between departments. Specifically, he would like to minimize the total distance traveled per day.

In order to accomplish this, Griffin creates two tables. Table 3.3 shows the distance between the five areas shown in Figure 3.17. Table 3.4 shows the number of interdepartmental trips personnel make each day between the various departments.

TABLE 3.3 Distances (in meters) between Areas, Blackhurst Engineering

AREA	A	B	C	D	E
A	—				
B	30	—			
C	40	50	—		
D	50	40	30	—	
E	70	70	35	35	—

TABLE 3.4 Numbers of Daily Interdepartmental Trips, Blackhurst Engineering

DEPARTMENT	ACCOUNTING	MARKETING	PRODUCTION	ENGINEERING	SHIPPING
Accounting	—				
Marketing	80	—			
Production	35	110	—		
Engineering	60	40	55	—	
Shipping	10	25	90	5	—

After ranking the interdepartmental trip data in Table 3.4 from highest to lowest (Table 3.5), Griffin notes that the greatest number of interdepartmental trips are made between Production and Marketing (110 trips) and between Shipping and Production (90). In addition, the smallest number of trips are made between Shipping and Accounting (10) and between Shipping and Engineering (5). Based on this information, Griffin decides to locate Production and Marketing in areas C and D, respectively, and Accounting and Engineering in areas A and B, respectively (see Figure 3.18).

TABLE 3.5 Ranked Number of Daily Interdepartmental Trips, Blackhurst Engineering

DEPARTMENTS	AVERAGE TRIPS PER DAY
Production ⇔ Marketing	110
Shipping ⇔ Production	90
Marketing ⇔ Accounting	80
Engineering ⇔ Accounting	60
Engineering ⇔ Production	55
Engineering ⇔ Marketing	40
Production ⇔ Accounting	35
Shipping ⇔ Marketing	25
Shipping ⇔ Accounting	10
Shipping ⇔ Engineering	5

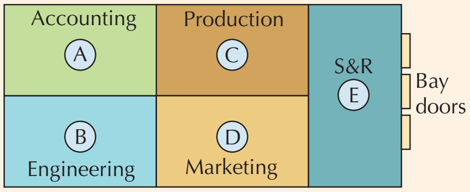


FIGURE 3.18 **Initial Layout Assignments at Blackhurst Engineering**

Griffin evaluates his proposed solution by multiplying the number of interdepartmental trips by the distances between departments. As Table 3.6 shows, the proposed solution results in total distance traveled per day of 19,925 meters.

TABLE 3.6 **Total Distance Traveled per Day, Initial Solution**

INTERDEPARTMENTAL TRAVEL	DISTANCE TRAVELED PER DAY (METERS)
Production ⇔ Marketing	110 trips * 30 = 3,300
Shipping ⇔ Production	90 * 35 = 3,150
Marketing ⇔ Accounting	80 * 50 = 4,000
Engineering ⇔ Accounting	60 * 30 = 1,800
Engineering ⇔ Production	55 * 50 = 2,750
Engineering ⇔ Marketing	40 * 40 = 1,600
Production ⇔ Accounting	35 * 40 = 1,400
Shipping ⇔ Marketing	25 * 35 = 875
Shipping ⇔ Accounting	10 * 70 = 700
Shipping ⇔ Engineering	5 * 70 = 350
Total distance traveled	19,925 meters

Looking at his solution, Griffin realizes that Production has more interactions with Engineering than Marketing does, while Marketing has more interactions with Accounting than Production does. Griffin wonders if he could improve his results by switching the locations of the Accounting and Engineering departments.

Figure 3.19 shows the revised layout. Recalculating the results (Table 3.7), Griffin realizes that this change cuts the total distance traveled by 600 meters (19,925 − 19,325 meters), or about 3%.

TABLE 3.7 **Total Distance Traveled per Day, Revised Solution**

INTERDEPARTMENTAL TRAVEL	DISTANCE TRAVELED PER DAY (METERS)
Production ⇔ Marketing	110 trips * 30 = 3,300
Production ⇔ Shipping	90 * 35 = 3,150
Marketing ⇔ Accounting	80 * 40 = 3,200
Engineering ⇔ Accounting	60 * 30 = 1,800
Engineering ⇔ Production	55 * 40 = 2,200
Engineering ⇔ Marketing	40 * 50 = 2,000
Production ⇔ Accounting	35 * 50 = 1,750
Shipping ⇔ Marketing	25 * 35 = 875
Shipping ⇔ Accounting	10 * 70 = 700
Shipping ⇔ Engineering	5 * 70 = 350
Total distance traveled	19,325 meters

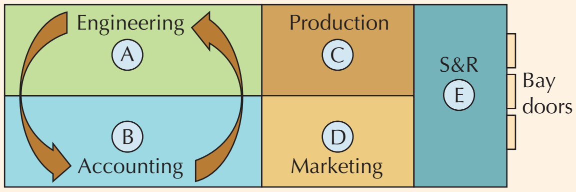


FIGURE 3.19 **Revised Layout Assignments at Blackhurst Engineering**

CHAPTER SUMMARY

In this chapter, we looked at some of the important issues managers face when selecting a manufacturing or service process. We started with a discussion of manufacturing processes, emphasizing the strengths and weaknesses of different types, and we described the impact of customization on the manufacturing process and the supply chain. As our discussion made clear, managers must be careful in selecting both the manufacturing process and the degree and point of customization.

We then turned our attention to service processes. We looked at three defining dimensions of services: the service package (the mix of physical and intangible activities), service customization, and customer contact. We showed how services face different managerial challenges, depending on where they stand on these dimensions. We also discussed how organizations can use this knowledge to position their services vis-à-vis their competition. Finally, we ended the chapter by demonstrating two approaches to developing layouts in manufacturing and service environments.

KEY FORMULAS

Takt time (page 59):

$$\text{Takt time} = \frac{\text{available production time}}{\text{required output rate}} \tag{3.1}$$

Theoretical minimum number of workstations (page 59):

$$W_{Min} = \frac{\sum_{i=1}^{I} T_i}{\text{takt time}} \tag{3.2}$$

where:

T_i = time required for the *i*th task

$\sum_{i=1}^{I} T_i$ = total time for all *I* tasks

Cycle time for a production line (page 59):

$$CT = \text{maximum amount of time spent in any one workstation} \tag{3.3}$$

Idle time (page 59):

$$IT = W_{Actual}CT - \sum_{i=1}^{I} T_i \tag{3.4}$$

where:

W_{Actual} = actual number of workstations

Percent idle time (page 60):

$$PI = 100\%\left[\frac{IT}{W_{Actual}CT}\right] \tag{3.5}$$

Efficiency delay (page 60):

$$ED = 100\% - PI \tag{3.6}$$

KEY TERMS

SOLVED PROBLEM

PROBLEM

Monster Bags

Every Halloween, the sisters of Alpha Delta Pi put together "Monster Bags" for children at the local hospital. Each Monster Bag consists of a paper bag stuffed with candy. Each bag has a character's face drawn on it, with yarn hair and paper arms and legs attached.

For the past three years, several sisters have worked individually, putting together bags on their own. But because some of the women are much better artists than others, the quality of the Monster Bags has varied greatly.

Erika Borders, a supply chain major, has been thinking about this problem. She realizes that making each bag really consists of several steps:

A Draw the face on the bag.
B Cut out the arms and legs.
C Attach the arms and legs.
D Cut the yarn for the hair.
E Attach the hair to the bag.
F Fill the bag with candy.
G Staple the bag closed.

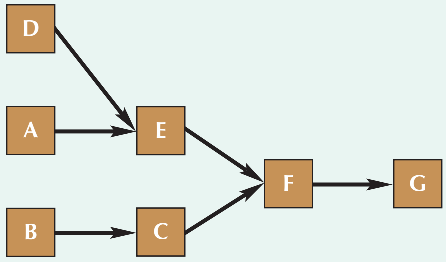
Erika decides that the ideal solution would be to develop a production line to make the bags. This way, the most talented artists can focus on what they do best—drawing the characters' faces. She has developed the time estimates and predecessor data for the tasks:

TASK	TIME (SECONDS)	IMMEDIATE PREDECESSORS
A	45	None
B	60	None
C	30	B
D	15	None
E	25	A, D
F	10	C, E
G	10	F
Total	195	

Alpha Delta Pi needs to make 200 bags, and Erika feels she would have no problem getting volunteers to help if they could get all the bags done in four hours.

Solution

After a couple of tries, Erika draws out the precedence diagram for the tasks:



She then calculates the takt time for her production line:

$$\text{Takt time} = \frac{\text{available production time}}{\text{required output rate}} = \frac{14{,}400 \text{ seconds}}{200 \text{ bags}} = 72 \text{ seconds}$$

and the theoretical minimum number of workstations:

$$W_{Min} = \frac{\sum_{i=1}^{I} T_i}{\text{takt time}} = \frac{195 \text{ seconds}}{72 \text{ seconds}} = 2.7, \text{ or } 3 \text{ workstations}$$

Next, Erika begins to assign tasks to the various workstations. The rule she uses is to assign the largest eligible task (i.e., the largest task that has all its predecessors assigned and that will still fit in the workstation without exceeding the takt time). In the case of a tie, she assigns the task with the most tasks depending directly on it. Working on one task at a time, Erika develops an initial solution:

WORKSTATION 1	
Task **B**	60 seconds
Total	60 seconds

WORKSTATION 2	
Task **A**	45 seconds
Task **D**	15 seconds
Total	60 seconds

WORKSTATION 3	
Task **C**	30 seconds
Task **E**	25 seconds
Task **F**	10 seconds
Total	65 seconds

WORKSTATION 4	
Task **G**	10 seconds
Total	10 seconds

Erika is not completely happy with her solution; workstation 4 has only 10 seconds of work, while every other workstation has 60 seconds or more. The current solution would generate a lot of idle time. To balance things out better, she decides to move task **D** into workstation 3 and tasks **E** and **F** into workstation 4:

WORKSTATION 1	
Task **B**	60 seconds
Total	60 seconds

WORKSTATION 2	
Task **A**	45 seconds
Total	45 seconds

WORKSTATION 3	
Task **D**	15 seconds
Task **C**	30 seconds
Total	45 seconds

WORKSTATION 4	
Task **E**	25 seconds
Task **F**	10 seconds
Task **G**	10 seconds
Total	45 seconds

Although Erika was not able to fit all the tasks into the theoretical minimum number of workstations, the new solution is much better balanced. Doing so also reduces the cycle time from 65 seconds to 60 seconds. Total idle time for the line is now:

$$\text{Idle time} = IT = W_{Actual}CT - \sum_{i=1}^{I} T_i$$

$$= 4(60 \text{ seconds}) - 195 \text{ seconds} = 45 \text{ seconds}$$

$$\text{Percent idle time} = PI = 100\%\left[\frac{IT}{W_{Actual}CT}\right] = 100\%\left(\frac{45 \text{ seconds}}{240 \text{ seconds}}\right) = 18.8\%$$

Efficiency delay = ED = 100% − PI = 81.2%

Now all Erika needs to do is to line up four volunteers, including a good artist to handle workstation 2. So where *are* the pledges?

DISCUSSION QUESTIONS

1. Suppose a firm invests in what turns out to be the "wrong" process, given the business strategy. What will happen? Can you think of an example?
2. In general, would you expect to see production lines upstream or downstream of the customization point in a supply chain? What about job shops? Explain.
3. At many college athletic events, you can find plastic drink cups with the school logo printed on them. Years ago, these cups came molded in a variety of colors. Now nearly all the cups are white with only the printed logos containing any color. Use the concept of the customization point to explain what has happened and why.
4. Between 1964 and 1966, Ford made more than 1 million Mustangs. Today car collectors are spending tens of thousands of dollars to restore to "like new" vintage Mustangs that originally sold for around $3,000. What types of manufacturing processes do you think were originally used to produce Mustangs? What types of manufacturing processes do you think are used in the restoration of such cars? Why the difference?

5. How does a group technology process resemble a classic batch process? How does it resemble a classic production line? What are the advantages/disadvantages of such a hybrid manufacturing process?
6. Many universities now offer online courses in lieu of traditional classes. These courses often contain lecture notes, linkages to videos and other documents, and online testing capabilities. From a services perspective, how are online courses positioned vis-à-vis large lecture classes? What are the advantages and disadvantages of online courses? What are the managerial challenges?

PROBLEMS

(* = easy; ** = moderate; *** = advanced)

Problems for Section 3.4 Layout Decision Models

1. Burns Boats wants to assemble 50 boats per eight-hour day, using a production line. Total task time for each boat is 45 minutes.
   a. (*) What is the takt time? What is the theoretical minimum number of workstations needed?
   b. (**) Suppose the longest individual task takes four minutes. Will Burns be able to accomplish its goal? Justify your answer.
2. (*) A production line has four workstations and a 50-second cycle time. The total amount of actual task time across all four workstations is 170 seconds. What is the idle time? The percent idle time? The efficiency delay?
3. (**) Polar Containers makes high-end coolers for camping. The total task time needed to make a cooler is 360 seconds, with the longest individual task taking 50 seconds. Polar Containers would like to set up a line capable of producing 50 coolers per eight-hour day. What is the takt time? What is the maximum output per day? (*Hint:* Consider the longest individual task time.)
4. LightEdge Technologies would like to put in place an assembly line in its Mexican facility that puts together Internet servers. The tasks needed to accomplish this, including times and predecessor relationships, are as follows:

TASK	TIME (MINUTES)	IMMEDIATE PREDECESSOR
A	2.9	None
B	0.2	None
C	0.25	A, B
D	0.4	A, B
E	1.7	C
F	0.1	C, D
G	0.7	D
H	1.7	E, F, G
I	1.2	H
J	2.3	I
K	2.7	I
L	1.5	J, K

   a. (*) Draw a precedence diagram for the tasks. Suppose the takt time is 240 seconds (four minutes). What is the theoretical minimum number of workstations?
   b. (**) Develop workstation assignments using the "largest eligible task" rule (i.e., assign the largest task that will fit into the workstation without exceeding the takt time).
   c. (**) How many workstations does your solution require? What is the cycle time for the line? What is the idle time?
5. The state tax department wants to set up what would amount to a series of identical production lines (running eight hours a day) for processing state tax returns that are submitted on the state's "EZ" form. The various tasks, times, and precedence relationships for each line follow:

TASK	TIME (MINUTES)	DIRECT PREDECESSORS
A. Open return; verify filer's name, address, and taxpayer ID.	0.75	None
B. Make sure W2 and federal information match computer records.	1.25	A
C. Check key calculations on return for correctness.	2.50	B
D. Print report to go with return.	0.50	C
E. Route return to refund, payment, or special handling department, based on the results.	0.30	D
F. Update status of return on computer system.	3.0	D

   The director has determined that each line needs to process 150 returns a day. The director has asked you to develop a proposed layout that would be shared across the lines.
   a. (*) What is the takt time for each line? What is the theoretical minimum number of workstations needed on each line?
   b. (**) Make workstation assignments using the "largest eligible task" rule. Calculate the cycle time, idle time, percent idle time, and efficiency delay for the resulting line.
   c. (***) Given the task times listed above, what is the minimum cycle time that can be achieved by a line? What is the maximum daily output that could be achieved by a single line?

6. Rayloc rebuilds automotive components. Its main facility has a work cell dedicated to rebuilding fuel pumps. The tasks, times, and predecessor relationships are as follows:

TASK	TIME (SECONDS)	IMMEDIATE PREDECESSOR
A	100	None
B	150	None
C	93	**A**
D	120	**B**
E	86	**B**
F	84	**C**
G	65	**D**, **E**
H	15	**F**, **G**

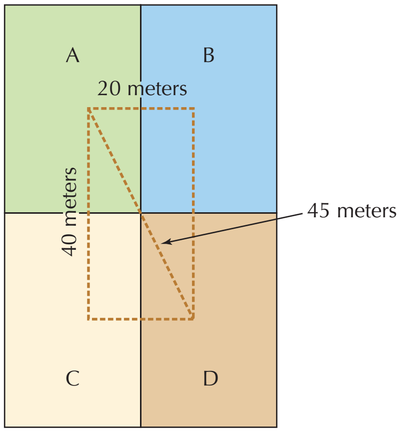
a. (**) Draw a precedence diagram for the tasks. Rayloc would like the cell to be able to handle 100 pumps a day. What is the takt time? What is the theoretical minimum number of workstations needed?
b. (**) Develop workstation assignments using the "largest eligible task" rule.
c. (**) How many workstations does your solution require? What is the cycle time for the line? What is the idle time? What is the percent idle time?
d. (***) Suppose Rayloc would like to double the output to 200 pumps a day. Is this possible, given the tasks listed above? Explain why or why not.

7. The local university has developed an eight-step process for screening the thousands of admissions applications it gets each year. The provost has decided that the best way to take a first cut at all these applications is by employing a line process. The following table shows the times and predecessors for the various tasks:

TASK	TIME (MINUTES)	IMMEDIATE PREDECESSOR
A	1.2	None
B	1	**A**
C	0.65	**B**
D	1.1	**B**
E	1.3	**C**
F	0.7	**D**
G	0.8	**D**
H	0.9	**E**, **F**, **G**

a. (**) Draw a precedence diagram for the tasks. Suppose the university needs to process 30 applications an hour during the peak season. What is the takt time? What is the theoretical minimum number of workstations?
b. (**) Develop workstation assignments by using the "largest eligible task" rule.
c. (**) How many workstations does your solution require? What is the cycle time for the line? What is the idle time? What are the percent idle time and the efficiency delay?
d. (***) In theory, what is the fastest cycle time possible, given the tasks listed above? How many applications per hour does this translate into?

8. (**) As the new facilities manager at Hardin Company, you have been asked to determine the layout for four departments on the fourth floor of the company's headquarters. Following is a map of the floor with distances between the areas:



The number of interdepartmental trips made per day is as follows:

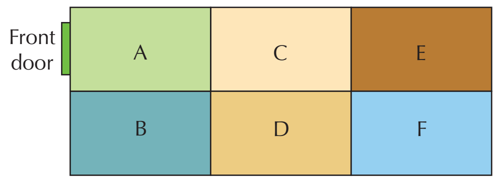
DEPARTMENT	1	2	3	4
1	—			
2	10	—		
3	5	60	—	
4	30	40	50	—

Generate at least *two* alternative layout solutions. What is the maximum possible number of arrangements? Which of your two alternatives is best? Why?

9. Dr. Mike Douvas is opening a new sports clinic and is wondering how to arrange the six different departments of the clinic:

1. Waiting
2. Reception
3. Records and staff lounge
4. Examination
5. Outpatient surgery
6. Physical therapy

A map of the clinic follows. The six marked areas are big enough to handle any of the departments, although Dr. Douvas wants to have Reception near the front door (for obvious reasons). Areas that share a side are approximately 15 feet apart, while those that share a corner are 25 feet apart. The distances between A and E and between B and F are 30 feet, while the distances between A and F and between B and E are approximately 40 feet.



Dr. Douvas also has estimates of the number of trips made by patients and staff between the various departments each day:

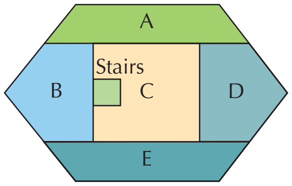
	WAITING	RECEPTION	RECORDS/ LOUNGE	EXAMINATION	OUTPATIENT SURGERY	PHYSICAL THERAPY
Waiting	—					
Reception	100	—				
Records/Lounge	0	150	—			
Examination	35	5	10	—		
Outpatient Surgery	15	5	10	5	—	
Physical Therapy	50	10	15	40	0	

a. (**) Given that Dr. Douvas wants Reception assigned to area A, how many possible arrangements are there?

b. (**) Generate the best solution you can, given the information below. Calculate the total distance traveled for your solution.

c. (***) Now select two departments to switch (except Reception). By carefully choosing two, can you come up with a better solution? Justify your answer.

10. (***) Omega Design is moving into an old Victorian building with a very unusual floor layout:



Distances, in meters, between the areas are as follows:

AREA	A	B	C	D	E
A	—				
B	14	—			
C	8	8	—		
D	14	20	8	—	
E	18	14	8	14	—

The numbers of daily interdepartmental trips are as follows:

DEPARTMENT	1	2	3	4	5	6
1	—					
2	23	—				
3	24	52	—			
4	13	5	17	—		
5	21	56	28	25	—	
6	60	15	57	3	42	—

Use the "minimal distance traveled" logic to develop a potential layout for Omega. What other information—including qualitative factors—might you want to know when developing your solution?

CASE STUDY

Manufacturing and Service Processes: Loganville Window Treatments

Introduction

For nearly 50 years, Loganville Window Treatments (LWT) of Loganville, Georgia, has made interior shutters that are sold through decorating centers. Figure 3.20 shows some of the various styles of shutters LWT makes.

Past Manufacturing and Service Operations: 2017

Traditionally, LWT supported a limited mix of standard products. At any particular point in time, the mix of products might consist of six different styles offered in five predetermined sizes, resulting in 30 possible end products. LWT would produce each of these end products in batches of 500 to 1,000 (depending on the popularity of each style/size combination) and hold the finished products in the plant warehouse. When a decorating center called in with an order, LWT would either meet the order from the finished goods inventory or hold the order to be shipped when the next batch was finished.

LWT's products were sold through independent decorating centers located across the United States and Canada. LWT would send each of these decorating centers a copy of its catalog, and the decorating centers would use these catalogs to market LWT's products to potential customers. It was the responsibility of the decorating centers to work with customers to price out the shutters, make sure the correct size and style were ordered from LWT, and resolve any problems. As a result, LWT almost never dealt directly with the final customers.

Manufacturing and Service Operations: 2018

By 2017, the influx of low-cost shutters made in China had forced LWT to reconsider its business model. Specifically, because of the low labor costs in China (20% of LWT's labor costs), Chinese manufacturers could make exact copies of LWT's products for substantially less and hold them in warehouses across the United States and Canada. LWT's traditional

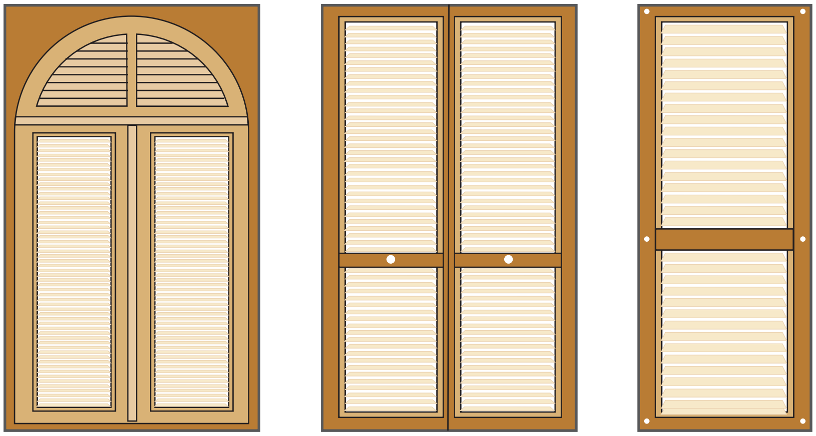


FIGURE 3.20
Sample Products Made by LWT

customers—the decorating centers—were turning more and more to these alternative sources.

LWT decided to fight back. As Chuck Keown, president of LWT, put it:

> *The only permanent advantage that we have over our competitors is that we are located here in the United States, closer to the final customer. So from now on, we will be a make-to-order manufacturer. We will deal directly with customers and make shutters to whatever specific measurements and finish they need. This means we can no longer count on producing batches of 500 to 1,000 shutters at a time and holding them in inventory. Rather, we will need to be able to make a few at a time in one-off sizes, if that's what the customer needs.*
>
> *On the service and marketing side of the house, we will now take orders directly from the customer. We will reach them through the Internet and through catalogs. We will work with them to determine what style best suits their needs, and to take the measurements needed to make the shutters. When there is a problem, we will work directly with the customer to resolve them.*
>
> *Yes, this will require dramatic changes to our business. But it also means we will be able to charge a premium for our products and create a relationship with the customers that our Chinese rivals will find difficult to emulate. As I see it, this is the only way we can survive.*

Questions

1. As of 2017, what type of manufacturing process did LWT appear to be using? What level of customization was it offering? *Where* was the point of customization?
2. Using Table 3.2 and Figure 3.12 as guides, how would you describe the service side of LWT's business prior to 2018? What were the managerial challenges?
3. What type of manufacturing process is needed to support the changes proposed by Chuck Keown? What level of customization will LWT be offering? *Where* will the point of customization be?
4. Using Table 3.2 and Figure 3.12 as guides, how will the service side of the house change in 2018? What will the *new* managerial challenges be?
5. Develop a list of 8 to 10 things that must happen in order to accomplish the changes Chuck Keown envisions. Will the new business model be more or less difficult to manage than the old one? Justify your answer.

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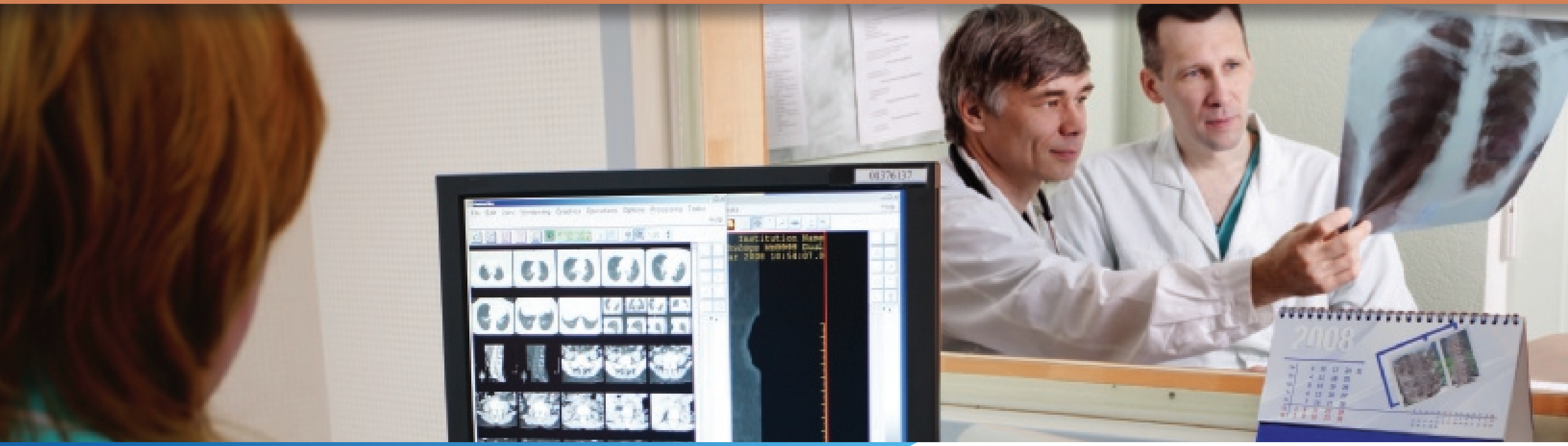

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CHAPTER
four

Business Processes

CHAPTER OUTLINE

CHAPTER OBJECTIVES

By the end of this chapter, you will be able to:

- Explain what a business process is and how the business process perspective differs from a traditional, functional perspective.
- Create process maps for a business process and use them to understand and diagnose a process.
- Calculate and interpret some common measures of process performance.
- Discuss the importance of benchmarking and distinguish between competitive benchmarking and process benchmarking.
- Describe the Six Sigma methodology, including the steps of the DMAIC process.
- Use and interpret some common continuous improvement tools.
- Explain what the Supply Chain Operations Reference (SCOR) model is and why it is important to businesses.

INTERMOUNTAIN HEALTHCARE

Gennadiy Poznyakov/Fotolia

In the United States, the rising cost of health care has been a topic of concern for many years. One would expect, then, that health care providers would quickly move to incorporate any new practices that would improve both the quality and cost-effectiveness of their services. Yet this has not always been the case. In "Fixing Healthcare on the Frontlines,"[1] Richard Bohmer, a physician and professor of management practice at the Harvard Business School, notes two remarkable statistics:

1. It takes 10 to 20 years for new medical practices to move from the development stage to widespread adoption by health care providers.
2. "The chance of receiving healthcare that meets generally accepted standards is about 55%."

But how can this be? One reason noted by Bohmer and others is that health care providers have historically done a poor job putting in place business processes that standardize treatment steps for well-understood conditions, such as diabetes or hypertension. Clearly, standardizing the steps followed by caregivers has the potential to improve patient outcomes in such situations while simultaneously driving down variability and costs.

Here's how one health care provider, Intermountain Healthcare, went about tackling the problem:

- For common and well-understood conditions, teams of specialist at Intermountain developed standardized processes, called "protocols," which define in a step-by-step manner how each condition should be diagnosed and treated.
- The protocols are then computerized and shared with caregivers in Intermountain's network of hospitals and clinics, who then follow the protocols when treating patients.
- To ensure that the protocols are both up-to-date and workable, Intermountain regularly updates the protocols based on the latest scientific evidence as well as actual caregivers' experiences. Furthermore, while the protocols are meant to capture "best practices" at any point in time, caregivers can override the protocols when they feel conditions warrant.

Because there is a great deal of overlap in patient needs, Intermountain found that over 90% of its case load could be addressed through just 70 protocols. The other 10% of cases include patients with complex or unique needs that doctors must handle on a case-by-case basis. Both Intermountain and its patients have benefited from the use of protocols. One example reported by James and Savitz illustrates the types of benefits that can be achieved: "a new [infant] delivery protocol helped reduce rates of elective induced labor, unplanned cesarean sections, and admissions to newborn intensive care units. That one protocol saves an estimated $50 million in Utah each year. If applied nationally, it would save about $3.5 billion."[2]

[1] R. Bohmer, "Fixing Health Care on the Front Lines," *Harvard Business Review*, April 2010, 62–69.
[2] B. James and L. Savitz, "How Intermountain Trimmed Health Care Costs through Robust Quality Improvement Efforts," *Health Affairs*, May 2011, **http://content.healthaffairs.org/content/30/6/1185.full.**

INTRODUCTION

In recent years, corporate executives and management theorists have recognized the importance of putting in place business processes that effectively manage the flow of information, products, and money across the supply chain. One reason is the dollars involved: Experts estimate that total supply chain costs represent the majority of the total operating budget for most organizations; in some cases, they may be as high as 75%.[3]

Another reason is the increased emphasis on providing value to the customer. Look again at Intermountain's experience with its infant delivery protocol: While Intermountain saves over $50 million per year, mothers (and babies!) benefit directly from fewer unplanned surgical procedures or visits to the ICU.

[3] F. Quinn, "What's the Buzz? Supply Chain Management: Part 1," *Logistics Management* 36, no. 2 (February 1997): 43.

TABLE 4.1 Examples of Business Processes

PRIMARY PROCESSES	SUPPORT PROCESSES	DEVELOPMENT PROCESSES
Providing a service	Evaluating suppliers	Developing new products
Educating customers	Recruiting new workers	Performing basic research
Manufacturing	Developing a sales and operations plan (S&OP)	Training new workers

The purpose of this chapter is to give you a solid understanding of what business processes are and how the business process perspective differs from more traditional perspectives. We will describe various tools and techniques companies use to manage and improve business processes. In particular, we will introduce you to the Six Sigma methodology, including the DMAIC (Define–Measure–Analyze–Improve–Control) approach to business process improvement. We end the chapter with a discussion of the Supply Chain Operations Reference (SCOR) model, which gives companies a common language and model for designing, implementing, and evaluating supply chain business processes.

4.1 BUSINESS PROCESSES

Process
According to APICS, "A set of logically related tasks or activities performed to achieve a defined business outcome."

Primary process
A process that addresses the main value-added activities of an organization.

Support process
A process that performs necessary, albeit not value-added, activities.

Development process
A process that seeks to improve the performance of primary and support processes.

So, just what do we mean by the term *business process*? APICS defines a **process** as "a set of logically related tasks or activities performed to achieve a defined business outcome."[4] For our purposes, these outcomes can be physical, informational, or even monetary in nature. Physical outcomes might include the manufacture and delivery of goods to a customer; an informational outcome might be registering for college courses; and a monetary outcome might include payment to a supply chain partner for services rendered. Of course, many business processes have elements of all three.

Primary processes address the main value-added activities of an organization. They include activities such as delivering a service and manufacturing a product. These processes are considered "value-added" because some customer is willing to pay for the resulting outputs. In contrast, **support processes** perform necessary, albeit not value-added, activities. An example is tuition billing. No student wants to pay tuition, and the university would rather not spend the overhead required to collect it, but the university would not be able to sustain itself for very long without monetary flows from the students. Finally, **development processes** are processes that improve the performance of primary and support processes.[5] Table 4.1 gives examples of primary, support, and development processes.

As with our discussion of supply chains in Chapter 1, you may be saying to yourself that "business processes aren't new," and, once again, you'd be right. What *is* new is the level of attention these processes have attracted in recent years. Prior to the 1990s, most managerial attention was on the activities within specific business *functions*, such as marketing, operations, logistics, and finance. The assumption was that if companies concentrated on how these functions were organized, how individuals were trained, and how the individual functional strategies lined up with the overall business strategy (Chapter 2), then everything would be fine.

The problem was, however, that managing functions is not the same as managing what a business *does*. Look again at the business processes listed in Table 4.1. Nearly every one of these processes spans multiple functional areas and even multiple supply chain partners.

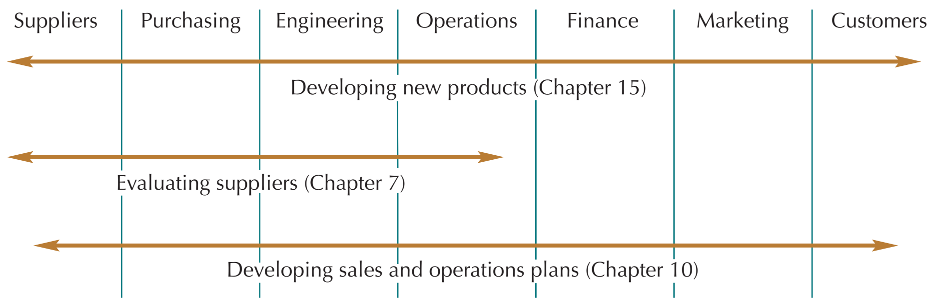
Figure 4.1 shows three of the many business processes we will discuss in this book and how they cut across both functions and organizations. There are other processes that we have not shown here, but our point is this: For many business processes, no single function or supply chain partner has a complete view or complete control of the situation. Developing superior business processes, therefore, requires a cross-functional and cross-organizational perspective that actively looks at the logical flow of activities that make up a business process. We will expand on this idea below.

Improving Business Processes

Let's illustrate the idea of improving business processes with an example many college students are familiar with: enrolling in classes each semester. Not too long ago, students had to interact

[4] J. H. Blackstone, ed., *APICS Dictionary*, 15th ed. (Chicago, IL: APICS, 2016).
[5] B. Andersen, *Business Process Improvement Toolbox* (Milwaukee, WI: ASQ Quality Press, 1999).

FIGURE 4.1
Examples of Business Processes That Cut across Functions and Organizations



with three distinct functional areas in order to register: the individual colleges or departments (which granted permission to take classes), the registrar's office (which managed the actual enrollment process), and the cashier's office (which handled tuition payments). A student would visit his home college or department to pick up the proper permission forms, schedule his or her classes, and finally pay tuition. Of course, any problem in the system could force the student to revisit one or more of these areas.

This process was convenient for everyone except the students. Now nearly all colleges and universities have reorganized these activities into a single process, with a focus on speed, accuracy, and convenience to the students. Students can now register and pay tuition all with one visit to a Web site. In some cases, students can even purchase their books and have them automatically delivered or downloaded to them. The key point is this: Improving the enrollment process required the different functional areas to look beyond their own activities and see the process through the *customers'* (i.e., students') eyes.

Improving business process is at the very core of operations and supply chain management. For one thing, the performance level of most processes tends to decrease over time unless forces are exerted to maintain it. In addition, even if an organization does not feel a need to improve its business processes, it may be forced to due to competitive pressures. Procter & Gamble's Streamlined Logistics initiative (see the *Supply Chain Connections* feature) forced competitors, such as Kraft Foods, to undertake similar process involvement efforts.[6] Finally, today's customers are becoming more and more demanding; what a customer might have considered quite satisfactory a few years ago might not meet his or her requirements today.

Bill Aron/PhotoEdit, Inc.

Most universities have already combined course registration with tuition payments into a single, integrated process. How long do you think it will be until all course and textbook information is integrated electronically into this process?

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[6]S. Tibey, "How Kraft Built a 'One-Company' Supply Chain," *Supply Chain Management Review* 3, no. 3 (Fall 1999): 34–42.

SUPPLY CHAIN CONNECTIONS

PROCTER & GAMBLE[7]

Wilfredo Lee/AP Images

PROCTER & GAMBLE (P&G) is one of the world's largest consumer goods firms, with such well-known brands as Tide detergent, Crest toothpaste, and Pampers disposable diapers. At one time, P&G was organized around five business sectors: laundry and cleaning, paper goods, beauty care, food and beverages, and health care. To the folks within P&G, this made a lot of sense. Dividing such a large organization along product lines allowed each business sector to develop product, pricing, and promotion policies, as well as supply chain strategies, independent of one another.

But to the distributors and retailers who were P&G's direct customers, the view was quite different. Each of these customers had to deal with five separate billing and logistics processes—one for each business sector (Figure 4.2).

As Ralph Drayer, vice president of Efficient Consumer Response for Procter & Gamble, noted, this created a wide range of problems:

> *[P&G] did not allow customers to purchase all P&G brands together for delivery on the same truck. Some customers might go several days without receiving an order, only to have several trucks with P&G orders arrive at the receiving dock at the same time on the same morning. Different product categories were shipped on different trucks with different invoices. The trade promotions process was so complex that more than 27,000 orders a month required manual corrections.... The separate pricing and promotion policies, coupled with non-coordinated management of logistics activities across the five business sectors, resulted in as many as nine prices per item and order quantities of less-than-full truckload.*

In response, P&G launched its Streamlined Logistics initiative. Among many other things, it drastically reduced the number of new products being introduced

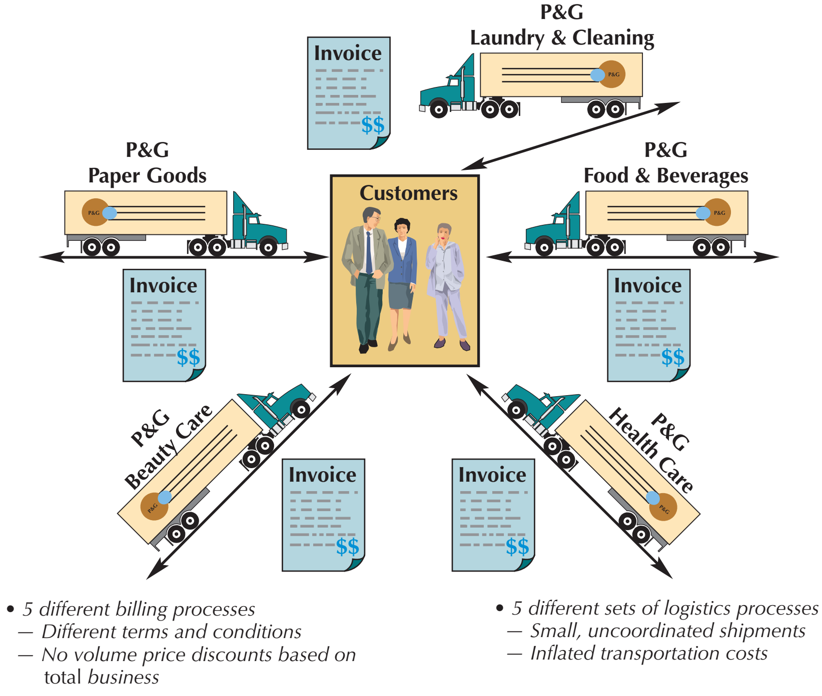
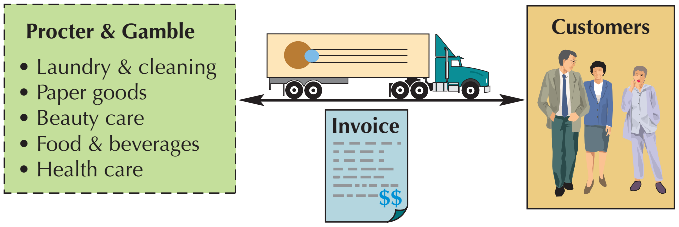


FIGURE 4.2 Procter & Gamble before the Streamlined Logistics Initiative

[7]Adapted from R. Drayer, "Procter & Gamble's Streamlined Logistics Initiative," *Supply Chain Management Review* 3, no. 2 (Summer 1999): 32–43. Reprinted with permission of Supply Chain Management Review.



- *One integrated billing process*
  - *Administrative cost savings passed on to customers*
  - *Volume discounts applied across all purchases*
- *One set of logistics processes*
  - *Full-truckload quantities shipped 98% of the time, resulting in substantial transportation cost savings*

FIGURE 4.3 Procter & Gamble after the Streamlined Logistics Initiative

(many of which only served to confuse consumers) and simplified the pricing and promotion structure. But, more importantly, P&G redesigned the information and physical flows across the business sectors so that customers had to deal with only *one* P&G billing process and *one* set of logistics processes (Figure 4.3).

The results were dramatic:

- Full truckloads were shipped 98% of the time, resulting in dramatically lower transportation costs.
- The number of invoices the typical P&G customer had to handle fell anywhere from 25% to 75%. At a processing cost of $35 to $75 for each invoice, this represented substantial savings to P&G's customers.
- Customers were able to get volume discounts from P&G based on their *total* purchase volume. Under the previous system, this had been difficult, if not impossible, to do.

Procter & Gamble's Streamlined Logistics initiative not only improved profitability for P&G and its customers but also served as a model for other manufacturers in the industry who have made similar efforts to simplify and streamline their own business processes.

4.2 MAPPING BUSINESS PROCESSES

Before a firm can effectively manage and improve a business process, it must understand the process. One way to improve understanding is by developing graphic representations of the organizational relationships and/or activities that make up a business process. This is known as **mapping.** Done properly, mapping serves several purposes:

Mapping
The process of developing graphic representations of the organizational relationships and/or activities that make up a business process.

- It creates a common understanding of the content of the process: its activities, its results, and who performs the various steps.
- It defines the boundaries of the process.
- It provides a baseline against which to measure the impact of improvement efforts.

Process Maps

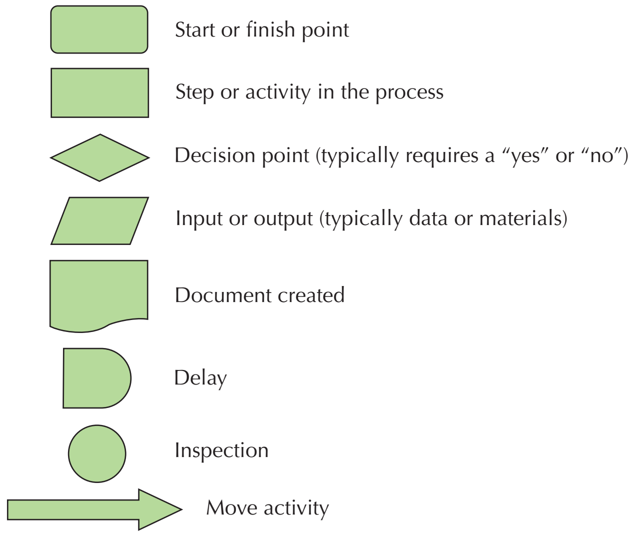
Process map
A detailed map that identifies the specific activities that make up the informational, physical, and/or monetary flow of a process.

A **process map** identifies the specific activities that make up the information, physical, or monetary flow of a process. Process maps often give managers their first complete picture of how a process works. Experts have developed a set of graphical symbols to represent different aspects of the process. Figure 4.4 shows some of the most common symbols used.

Because of the level of detail required, process flowcharts can quickly become overly complex or wander off the track unless a conscious effort is made to maintain focus. Some useful rules for maintaining this focus include:

1. **Identify the entity that will serve as the focal point.** This may be a customer, an order, a raw material, or the like. The mapping effort should focus on the activities and flows associated with the movement of that entity through the process.
2. **Identify clear boundaries and starting and ending points.** Consider a manufacturer who wants to better understand how it processes customer orders. To develop the process map, the manufacturer must decide on the starting and ending points. Will

FIGURE 4.4
Common Process Mapping Symbols



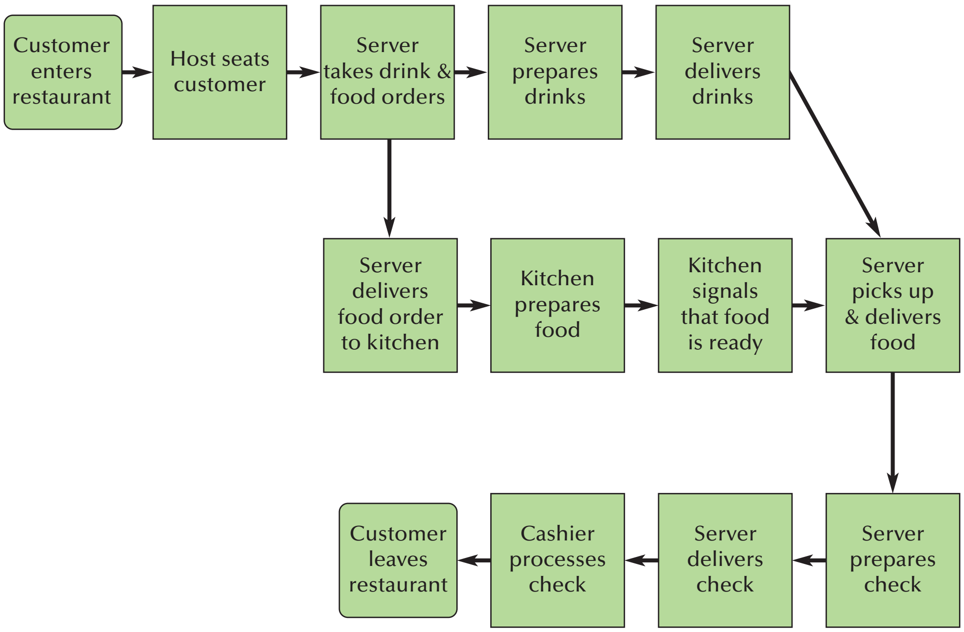
the starting point be when the customer places the order or when the manufacturer receives it? Similarly, will the flowchart end when the order is shipped out of the plant or when the order is actually delivered to the customer? The manufacturer might also decide to focus only on the physical and information flows associated with the order and not the monetary flows.

3. **Keep it simple.** Most people developing process maps for the first time tend to put in *too* much detail. They develop overly complex maps, often subdividing major activities into several smaller ones that don't provide any additional insight or include logical branches to deal with every conceivable occurrence, even ones that very rarely occur. There are no simple rules of thumb for avoiding this trap, other than to ask whether the additional detail is important to understanding the process and whether it is worth the added complexity.

Let's illustrate these ideas with an example we are all familiar with: a customer visiting a restaurant. The customer is greeted by a host, who then seats the customer. A server takes the customer's order, delivers the drinks and food, and writes up and delivers the check. Finally, a cashier takes the customer's money.

Figure 4.5 shows a simplified map of the Bluebird Café, which we first discussed in Chapter 3. In this example, the focal point is the customer: The process begins when the customer enters

FIGURE 4.5
Process Map for the Bluebird Café



the Bluebird Café and ends when he or she leaves. Notice, too, that there are many activities that occur in the restaurant that are *not* included in this particular map—scheduling employee work hours, planning deliveries from suppliers, prepping food, etc. This is because our current focus is on the customer's interactions with the restaurant. Even so, our "simplified" map still has 11 distinct steps.

With the major customer interaction points laid out, we can start to see how important each of the steps is to the customer's overall satisfaction with his or her dining experience. We might also start to ask how the Bluebird Café can measure and perhaps improve its performance. Example 4.1 illustrates a somewhat more complex process map for a fictional distribution center. As you read through the example, ask yourself the following questions:

- What is the focal point of the process mapping effort?
- What are the boundaries and the starting and stopping points for the process map?
- What detail is not included in this example?

EXAMPLE 4.1

Process Mapping at a Distribution Center

A San Diego distribution center (DC) has responsibility for supplying products to dealers located within a 30-mile radius. Lately, the DC has been receiving a lot of complaints from dealers regarding lost orders and the time required to process orders for items that are already in stock at the DC. A process improvement team has decided to study the process in more detail by tracing the flow of a dealer order through the DC, starting from when the dealer emails in the order and ending with the order's delivery to the dealer. The team has collected the following information:

- The dealer emails an order to the DC, which is automatically printed out on the copier in the main office. Sometimes the paper gets jammed in the copier machine or an order gets thrown away accidentally. Employees estimate that about 1 in 25 orders is "lost" in this manner.
- The printed order sits in an inbox anywhere from 0 to 4 hours, with an average of 2 hours, before the order is picked up by the DC's internal mail service.
- It takes the internal mail service 1 hour, on average, to deliver the order to the picking area (where the desired items are picked off the shelves). In addition, 1 out of 100 orders is accidentally delivered to the wrong area of the DC, resulting in additional "lost" orders.
- Once an order is delivered to the picking area, it sits in the clerk's inbox until the clerk has time to process it. The order might wait in the inbox anywhere from 0 to 2 hours, with an average time of 1 hour.
- Once the clerk starts processing the order, it takes her about 5 minutes to determine whether the item is in stock.
- If the requested product is in stock, a worker picks the order and puts it into a box. Average picking time is 20 minutes, with a range of 10 minutes to 45 minutes.
- Next, an inspector takes about 2 minutes to check the order for correctness. Even with this inspection, 1 out of 200 orders shipped has the wrong items or quantities.
- A local transportation firm takes the completed order and delivers it to the dealer (average delivery time is 2 hours but can be anywhere from 1 to 3 hours). The transportation firm has an exemplary performance record: Over the past 5 years, the firm has never lost or damaged a shipment or delivered to the wrong dealer.
- If the item being ordered is out of stock, the clerk notifies the dealer and passes the order on to the plant, which will arrange a special shipment directly to the dealer, usually within a week.

Using the symbols from Figure 4.5, the process improvement team draws the process map for the order-filling process of in-stock items (Figure 4.6). The map includes detailed information on the times required at each step in the process, as well as various quality problems. Adding up the times at each process step, the team can see that the average time between ordering and delivery for an in-stock item is about 6.4 hours (387 minutes) and can be as long as 11.3 hours (682 minutes). If an item is not in stock, it will take even longer to be delivered.

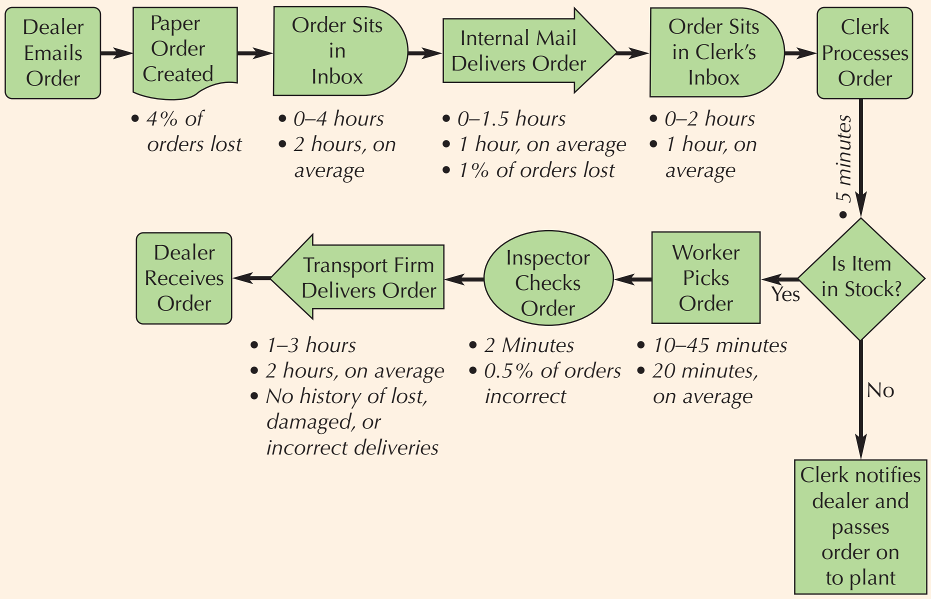


FIGURE 4.6 Order-Filling Process for In-stock Items

Of the 6.4 hours an order spends on average in the process, a full 3 hours is waiting time. Finally, 5% of the orders are "lost" before they even get to the picking area. For the orders that do survive to this point, 1 out of 200 will be shipped with the incorrect items or quantities. Clearly, there is room for improvement.

Once the process has been mapped, the team considers ways to improve the process. It is clear that the order-filling process is hampered by unnecessary delays, "lost" paperwork, and an inspection process that yields less-than-perfect results. One potential improvement is to have the dealers email their orders directly to the picking area. Not only would this cut down on the delays associated with moving a paper copy through the DC, but it would also cut down on the number of "lost" orders. Errors in the picking and inspection process will require additional changes.

Keep in mind that the idea is to document the process *as it is*—not the way people remember it. In some cases, employees might need to physically walk through a process, "stapling themselves" to a document or a product. Second, management needs to decide which parts of the process to look at. Areas that are beyond a manager's control or are not directly related to the problem at hand can be omitted from the process mapping effort. In Example 4.1, the focus was on *in-stock* items, so the flowchart did not go into detail regarding what happens if the product is out of stock.

Table 4.2 lists some guidelines to use in identifying opportunities to improve a process. In general, personnel should critically examine each step in the process. In many cases, steps can be improved dramatically or even eliminated.

Swim Lane Process Maps

Swim lane process map
A process map that graphically arranges the process steps so that the user can see who is responsible for each step.

Sometimes we are interested in understanding not only the steps in a process but *who* is involved and how these parties interact with one another. In the restaurant example, at least four people were involved in serving the customer—the host, the server, the cook, and the cashier. **Swim lane process maps** graphically arrange the process steps so that the user can see who is responsible for each step. This has two distinct benefits. First, swim lane maps allow the user to see where the process is handed off from one party to another, or where multiple parties are

TABLE 4.2 Guidelines for Improving a Process

1. Examine each delay symbol
   What causes the delay? How long is it?
   How could we reduce the delay or its impact?
2. Examine each activity symbol
   Is this an unnecessary or redundant activity?
   What is the value of this activity relative to its cost?
   How can we prevent errors in this activity?
3. Examine each decision symbol
   Does this step require an actual decision (e.g., "Do we want to accept this customer's order?"), or is it a simple checking activity (e.g., "Is the inventory in stock?")? If it is a checking activity, can it be automated or eliminated? Is it redundant?
4. Look for any loops (arrows that go back to a previous point in the process).
   Would we need to repeat these activities if we had no failures (e.g., cooking a new steak for a customer because the first one was cooked incorrectly)?
   What are the costs associated with this loop (additional time, resources consumed, etc.)? Can this loop be eliminated? If so, how?

involved in carrying out a process step. Too often, a lack of coordination or communication at these interface points leads to problems. Second, by visualizing the key parties involved in a process, swim lane maps often forces organizations to address the question, "Who is ultimately responsible for the success of the process?"

Figure 4.7 shows a swim lane process map for the San Diego DC order-filling process described in Example 4.1. In setting up a swim lane map, the first "lane" is usually reserved for the customer of the process. This customer can be an internal (i.e., within the company) or external customer. As Figure 4.7 shows, the order-filling process involves seven different parties, including the dealer who places the order. Furthermore, there are three parties—the sales office, internal mail, and picking clerk—that handle the order before it gets to the workers who actually do the picking. All these hand-offs and delays clearly add time and potential errors to the order-filling process.

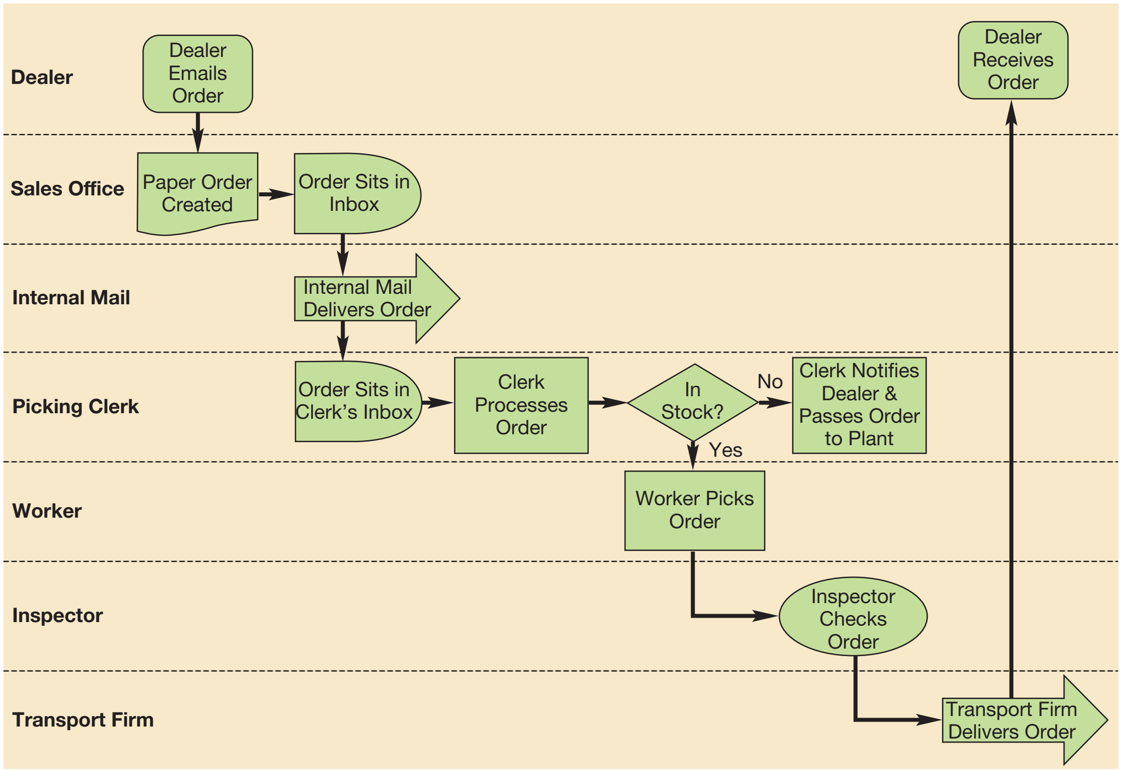


FIGURE 4.7 Swim Lane Process Map for Order-Filling Process

4.3 MANAGING AND IMPROVING BUSINESS PROCESSES

By now, you should appreciate how critical business processes are to the success of an organization. But you still might wonder how businesses should go about managing and improving these processes. For instance:

- How do we know if a business process is meeting customers' needs? Even if customers' needs are being met, how do we know whether the business process is being run efficiently and effectively?
- How should we organize for business process improvement? What steps should we follow? What roles should people play?
- What types of tools and analytical techniques can we use to rigorously evaluate business processes? How can we make sure we manage based on fact and not opinion?

Organizations have been asking these questions for years. As a result, experts have developed various measures, methodologies, and tools for managing business processes. In fact, the body of knowledge continues to evolve as more is learned about what works and what doesn't. In this section, we will introduce you to current thinking in the area.

Measuring Business Process Performance

Before we can answer the question "How is the process performing?" we must first understand what it is the customer wants and calculate objective performance information for the process. Let's reconsider the process mapping exercise in Example 4.1 for a moment. Suppose one of the San Diego DC's key customers has told DC management that:

1. All deliveries for in-stock items must be made within 8 hours from when the order was placed.
2. Order conformance quality must be 99% or higher. That is, 99% of the orders must be delivered with the right items in the right quantities.

Furthermore, the customer has told DC management that these are *order qualifiers*: If the DC cannot meet these minimum requirements, then the customer will take his business elsewhere. In Example 4.1, the DC managers determined that the time between ordering and delivery for an in-stock item could be as long as 11.3 hours and that fewer than 95% of the orders were processed properly. Clearly, there is a gap between what the customer needs and what the process is currently able to provide.

There are countless possible measures of process performance, many of which are derived from the four core measures described in detail in Chapter 2:

1. **Quality**—Quality can be further divided into dimensions such as performance quality, conformance quality, and reliability. Chapter 5 includes a comprehensive discussion of the various dimensions of quality.
2. **Cost**—Cost can include such categories as labor, material, and quality-related costs, to name just a few.
3. **Time**—Time includes such dimensions as delivery speed and delivery reliability.
4. **Flexibility**—Flexibility includes mix, changeover, and volume flexibility.

In addition, some specific measures that are frequently used to evaluate process performance are productivity, efficiency, and cycle (or throughput) time. Productivity and efficiency measures are particularly important to managers because they evaluate business process performance from the perspective of the firm. We discuss each of these in more detail.

Productivity

Productivity
A measure of process performance; the ratio of outputs to inputs.

One measure that often comes up in discussions is **productivity.** Productivity is a ratio measure, defined as follows:

$$\text{Productivity} = \text{outputs/inputs} \quad \textbf{(4.1)}$$

Productivity measures are always expressed in terms of units of output per unit of input. The outputs and inputs can be expressed in monetary terms or in some other unit of measure.

In general, organizations seek to improve productivity by raising outputs, decreasing inputs, or both. Some examples of productivity measures include the following:

(Number of customer calls handled)/(support staff hours)

(Number of items produced)/(machine hours)

(Sales dollars generated)/(labor, material, and machine costs)

Single-factor productivity A productivity score that measures output levels relative to single input.

Multifactor productivity A productivity score that measures output levels relative to more than one input.

The first two examples represent single-factor productivity measures. **Single-factor productivity** measures output levels relative to a single input. In the first example, we are interested in the number of calls handled per support staff hour, while the second measure looks at the number of items produced per machine hour. The assumption is that there is a one-to-one relationship between the output and input of interest that can be managed. In contrast, when it's hard to separate out the effects of various inputs, **multifactor productivity** measures should be used. Look at the last example. "Sales dollars generated" is an output that depends on multiple factors, including labor, material, and machine costs. Considering just labor costs may be inappropriate, especially if labor costs could be driven down by driving up some other cost (e.g., machine costs). In situations like this, multifactor productivity measures may be preferable.

While there are some common productivity measures used by many firms, often organizations develop productivity measures that are tailored to their particular needs. Firms use productivity measures to compare their performance to that of other organizations, as well as to compare performance against historic levels or set targets.

EXAMPLE 4.2

Measuring Productivity at BMA Software

For the past 15 weeks, a project team at BMA Software has been working on developing a new software package. Table 4.3 shows the number of programmers assigned to the project each week, as well as the resulting total lines of computer code generated.

TABLE 4.3 Programming Results for the First 15 Weeks of the Project

WEEK	LINES OF CODE	NO. OF PROGRAMMERS
1	8,101	4
2	7,423	4
3	8,872	4
4	8,483	4
5	8,455	5
6	10,100	5
7	11,013	5
8	8,746	5
9	13,710	7
10	13,928	7
11	13,160	7
12	13,897	7
13	12,588	6
14	12,192	6
15	12,386	6

Susan Clarke, the project manager, has heard rumblings from other managers that her programmers aren't being as productive as they were a few weeks earlier. In order to determine whether this is true, Susan develops a measure of programmer productivity, defined as (lines of code)/(total number of programmers). Using this measure, Susan calculates the productivity numbers in Table 4.4 for the first 15 weeks of the project.

The results indicate that the programmers have actually been *more* productive over the past few weeks (weeks 13–15) than they were in the weeks just prior. In fact, the weekly productivity results for weeks 13–15 are higher than the average weekly productivity for all 15 weeks (1,992.70). Of course, Susan recognizes that there are other performance measures to consider, including the quality of the lines coded (whether they are bug-free) and the difficulty of the lines being coded (which would tend to hold down the number of lines generated).

TABLE 4.4 Productivity Results for the First 15 Weeks of the Project

WEEK	LINES OF CODE	NO. OF PROGRAMMERS	PRODUCTIVITY (LINES OF CODE PER PROGRAMMER)
1	8,101	4	2,025.25
2	7,423	4	1,855.75
3	8,872	4	2,218.00
4	8,483	4	2,120.75
5	8,455	5	1,691.00
6	10,100	5	2,020.00
7	11,013	5	2,202.60
8	8,746	5	1,749.20
9	13,710	7	1,958.57
10	13,928	7	1,989.71
11	13,160	7	1,880.00
12	13,897	7	1,985.29
13	12,588	6	2,098.00
14	12,192	6	2,032.00
15	12,386	6	2,064.33
		Average Productivity:	1,992.70

Efficiency

Efficiency
A measure of process performance; the ratio of actual outputs to standard outputs. Usually expressed in percentage terms.

Standard output
An estimate of what should be produced, given a certain level of resources.

While measures of productivity compare outputs to inputs, measures of **efficiency** compare *actual* outputs to some standard—specifically:

$$\text{Efficiency} = 100\%\,(\text{actual outputs}/\text{standard outputs}) \qquad \textbf{(4.2)}$$

The **standard output** is an estimate of what should be produced, given a certain level of resources. This standard might be based on detailed studies or even historical results. The efficiency measure, then, indicates actual output as a percentage of the standard. An efficiency score of less than 100% suggests that a process is not producing up to its potential.

To illustrate, suppose each painter on an assembly line is expected to paint 30 units an hour. Bob actually paints 25 units an hour, while Casey paints 32. The efficiency of each painter is, therefore, calculated as follows:

$$\text{Efficiency}_{\text{Bob}} = 100\%\frac{25}{30} = 83\% \quad \text{Efficiency}_{\text{Casey}} = 100\%\frac{32}{30} = 107\%$$

Currently, Bob is performing below the standard. If his efficiency were to remain at this level, management might either intervene with additional training to raise his hourly output level or reassign Bob to another area.

EXAMPLE 4.3
Measuring Efficiency at BMA Analytics

Based on the results of her productivity study, Susan Clarke decides to set a standard for her software developers of 1,800 lines of code per developer per week. Susan consciously set the standard slightly below the average productivity figure shown in Table 4.4. Her reasoning is that she wants her developers to be able to meet the standard, even when they are dealing with particularly difficult code.

In week 16, Susan hires a new developer, Charles Turner. After five weeks on the job, Charles has recorded the results in Table 4.5.

TABLE 4.5 Programming Results for Charles Turner

WEEK	LINES OF CODE
16	1,322
17	1,605
18	1,770
19	1,760
20	1,820

Susan calculates Charles's efficiency by dividing the actual lines of code produced each week by the standard value of 1,800. Therefore, Charles's efficiency for week 16 is calculated as:

$$\text{Efficiency}_{\text{Week16}} = 100\%(1{,}332/1{,}800) = 73.4\%$$

Results for all five weeks are shown in Table 4.6.

TABLE 4.6 Efficiency Results for Charles Turner

WEEK	LINES OF CODE	EFFICIENCY
16	1,322	73.4%
17	1,605	89.2%
18	1,770	98.3%
19	1,760	97.8%
20	1,820	101.1%

Although Charles started off slowly, his efficiency has steadily improved over the five-week period. Susan is pleased with the results and recognizes that Charles needs some time to become familiar with the project. Nonetheless, she will continue to track Charles's efficiency performance.

Cycle Time

Cycle time
The total elapsed time needed to complete a business process. Also called throughput time.

The last measure of process performance we will discuss is cycle time. **Cycle time** (also called throughput time) is the total elapsed time needed to complete a business process. Many authors have noted that cycle time is a highly useful measure of process performance.[8] For one thing, in order to reduce cycle times, organizations and supply chains typically must perform well on other dimensions, such as quality, delivery, productivity, and efficiency.

Consider the order-filling process in Figures 4.6 and 4.7. In this case, cycle time is the time that elapses from when the dealer emails the order until she receives the product. Notice how the process suffers from delays due to waiting, lost orders, and incorrect orders. Therefore, in order to reduce cycle time, the San Diego DC must address these other problems as well. Notice, too, that reducing cycle times does not mean "fast and sloppy." The process cannot be considered "complete" until the dealer receives a *correctly filled* order.

A second advantage of cycle time is that it is a straightforward measure. In comparison to cost data, quality levels, or productivity measures—all of which may be calculated and interpreted differently by various process participants—the time it takes to complete a business process is unambiguous.

[8]J. Blackburn, *Time-Based Competition: The Next Battle Ground in American Manufacturing* (Homewood, IL: Irwin, 1991); G. Stalk and T. Hout, *Competing against Time: How Time-Based Competition Is Reshaping Global Markets* (New York: Free Press, 1990); C. Meyer, *Fast Cycle Time: How to Align Purpose, Strategy, and Structure for Speed* (New York: Free Press, 1993).

TABLE 4.7
Competitive Benchmarking Data for Selected U.S. Airline Carriers

AIRLINE CARRIER	PERCENTAGE OF FLIGHTS ARRIVING ON TIME, 12 MONTHS ENDING MARCH 2016	PERCENTAGE OF FLIGHTS CANCELLED, MARCH 2016	MISHANDLED BAGGAGE REPORTS PER 1,000 PASSENGERS, MARCH 2016
American	81.3%	0.5%	3.19
Delta	86.7%	0.1%	1.57
Frontier	77.5%	2.6%	2.62
Hawaiian	89.9%	0.1%	2.78
JetBlue	76.7%	0.5%	1.60
Southwest	81.0%	1.1%	2.65
United	79.9%	1.1%	2.58
Virgin America	79.4%	1.2%	0.82

Source: Based on U.S. Department of Transportation, "Air Travel Consumer Report," May 2016, **www.dot.gov/sites/dot.gov/files/docs/2016MayATCR.pdf.**

Percent value-added time
A measure of process performance; the percentage of total cycle time that is spent on activities that actually provide value.

In addition to measuring cycle time in absolute terms, it is often useful to look at the **percent value-added time,** which is simply the percentage of total cycle time that is spent on activities that actually provide value:

$$\text{Percent value-added time} = 100\%\,(\text{value-added time})/(\text{total cycle time}) \qquad \textbf{(4.3)}$$

For example, what is the percent value-added time for the typical "quick change" oil center? Even though the customer may spend an hour in the process, it usually takes only about 10 minutes to actually perform the work. According to Equation (4.3), then:

$$\text{Percent value-added time} = 100\%\,(10\text{ minutes})/(60\text{ minutes}) = 16.7\%$$

Of course, cycle time is not a perfect measure. Our discussion in Chapter 2 of trade-offs between performance measures applies here as well. It might not be cost-effective, for example, to drive down cycle times at the drivers' license bureau by quadrupling the number of officers (but don't you wish they would?). Therefore, organizations that use cycle time to measure process performance should also use other measures to make sure cycle time is not being reduced at the expense of some other key performance dimension.

Benchmarking

Benchmarking
According to Cook, "The process of identifying, understanding, and adapting outstanding practices from within the same organization or from other businesses to help improve performance."

Competitive benchmarking
The comparison of an organization's processes with those of competing organizations.

Process benchmarking
The comparison of an organization's processes with those of noncompetitors that have been identified as superior processes.

Organizations often find it helpful to compare their business processes against those of competitors or even other firms with similar processes. This activity is known as **benchmarking.** Sarah Cook defines benchmarking as "the process of identifying, understanding, and adapting outstanding practices from within the same organization or from other businesses to help improve performance."[9] Benchmarking involves comparing an organization's practices and procedures to those of the "best" in order to identify ways in which the organization or its supply chain can make improvements.

Some experts make a further distinction between competitive benchmarking and process benchmarking. **Competitive benchmarking** is the comparison of an organization's processes with those of competing organizations. In contrast, **process benchmarking** refers to the comparison of an organization's processes with those of noncompetitors that have been identified as having superior processes. As an example of the latter, many organizations have carefully studied Walmart's supply chain practices, even though Walmart might not be a direct competitor.

To give you an idea of the power of benchmarking, let's look at some competitive benchmarking results for the U.S. airline industry. The U.S. Department of Transportation (DOT) tracks and reports the performance of various U.S. carriers across several measures of interest to consumers, including the percentage of flights that arrive on time (within 15 minutes of schedule), the percentage of flights cancelled, and mishandled baggage reports filed per 1,000 passengers, and it reports these results at regular intervals. Table 4.7 shows March, 2016 results for a subset of U.S. carriers.

While some of these results might be due to conditions beyond the companies' control (e.g., weather), the hard-nosed nature of these data still gives carriers a clear idea of where they

[9] S. Cook, *Practical Benchmarking: A Manager's Guide to Creating a Competitive Advantage* (London: Kogan Page, 1995), p. 13.

TABLE 4.8
2008 Competitive Benchmarking Results for North American Automakers

MANUFACTURER	TOTAL ASSEMBLY HOURS PER VEHICLE	HOURS PER ENGINE	PRETAX PROFIT PER VEHICLE
Chrysler	21.31	3.35	–$142
Ford	22.65	4.32	–$1,467
GM	22.19	3.44	–$729
Honda	20.90	4.93	$1,641
Toyota	22.35	3.13	$922
Nissan	23.45	n/a	$1,641

Source: Based on *Harbour Report North America 2008,* Oliver Wyman, 2008.

stand relative to the competition. Whose management team do you think is happy with the results? Whose management team is not?

On the manufacturing side, Table 4.8 looks at some 2008 competitive benchmarking data that compare North American automotive plant performance across different manufacturers. The results suggest that while the productivity gap had closed between U.S. and Japanese-based manufacturers, the latter still enjoyed a significant per-vehicle profit advantage.

The Six Sigma Methodology

Of all the various approaches to organizing for business process improvement, the Six Sigma methodology arguably best represents current thinking. It certainly is popular, with many top companies, such as GE, Motorola, and Bank of America, citing it as a key element of their business strategy. Six Sigma has its roots in the quality management discipline. (Quality management is such an important topic to operations and supply chain managers that we have devoted Chapter 5 to the subject.)

The term *Six Sigma* refers to both a quality metric and a methodology. In *statistical terms,* a process that achieves Six Sigma quality will generate just 3.4 defects per 1 million opportunities (DPMO). As a *methodology* for process improvement, Six Sigma has a much broader meaning. Motorola[10] describes the **Six Sigma methodology** as:

A business improvement methodology that focuses an organization on:

- Understanding and managing customer requirements
- Aligning key business processes to achieve those requirements
- Utilizing rigorous data analysis to understand and ultimately minimize variation in those processes
- Driving rapid and sustainable improvement to business processes

Six Sigma methodology
According to Motorola, a business improvement methodology that focuses an organization on understanding and managing customer requirements, aligning key business processes to achieve those requirements, utilizing rigorous data analysis to understand and ultimately minimize variation in those processes, and driving rapid and sustainable improvement to business processes.

Let's consider this definition for a moment. The first two points reinforce the idea that business process improvement efforts need to be driven by the needs of the customer. In this case, the "customer" can be someone inside the organization as well as someone from outside the organization. The third point emphasizes the use of rigorous data analysis tools to ensure that any diagnoses or recommendations are based on *fact* and not just opinion. Finally, there must an organizational mechanism in place for carrying out these efforts in a timely and efficient manner.

Six Sigma People. Six Sigma process improvement efforts are carried out by project teams consisting of people serving specialized roles. In the lexicon of Six Sigma, the teams consist of champions, master black belts, black belts, green belts, and team members. **Champions** are typically senior-level executives who "own" the projects and have the authority and resources needed to carry them out. This can be particularly important if a Six Sigma effort requires large investments of time or money, or if multiple functional areas or supply chain partners are affected. **Master black belts** are "fulltime Six Sigma experts who are responsible for Six Sigma strategy, training, mentoring, deployment and results."[11] These individuals often work across organizations and consult with projects on an as-needed basis, but are not permanently assigned to the projects.

Champion
A senior-level executive who "owns" a Six Sigma project and has the authority and resources needed to carry it out.

Master black belt
A full-time Six Sigma expert who is "responsible for Six Sigma strategy, training, mentoring, deployment and results."

Black belts are "fully-trained Six Sigma experts with up to 160 hours of training who perform much of the technical analyses required of Six Sigma projects, usually on a full-time

Black belt
A fully trained Six Sigma expert "with up to 160 hours of training who perform[s] much of the technical analyses required of Six Sigma projects, usually on a full-time basis."

[10]Motorola University, **www.intrarts.com/Motorola/sigma.shtml.**

[11]J. Evans and W. Lindsay, *The Management and Control of Quality* (Mason, OH: Thomson South-Western, 2005).

PROFESSIONAL PROFILE

MILO JASSO, MERCK & CO., INC.

Courtesy of Milo Jasso

In his current role as interim director of supply chain at Merck's Wilson, North Carolina facility, Milo Jasso faces a number of challenges. Merck is one of the world's largest global health care companies, with products that include prescription medicines, vaccines, biologic therapies, and animal health products. The Wilson site where Milo works is a 500,000-square-foot facility that handles final packaging and distribution of solid dosage drugs for a number of other Merck plants. Because the Wilson site represents one of the last nodes in the supply chain, Milo and his team must effectively manage the business processes that "bridge the gap" between dozens of suppliers on the upstream side and Merck's fulfillment center and more than 90 different countries on the downstream side. As Milo notes, pharmaceutical distribution has some very unique challenges, some of which include:

- "Cold chain" distribution—Some pharmaceutical products require controlled refrigeration from the time they leave the Wilson facility until they arrive at their destination.
- Regulation—Because the Wilson facility distributes product worldwide, Milo and his team have to be on top of different regulatory requirements that may impact how products are packaged and delivered. For example, some countries require that the maximum price for a drug be included on the outside label; other countries require any artwork on the product packaging to be preapproved.
- Technology—In response to ever-increasing demands for higher product quality and safety, Merck now provides each package unit with a unique serial number. This number will ultimately allow Merck to precisely track the location and distribution path for its products from the time they leave the plant until they arrive at their final destination. Such information will be particularly valuable in the fight against counterfeit drugs.

As with many supply chain management professionals, Milo has found his career building on skills he developed earlier. In fact, prior to his current assignment, Milo was an associate director for continuous improvement and learning. The skills he developed in this role have allowed Milo to bring a structured methodology to bear when improving processes and tackling problems. When asked what advice he would give to people entering the workforce, Milo had this to say, "If you are a new graduate, take the opportunity to gain full end-to-end knowledge of the business you are working in. The people who will be successful in the future are those who can span across the business and connect the dots."

basis."[12] **Green belts** have some basic training in Six Sigma methodologies and tools and are assigned to projects on a part-time basis. Finally, **team members** are individuals with knowledge or direct interest in a process. While they may be included on a Six Sigma project team they are usually not trained in Six Sigma. This chapter's *Professional Profile* describes how Milo Jasso is building upon his expertise in Six Sigma to address some of the supply chain challenges facing Merck, a pharmaceutical company.

Green belt
An individual who has some basic training in Six Sigma methodologies and tools and is assigned to a project on a part-time basis.

Team members
Individuals who are not trained in Six Sigma but are included on a Six Sigma project team due to their knowledge or direct interest in a process.

Six Sigma Processes. The Six Sigma methodology has its own specialized business processes that project teams follow. The first of these is the **DMAIC (Define–Measure–Analyze–Improve–Control)** process, which outlines the steps that should be followed to improve an *existing* business process. The steps are as follows:

DMAIC (Define–Measure–Analyze–Improve–Control)
A Six Sigma process that outlines the steps that should be followed to improve an *existing* business process.

Step 1: *Define* the goals of the improvement activity. The Six Sigma team must first clarify how improving the process will support the business, and establish performance targets. This ensures that the team doesn't waste time on efforts that will not see a pay-off to either the customer or the business.

[12]Ibid.

Step 2: *Measure* the existing process. The second step requires the team members to develop a basic understanding of how the process works. What are the process steps? Who are the parties who carry out or are otherwise touched by the process? How is the process currently performing? What data do we need to analyze the process and evaluate the impact of any changes?

Step 3: *Analyze* the process. Next, the Six Sigma team identifies the relationships and factors that cause the process to perform the way it does. In doing so, the team must make sure to identify the true underlying causes of the process's performance. We will talk later about two approaches for accomplishing this: cause-and-effect diagrams and the "Five Whys" approach.

Step 4: *Improve* the process. During this step, the team identifies ways to eliminate the gap between the current performance level and the performance targets established in step 1.

Step 5: *Control* the new process. The Six Sigma team must work with the individuals affected to maintain the process improvements. This may involve such activities as developing process control charts (described in Chapter 5), training workers in any new procedures, and updating information systems to monitor ongoing performance.

DMADV (Define–Measure–Analyze–Design–Verify) A Six Sigma process that outlines the steps needed to create *completely new* business processes or products.

The second Six Sigma process **DMADV (Define–Measure–Analyze–Design–Verify),** outlines the steps needed to create *completely new* business processes or products. We review DMADV in Chapter 15.

Continuous Improvement Tools

Continuous improvement The philosophy that small, incremental improvements can add up to significant performance improvements over time.

Organizations interested in process improvement have a broad collection of data analysis tools to help guide their efforts. Many of these tools, which first appeared in the engineering and quality management disciplines, were specifically designed to help users apply logical thinking and statistical concepts to process improvement efforts. The term **continuous improvement** refers to a managerial philosophy that small, incremental improvements can add up to significant performance improvements over time.

Root cause analysis A process by which organizations brainstorm about possible causes of problems (referred to as "effects") and then, through structured analyses and data-gathering efforts, gradually narrow the focus to a few root causes.

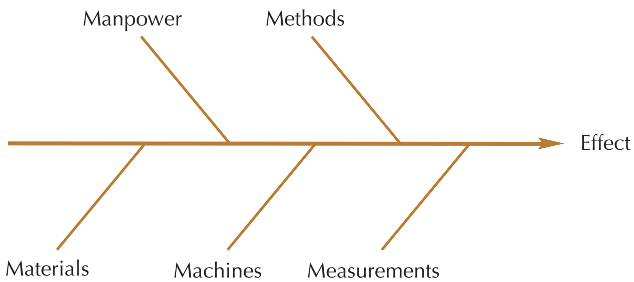
Already in this chapter we have talked about one continuous improvement tool: process mapping. This section highlights some additional tools: root cause analysis, cause-and-effect diagrams, scatter plots, check sheets, and Pareto charts. As the DMAIC steps suggest, firms need to follow a more formal process to make sure that they have indeed diagnosed problem(s) correctly. **Root cause analysis** is a process by which organizations brainstorm about possible causes of problems (referred to as "effects") and then, through structured analyses and data-gathering efforts, gradually narrow the focus to a few root causes. Root cause analysis fills the gap between the realization that a problem exists and the proposal and implementation of solutions to the problem.

Cause-and-effect diagram A graphical tool used to categorize the possible causes for a particular result.

Organizations often divide root cause analysis into three distinct phases: open, narrow, and closed. The *open phase* is devoted to brainstorming. All team members should be free to make suggestions, no matter how far-fetched they might seem at the time. Teams often use a **cause-and-effect diagram** (also known as a *fishbone diagram* or *Ishikawa diagram*) to organize their thoughts at this stage. Figure 4.8 shows a generic format for a cause-and-effect diagram.

To construct such a diagram, the team members must first describe the "effect" for which they are seeking a cause, such as late deliveries, high defect rates, or lost orders. This effect is

FIGURE 4.8
Cause-and-Effect Diagram



written on a large poster or chalkboard, at the end of a long arrow. Next, the team categorizes the possible causes and places them at the ends of branches drawn along the shaft of the arrow. These branches are often organized around five categories known as the **Five Ms:**

Five Ms
The five main branches of a typical cause-and-effect diagram: manpower, methods, materials, machines, and measurement.

- **Manpower**—People who do not have the right skills, authority, or responsibility
- **Methods**—Poor business practices; poor process, product, or service designs
- **Materials**—Poor-quality inputs
- **Machines**—Equipment that is not capable of doing the job
- **Measurements**—Performance measurements that are not geared toward eliminating the problem

EXAMPLE 4.4

Cause-and-Effect Diagram for a Pump Manufacturer

A Six Sigma team investigating variations in pump shaft dimensions at a pump manufacturer decided to develop a cause-and-effect diagram to identify the possible causes. The resulting diagram is shown in Figure 4.9. The team did not identify any potential causes along the "Measurements" branch; hence, it was left off. Notice that some of the branches are further subdivided in an effort to get to the true underlying causes. For example, "Low motivation" is listed as a possible cause under "Manpower." But why are employees unmotivated? One possible cause, "Low pay," is shown as a branch off of "Low motivation."

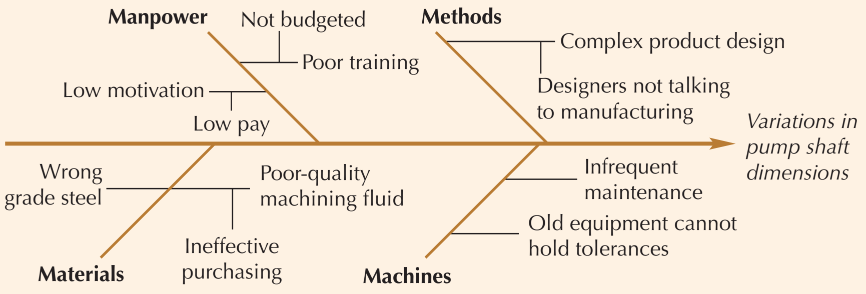


FIGURE 4.9 Cause-and-Effect Diagram for a Pump Manufacturer

The second phase of root cause analysis is known as the *narrow phase*. Here participants pare down the list of possible causes to a manageable number. Some teams formalize this process by using an approach called the **Five Whys.** With this approach, the team members brainstorm successive answers to the question "Why is this a cause of the original problem?" For each new answer, they repeat the question until they can think of no new answers. The last answer will probably be one root cause of the problem. The name comes from the general observation that the questioning process can require up to five rounds.

Five Whys
An approach used during the narrow phase of root cause analysis, in which teams brainstorm successive answers to the question "Why is this a cause of the original problem?" The name comes from the general observation that the questioning process can require up to five rounds.

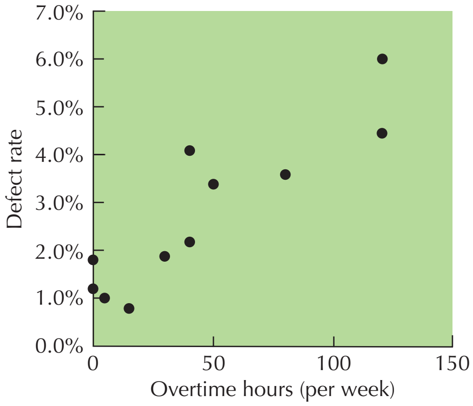
To illustrate, suppose a business is trying to understand why a major customer won't pay its bills on time. One possible explanation generated during the open phase is that, by delaying payment, the customer is getting a free loan at the business's expense ("Methods"). Using the Five Whys approach, the team members might ask the following series of questions:

Q1: WHY does the customer use our credit as a free loan?
A1: Because there are no penalties for doing so.
Q2: WHY are there no penalties for late payment of our invoices?
A2: Because we charge no penalty fees.
Q3: WHY don't we charge penalty fees?
A3: Because we have never encountered this problem before.

Process improvement efforts must be based on facts, not opinions. Although team members may *think* they have discovered the root cause of a problem, they must verify it before moving on to a solution. In the *closed phase* of root cause analysis, the team validates the suspected root cause(s) through the analysis of available data. Three commonly used data analysis tools are scatter plots, check sheets, and Pareto charts. A **scatter plot** is a graphic representation of the relationship between two variables, typically the potential root cause and the effect of interest.

Scatter plot
A graphical representation of the relationship between two variables.

FIGURE 4.10
Example Scatter Plot Showing the Relationship between Overtime Hours (Cause) and Defect Rate (Effect)



To illustrate, the scatter plot in Figure 4.10 shows how the defect rate at a manufacturer seems to increase as the amount of monthly overtime increases.

Figure 4.10 shows a strong relationship between the two variables of interest. But does the lack of a pattern in a scatter plot mean that a Six Sigma team has failed in its effort to identify a root cause? Not at all. In fact, a scatter plot that shows no relationship between a particular root cause and the effect of interest simply shortens the list of potential root causes that need to be investigated.

Check sheet
A sheet used to record how frequently a certain event occurs.

Pareto chart
A special form of bar chart that shows frequency counts from highest to lowest.

Whereas scatter plots highlight the relationship between two variables, check sheets and Pareto charts are used to assess the frequency of certain events. Specifically, **check sheets** are used to record how frequently certain events occur, and **Pareto charts** plot out the resulting frequency counts in bar graph form, from highest to lowest.

EXAMPLE 4.5

Check Sheets and Pareto Charts at Healthy Foods

Sasha Davas/Shutterstock

The Healthy Foods grocery store is attempting to isolate the root causes of unexpected delays at checkout counters. The open and narrow phases have resulted in a long list of possible causes, including the register being out of change, price checks, and customers going back to get items they forgot. In the closed phase, the quality team at Healthy Foods sets up check sheets at each checkout counter. Each time an unexpected delay occurs, the clerk records the reason for the delay. This process continues until the managers feel they have enough data to draw some conclusions. Table 4.9 shows summary results for 391 delays occurring over a one-week period.

To create the Pareto chart, the Six Sigma team ranks the causes in Table 4.9 from most frequent to least frequent and graphs the resulting data in bar graph form. The Pareto chart for Healthy Foods is shown in Figure 4.11.

TABLE 4.9 Check Sheet Results for Healthy Foods

CAUSE	FREQUENCY
Price check	142
Register out of money	14
Bagger unavailable	33
Register out of tape	44
Customer forgot item	12
Management override needed due to incorrect entry	86
Wrong item	52
Other	8
Total Delays	**391**

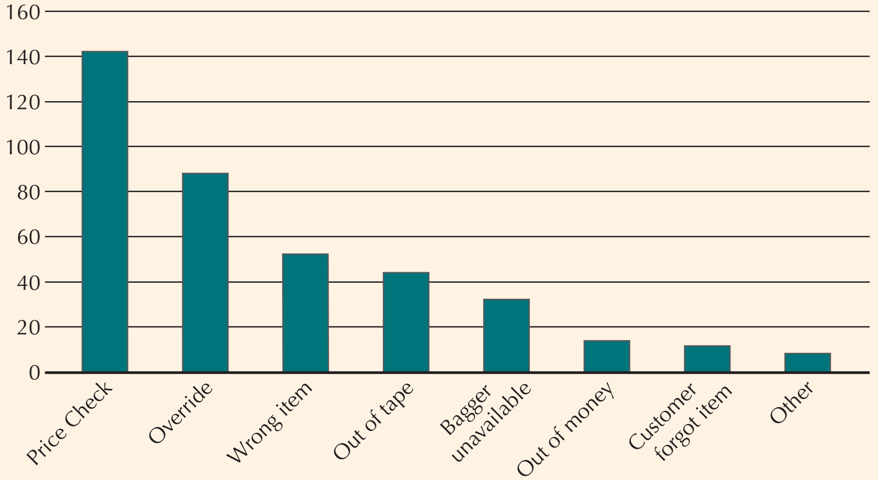


FIGURE 4.11 Pareto Chart Ranking Causes of Unexpected Delays at Checkout Counter

The check sheets and Pareto chart provide the process improvement team with some powerful information. Rather than complaining about customers who forget items (a small problem), the results suggest that Healthy Foods should instead concentrate on creating more comprehensive and accurate price lists and training clerks to properly use the cash registers. In fact, these two causes alone account for nearly 60% of the delays.

Run chart
A graphical representation that tracks changes in a key measure over time.

Bar graph
A graphical representation of data that places observations into specific categories.

Histogram
A special form of bar chart that tracks the number of observations that fall within a certain interval.

To complete our discussion of visual tools, Figure 4.12 contains examples and brief descriptions of **run charts, bar graphs,** and **histograms.**

In Example 4.6, we return to the Bluebird Café. The example demonstrates how the DMAIC process and continuous improvement tools can be used to address customer satisfaction problem.

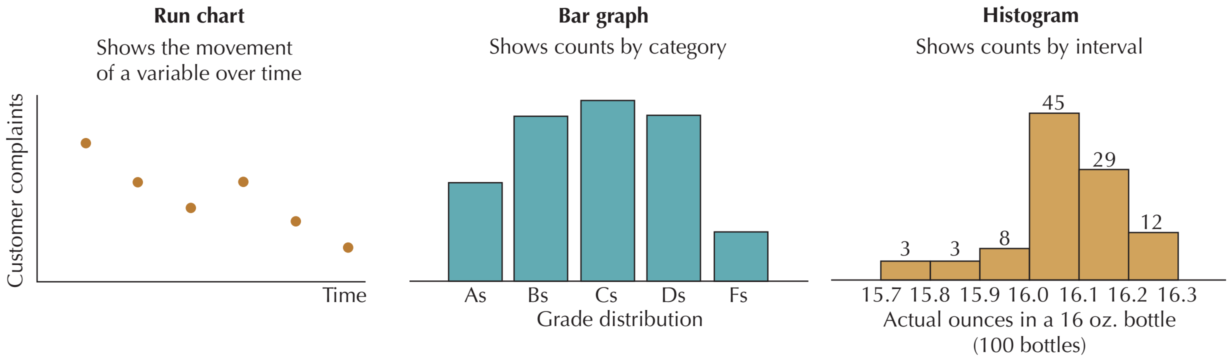


FIGURE 4.12 Additional Data Analysis Tools

EXAMPLE 4.6

Applying DMAIC and Continuous Improvement Tools at the Bluebird Café

Katie Favre, owner of the Bluebird Café, is browsing a Web site that allows individuals to rate restaurants on a 1-to-5 scale, with 1 = "Highly Dissatisfied" and 5 = "Highly Satisfied." Katie is disappointed to learned that, based on several hundred responses, the average rating for the Bluebird Café is only 3.83 and that 12% of respondents actually rated their dining experience as a 1 or 2. Unfortunately, the Web site does not provide any specific information about *why* the customers rated the café as they did. Katie takes great pride in the reputation of the Bluebird Café, and she decides to use the DMAIC process and continuous improvement tools to tackle the customer satisfaction issue.

Step 1: *Define* the Goals of the Improvement Activity

At a meeting with the management team, Katie emphasizes the importance of customer satisfaction to the ongoing success of the business. The Bluebird Café is located in a college town and has plenty of competition; local customers can go elsewhere if they are dissatisfied, and out-of-town visitors often depend on Internet-based ratings to decide where they will dine. With this in mind, Katie and the management team set a target average rating of 4.5 or greater for any future Internet ratings, with no more than 2% of respondents giving a rating of 1 or 2.

Step 2: *Measure* the Existing Process

Katie already has a process map that identifies the major steps required to serve a customer (Figure 4.5). While this is a good start, the team feels that more data are needed. Katie spends a week measuring the time it takes to perform various activities, as well as the percentage of time certain process steps are completed correctly. Figure 4.13 shows the updated process map.

The management team also wants to know what process characteristics lead customers to rate the restaurant as satisfactory or unsatisfactory. To get this information, Katie puts together a survey card (see Figure 4.14) that is given out to a random sample

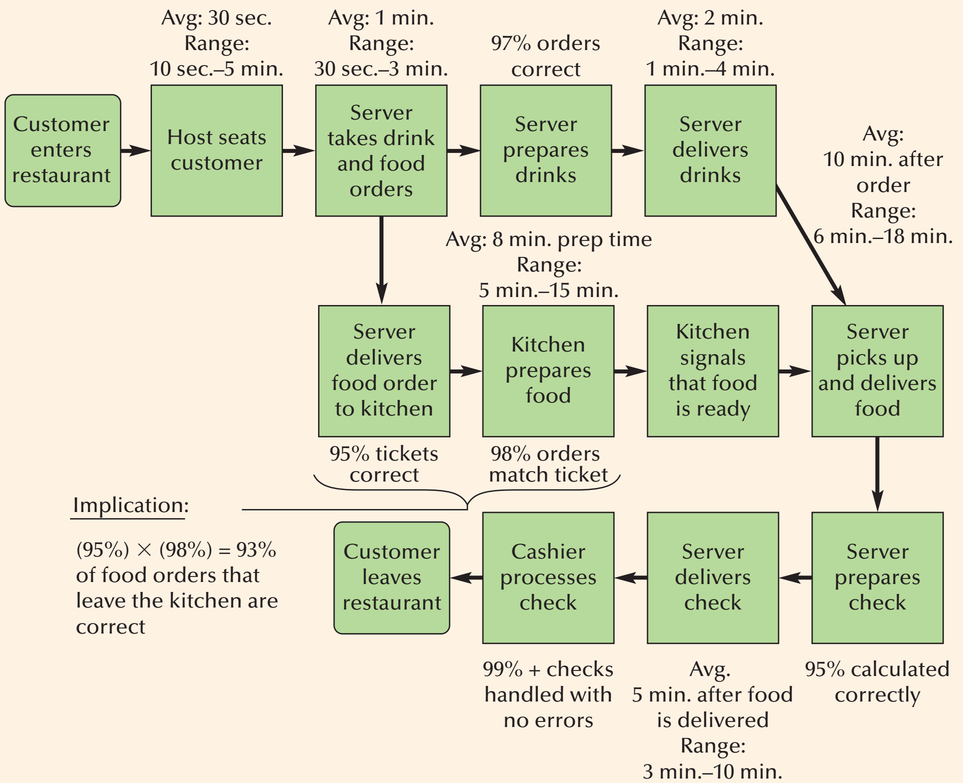


FIGURE 4.13 **Process Map for Bluebird Café, Updated to Show Performance Results for Various Steps**

GIVE US YOUR FEEDBACK, GET A FREE CUP OF JOE!

The Bluebird Café is always looking for ways to improve your dining experience. Please take a few moments to let us know how we are doing, and **your coffee (or tea or soda) will be on us!**

	Strongly Disagree				Strongly Agree
1. I was seated quickly.	1	2	3	4	5
2. My drink order was prepared correctly.	1	2	3	4	5
3. My drink order was delivered promptly.	1	2	3	4	5
4. My food order was prepared correctly.	1	2	3	4	5
5. My food order was delivered promptly.	1	2	3	4	5
6. The menu selection was excellent.	1	2	3	4	5
7. The prices represent a good value.	1	2	3	4	5
8. The café was clean and tidy.	1	2	3	4	5
9. The café has a pleasant ambiance.	1	2	3	4	5

On a scale of 0–100, how would you rate your **overall satisfaction** with your dining experience?

____

Are there any other ideas or comments you'd like to share with us?

____

____

____

FIGURE 4.14 Customer Survey Card for the Bluebird Café

of customers over several weeks. The survey cards are similar to check sheets, in that they allow the customer to identify particular areas of the café's performance that they are uncomfortable with. A total of 50 customers fill out the cards.

Step 3: *Analyze* the Process

Katie and her team are now ready to begin analyzing the process in earnest. Among the tools they use are scatter plots. Figure 4.15 takes the data from the 50 survey cards and plots each customer's overall satisfaction score against his or her response to Question 4 ("My food order was prepared correctly"). Figure 4.16 is similar, except now overall satisfaction scores are plotted against Question 5 results ("My food order was delivered promptly").

Both scatter plots suggest that there is a relationship between customer satisfaction and how correctly and promptly the order is filled, but the results seem particularly strong with regard to order correctness. Put another way, whether or not the food order was prepared correctly appears to have a significant impact on whether the customer is satisfied with the dining experience.

Katie and the team now use the open phase of root cause analysis to brainstorm about possible causes of the orders being prepared incorrectly. The team documents their ideas on a cause-and-effect diagram, from which they identify some potential causes, including "cook not properly trained," "server takes incorrect order information," and "food doesn't match menu."

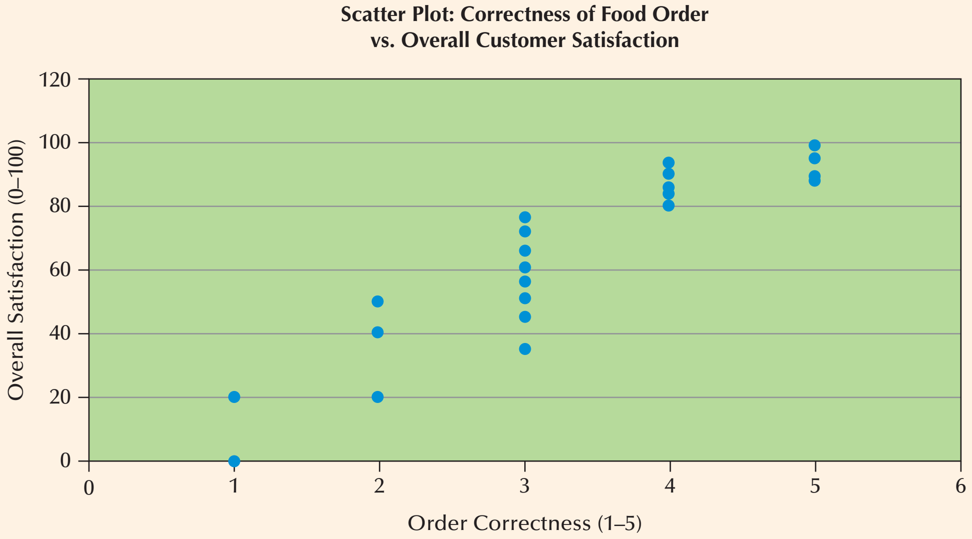


FIGURE 4.15 Scatter Plot Showing the Relationship between Survey Question 4 ("My food order was prepared correctly") and Customer's Overall Satisfaction Score

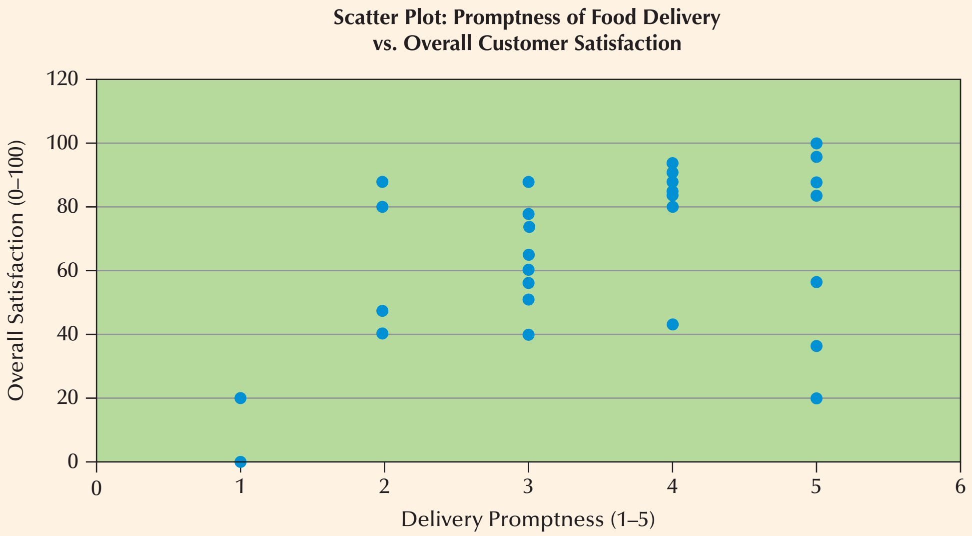


FIGURE 4.16 Scatter Plot Showing the Relationship between Survey Question 5 ("My food order was delivered promptly") and Customer's Overall Satisfaction Score

Entering the closed phase of root cause analysis, Katie develops a check sheet and, over the next few weeks, has the staff fill out these sheets each time a customer complains about an incorrect order. The check sheet data are then arranged into a Pareto chart, shown in Figure 4.17.

Step 4: *Improve* the Process

In looking at the Pareto chart, the team quickly realizes that the two highest-ranked items are really *communications* problems: The server gets the order wrong and the cook hears it incorrectly. Together, these problems account for roughly 60% of the incidences recorded. The third- and fourth-ranked items make up another 30% of the total and are tied to the failure of the kitchen staff to cook the food properly and match what's put on the plates to what's on the menu.

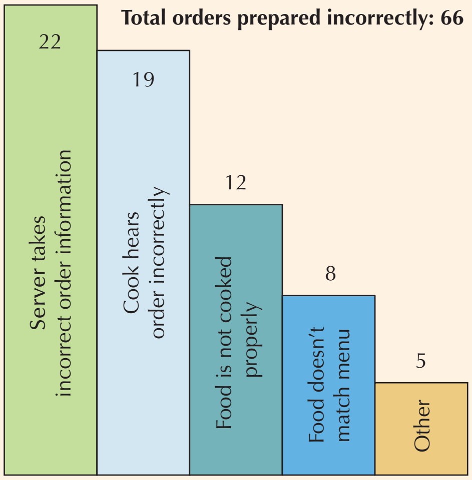


FIGURE 4.17 Pareto Chart Ranking Causes of Incorrect Food Orders at Bluebird Café

Armed with this information, the team makes some simple improvements aimed at bringing down the number of order prepared incorrectly:

1. Servers no longer take orders orally but write them down on an order ticket. The servers also repeat the orders back to the customers to verify that they have them right.
2. Cooks are given a written copy of the order ticket.
3. Servers compare the prepared dishes against the order ticket prior to taking it to the customer.
4. Cooks now refer to printed posters hanging on the wall that highlight important cooking steps and show pictures of how each dish should look.

Step 5: *Control* the New Process

With the changes in place, the café staff makes sure that all employees are familiar with the changes and follow the new procedures. Meanwhile, Katie continues to monitor the performance of the Bluebird Café using the Internet-based ratings as well as customer survey cards After four months, she is pleased to see that the average Internet rating for the Bluebird Café has risen to 4.25—not where she wants it to be, but it's on the right track.

4.4 BUSINESS PROCESS CHALLENGES AND THE SCOR MODEL

Most of the business process examples we have discussed to this point assume that we are working with a reasonably well-understood process that can be analyzed, improved, and controlled using the frameworks and tools described in Section 4.3. But this is not always true. Specifically:

- Some processes are artistic in nature. That is, they require flexibility in carrying out the various steps. Furthermore, customers actually *value* variability in the outcomes.
- Some processes may be so broken or so mismatched to the organization's strategy that only a total redesign of the process will do.
- Some processes cross organizational boundaries, which introduces additional challenges.

We talk about each of these challenges in turn.

How Standardized Should Processes Be?

According to some business experts, tools such as process mapping and the DMAIC cycle have become so popular that they have been *overused*—applied to process environments in which flexibility in the process and variability in outcomes are valued by the business and customers.

For example, while it certainly makes sense to standardize and control the process for administering intravenous drugs to a hospital patient, it makes less sense to control every step of a doctor's diagnosis process, especially when a patient has unique or unusual symptoms. To help managers understand when they should and shouldn't try to standardize processes, Joseph Hall and M. Eric Johnson developed a framework that divides processes into four main types based on (1) how much variability there is in the process and (2) whether customers actually value variability in outputs.[13]

Mass processes are perhaps the easiest to understand. Here, the goal of the process is to provide exactly the same output each time. The key to *mass customization* is *controlled* variation. For instance, when a customer orders a laptop computer from Dell, he or she can choose from a predetermined set of options. The goal is to provide some variability in output without undermining the stability of Dell's assembly operations.

At the other extreme from mass processes are *artistic processes* where *both* variability in the process and outputs are valued. A prime example would be a research and development (R&D) lab where employees are expected to use their creativity to identify new product or service opportunities. In fact, efforts to standardize R&D activities may actually interfere with the ability of a lab to generate breakthrough products or services.

The last type of process is what Hall and Johnson refer to as a *nascent, or broken process*. Unlike the other three types, processes that fall into this group have a fundamental mismatch between what the customer wants (standardized output) and what the process is currently capable of providing. Managers have two choices here: Reduce the variability of the process or switch to customers or markets that value output variability.

Business Process Reengineering (BPR)

Business process reengineering (BPR) According to APICS, "A procedure that involves the fundamental rethinking and radical redesign of business processes to achieve dramatic organizational improvements in such critical measures of performance as cost, quality, service, and speed."

An alternative approach to Six Sigma and the DMAIC process is **business process reengineering (BPR).** As APICS notes, BPR is "a procedure that involves the fundamental rethinking and radical redesign of business processes to achieve dramatic organizational improvements in such critical measures of performance as cost, quality, service, and speed."[14] Proponents of BPR suggest that organizations start the BPR process with a "blank sheet" of paper rather than try to understand and modify processes that may be severely outdated or dysfunctional. Which approach a firm uses—Six Sigma or BPR—depends on several factors, including how severe the problems are with the current business process and the ability of process participants to make radical changes.

Coordinating Process Management Efforts across the Supply Chain

In Example 4.6, the Six Sigma process improvement effort was focused on the activities within a single organization, in this case a café. But many times, firms must extend their efforts to include external supply chain partners. Extending process management to include external partners is an important step, as significant opportunities for improvement often lie at the interfaces between various partners. But doing so adds greater complexity, given that multiple organizations and their representatives are now participating in the effort. The SCOR model, described next, provides one framework for understanding and managing cross-organizational supply chain processes.

The SCOR Model

Supply Chain Operations Reference (SCOR) model A comprehensive model of the core management processes and individual process types that together define the domain of supply chain management.

We end this chapter with a discussion of the **Supply Chain Operations Reference (SCOR) model.**[15] The SCOR model is a comprehensive model of high-level business processes and detailed individual processes that together define the scope of supply chain management

[13]J. Hall and E. Johnson, "When Should a Process Be Art, Not Science?" *Harvard Business Review* (March 2009): 58–65.

[14]J. H. Blackstone, ed., *APICS Dictionary*, 15th ed. (Chicago, IL: APICS, 2016).

[15]SCOR Framework, **www.apics.org/apics-for-business/products-and-services/apics-scc-frameworks/scor.**

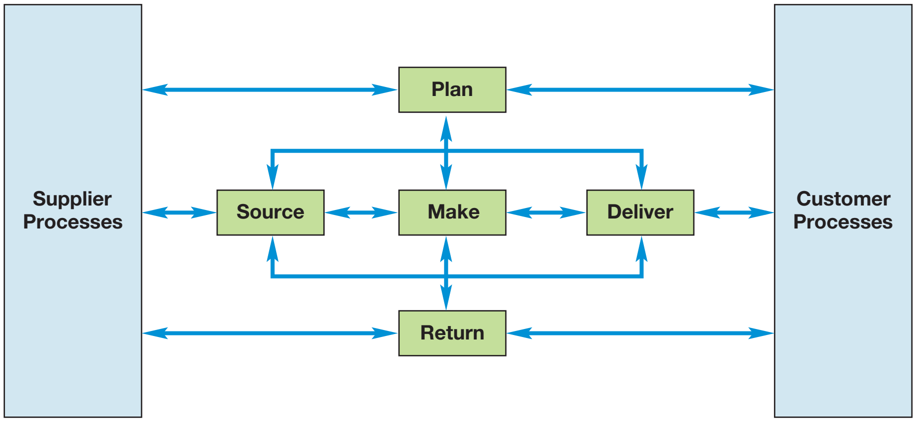


FIGURE 4.18
Overview of the SCOR Model Showing the Five Level 1 Processes
Source: Supply Chain Operations (Supply-Chain Council, 2011).

activity. The SCOR model is supported by the APICS Supply Chain Council, an industry group consisting of hundreds of companies and academics.

Why would companies spend time and money to develop a reference model such as SCOR? Actually, there are several good reasons. First, a reference model gives individuals a common language for discussing and comparing supply chain business processes. This can be especially important when benchmarking performance or coordinating with other firms to build a supply chain. Second, a reference model provides a template to guide the design and implementation of an organization's own supply chain processes. Third, seeing the processes laid out in a single, comprehensive model helps some managers better understand what supply chain management is all about.

The SCOR model looks at a firm's supply chain activities in three levels of increasing detail. Level 1 of the views SCM activities as being structured around five core management processes (Figure 4.18):

1. **Source**—Processes that procure goods and services to meet planned or actual demand.
2. **Make**—Processes that transform product to a finished state to meet planned or actual demand.
3. **Deliver**—Processes that provide finished goods and services to meet planned or actual demand. These processes include order management as well as logistics and distribution activities.
4. **Return**—Processes associated with returning or receiving returned products for any reason.
5. **Plan**—Processes that balance aggregate resources with requirements.

Level 2 processes break down level 1 activities into more detail. For example, SCOR differentiates between three types of "make" processes: make-to-stock, make-to-order, and engineer-to-order. As you might recall from our discussion in Chapter 3, make-to-stock, make-to-order, and engineer-to-order manufacturing processes differ with regard to the level of product customization and therefore require very different solutions.

Finally, SCOR level 3 processes describes in detail the actual *steps* required to execute level 2 processes. Companies can use these maps as a rough guide for developing their own unique processes or for identifying gaps. Consider the example in Figure 4.19, which shows the level 3 process map for one particular process type, "Make Engineer-to-Order Product."

The process map suggests that manufacturing an engineer-to-order product should consist of seven sequential process "elements," labeled in SCOR nomenclature as M3.1–M3.7. The map also shows the prescribed information inflows and outflows to these elements. For example, the second element, "Schedule Production Activities," should take place in response to information inflows, including the production plan, scheduled receipts, feedback from downstream "make" elements, and equipment and facilities schedules and plans. In turn, the information outflow of this element should be an updated production schedule used by the production, sourcing, and distribution areas. Note too that the entire "make engineer-to-order" process, as prescribed by the SCOR model, should contain information links to all five of the core management processes.