PART 2

5 Technology and Operations Management

LEARNING OUTCOMES

After studying this chapter, you should be able to:

- 5-1 Describe different types of technology and their role in manufacturing and service operations.
- 5-2 Explain how manufacturing and service technology and analytics strengthen the value chain.
- 5-3 Explain the benefits and challenges of using technology.
- 5-4 Describe key technology decisions.

After you finish this chapter go to **PAGE 106** for **STUDY TOOLS**

Tesla's innovation in battery technology helps them provide better performance, reduce costs, and lower prices.

Automotive technology has been advancing rapidly, particularly in the hybrid-electric arena. Many people now drive hybrid vehicles, and pure electric vehicles, such as Nissan's Leaf, Chevy's Volt, and the luxury Tesla Model S, are gaining popularity. Electric vehicles support sustainability, producing 40 percent less carbon dioxide and ozone than gasoline models, even when environmental considerations associated with manufacturing and electricity production are included. Tesla's innovation in battery technology helps them to provide better performance, reduce costs, and lower prices. Tesla is planning a $4 billion gigafactory along with a second backup site to produce its lithium-ion batteries. The Model S has a range of 265 miles, much longer than its competitors. Although the Model S is rather expensive, Tesla plans to introduce more affordable vehicles in the $30,000 range.

WHAT DO YOU THINK?
In what ways has technology benefited your life and work as a student?

Technology—both physical and information—has dramatically changed how work is accomplished in every industry—from mining to manufacturing, to education, to health care. Technology is the enabler that makes today's service and manufacturing systems operate productively and meet customer needs better than ever. Most of you probably cannot imagine living in a world without personal computers, the Internet, or wireless communications. However, new technology such as the electric car requires a rethinking of the customer benefit package, supply chain, and operations. With a limited range, the practicality of electric vehicles requires the ability to quickly charge batteries during longer trips. Tesla is building a nationwide network of 30-minute charging stations that will allow individuals to drive across the entire United States. It is also developing battery-swapping stations that can change the batteries faster than a typical gasoline fill-up. Tesla refuses to sell through independent dealers; it operates all its own showrooms and service centers to avoid the middleman price inflation and to build and maintain customer relationships. Its manufacturing plant has a high level of automation to manufacture body panels and uses an army of industrial robots to assist workers in the assembly process and to transport the vehicle through the plant. Robots even insert seats and glue and set windshields! (Search YouTube for "How the Tesla Model S is Made" for a behind-the-scenes tour.)

Technological innovation in goods, services, manufacturing, and service delivery is a competitive necessity. Jack Welch, retired CEO of General Electric, for example, pushed GE to become a leader among traditional old-economy companies in embracing the Internet after noticing his wife Christmas shopping on the Web. "I realized that if I didn't watch it, I would retire as a Neanderthal," he was reported as saying, "So I just started reading everything I could about it." He began by pairing 1,000 Web-savvy mentors with senior people to get his top teams up to Internet speed quickly.[1]

5-1 UNDERSTANDING TECHNOLOGY IN OPERATIONS

We may categorize technology into two basic groups. **Hard technology** *refers to equipment and devices that perform a variety of tasks in the creation and delivery of goods and services.* Some examples of hard technology are computers, microprocessors, optical switches, satellites, sensors, robots, automated machines, bar-code scanners, and radio-frequency identification (RFID) tags.

RFID tags are the modern successor to bar codes. RFID tags are tiny computer chips that can be placed on shipping containers, individual products, credit cards, prescription medicines, passports, livestock, and even people. They transmit radio signals to identify locations and track movements throughout the supply chain. They have many

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applications in both manufacturing and service industries. Retail, defense, transportation, and health care have begun requiring their suppliers to implement this technology. RFID can bring visibility and enhanced security to the handling and transportation of materials, baggage, and other cargo. RFID can help to identify genuine products from counterfeit knock-offs, thus helping to lower overall product and operational costs.[2] They have also been used to monitor residents in assisted living buildings and track the movements of doctors, nurses, and equipment in hospital emergency rooms.

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Soft technology *refers to the application of the Internet, computer software, and information systems to provide data, information, and analysis and to facilitate the accomplishment of creating and delivering goods and services.* Some examples are database systems, artificial intelligence programs, and voice-recognition software. Both types are essential to modern organizations (see the box about Amazon.com later in this chapter). As described in the introduction to this chapter, the hybrid and ultimately the electric vehicle are good examples of integrating hard and soft technology.

Information technology provides the ability to integrate all parts of the value chain through better management of data and information. This leads to more effective strategic and operational decisions to design better customer benefit packages that support customers' wants and needs, achieve competitive priorities, and improve the design and operation of all processes in the value chain.

Increasingly, both hard and soft technology are being integrated across the organization, allowing managers to make better decisions and share information across the value chain. Such systems, often called integrated operating systems (IOSs), include computer integrated manufacturing systems (CIMs), enterprise resource planning (ERP) systems, and customer relationship management (CRM) systems, all of which use technology to create better and more customized goods and services and deliver them faster at lower prices. We will discuss these systems in the following sections.

Soft technology refers to the application of the Internet, computer software, and information systems to provide data, information, and analysis and to facilitate the accomplishment of creating and delivering goods and services.

Computer-integrated manufacturing systems (CIMSs) represent the union of hardware, software, database management, and communications to automate and control production activities, from planning and design to manufacturing and distribution.

5-1a Manufacturing Technology

Although high-tech, automated manufacturing processes receive a lot of media attention, much of the technology used in small- and medium-sized manufacturing enterprises around the world is still quite basic. The accompanying boxes that highlight making jigsaw puzzles and motorcycle gears illustrate how technology is used and integrated into manufacturing operations. Clearly, there are worlds of differences in the technology used for making puzzles and gears. However, from an operations management standpoint, all organizations face common issues regarding technology:

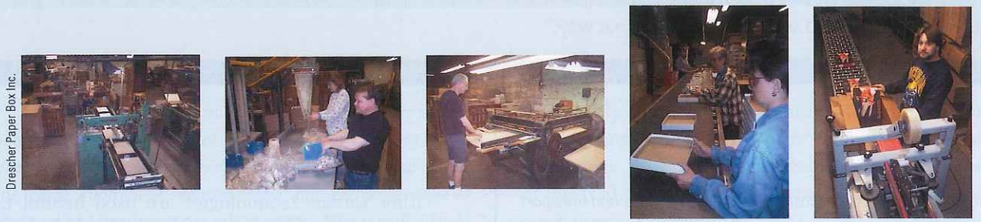
- The right technology must be selected for the goods that are produced.
- Process resources, such as machines and employees, must be set up and configured in a logical fashion to support production efficiency.
- Labor must be trained to operate the equipment.
- Process performance must be continually improved.
- Work must be scheduled to meet shipping commitments/customer promise dates.
- Quality must be ensured.

5-1b Computer-Integrated Manufacturing Systems (CIMSs)

Much of the technology used in manufacturing today is automated and linked with information technology. **Computer-integrated manufacturing systems (CIMSs)** *represent the union of hardware, software, database management, and communications to automate and control production activities, from planning and design to manufacturing and distribution.* CIMSs include many hard and soft technologies

DRESCHER PAPER BOX: MAKING JIGSAW PUZZLES

Drescher Paper Box in Buffalo, New York, formed in 1867, manufactures high-quality laminated cardboard jigsaw puzzles and board games and assembles them for retail stores. Drescher also produces cotton-filled jewelry boxes, candy boxes, business card boxes, and custom-made industrial boxes. Manufacturing jigsaw puzzles consists of three major steps: making the puzzle pieces, making the puzzle boxes, and final assembly. A printed picture is cut to size and laminated on a thick puzzle-board backing. Large presses are used to cut the puzzle into pieces, which are then bagged. The box-making process begins with blank cardboard. Boxes are scored and cut, then laminated with printed graphics. In the final assembly process, the puzzles are boxed and shrink-wrapped for shipment.


Drescher Paper Box Inc.

with a wide variety of acronyms, vendors, and applications and are essential to productivity and efficiency in modern manufacturing.

The roots of CIMSs began with **numerical control (NC)** *machine tools, which enable the machinist's skills to be duplicated by a programmable device (originally punched paper tape) that controls the movements of a tool used to make complex shapes.* **Computer numerical control (CNC)** *machines are NC machines whose operations are driven by a computer.*

Industrial robots were the next major advance in manufacturing automation. *A* **robot** *is a programmable machine designed to handle materials or tools in the performance of a variety of tasks.* Robots can be "taught" a large number of sequences of motions and operations and even to make certain logical decisions. Other typical applications are spray painting, machining, inspection, and material handling. Robots are especially useful for working with hazardous materials or heavy objects; for instance, in nuclear power plants robots are used to do work in highly radioactive areas. In services, robots help doctors complete intricate brain surgery by drilling very precise holes into the skull.

Integrated manufacturing systems began to emerge with computer-aided design/computer-aided engineering (CAD/CAE) and computer-aided manufacturing (CAM) systems. **CAD/CAE** *enables engineers to design, analyze, test, simulate, and "manufacture" products before they physically exist, thus ensuring that a product can be manufactured to specifications when it is released to the shop floor.* For example, Nissan is cutting in half the time needed to take new cars from design to showroom, using computer-aided design software. The Nissan Note subcompact was rolled out to the Japanese market just 10.5 months after its design was finalized, in contrast to the 20.75 months that the process used to take.[3] **CAM** *involves computer control of the manufacturing process, such as determining tool movements and cutting speeds.*

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Flexible manufacturing systems (FMSs) consist of two or more computer-controlled machines or robots linked by automated handling devices such as transfer machines, conveyors, and transport systems. Computers direct the overall sequence of operations and route the work to the appropriate machine, select and load the proper tools, and control the operations performed by the machine.

Kroger: Leveraging Two Seconds of Savings

Bar code scanners have been used in grocery stores for many years, requiring associates to scan items manually in the checkout lanes. Using a patented technology, the national grocery chain Kroger has been testing a new innovation called Advantage Checkout, designed to save customers time as well as to save the company operating costs and labor. Customers place items on a quick-moving conveyor belt. The items enter a tunnel lined with high-powered cameras to capture images of the products and scan the bar codes, then leave the tunnel on another conveyor to be bagged. The scanner can perform the function of several traditional or self-checkout lanes, takes up less floor space, and requires fewer workers. For a process that is done thousands of times in 2,400 stores, Kroger's CFO noted, "You can really leverage two seconds of savings that way."[4]

handling devices such as transfer machines, conveyors, and transport systems. Computers direct the overall sequence of operations and route the work to the appropriate machine, select and load the proper tools, and control the operations performed by the machine. More than one item can be machined or assembled simultaneously, and many different items can be processed in random order. Honda has been a pioneer in using FMSs and robotic technology. Its competitive priorities are moving toward design and demand flexibility so it is changing operating systems and technology to support these priorities. Honda assembly plants use flexible manufacturing cells where the robots can be reprogrammed to build different models of cars.[5] Today, many companies have achieved complete integration of CAD/CAE, CAM, and FMSs into what we now call computer-integrated manufacturing systems (CIMSs).

5-1c Service Technology

You have undoubtedly encountered quite a bit of service technology in your own daily lives. Technology is used in many services, including downloading music, banking, automated car washes, voice recognition in telephone menus, medical procedures, hotel and airline kiosks, and entertainment such as the robots used in Disney World's Hall of Presidents and Country Bear Jamboree attractions. One innovation that is being used by Stop & Shop, a grocery chain serving New England, is a portable device called EasyShop. EasyShop is a handheld terminal that allows loyalty card shoppers to scan items as they shop and receive targeted offers. Shoppers can also place an order at the deli department, for example, and then be alerted when the order is ready.[6]

Other service technologies are used behind the scenes in hotels, airlines, hospitals, and retail stores to facilitate service experiences. To speed order entry for pizza delivery, for instance, many firms use a touch-sensitive computer screen that is linked to a customer database. When a repeat customer calls, the employee need only ask for the customer's phone number to bring up the customer's name, address, and delivery directions (for a new customer, the information need only be entered once). The employee is able to address the customer immediately by name, enhancing the perception of service quality, and then enter the order quickly on the touch-sensitive screen to print for the kitchen, eliminating errors due to misreading of handwritten orders.[7]

CIMS FACTS

According to the National Research Council, companies with computer-integrated manufacturing system experience have been able to

- **decrease engineering design costs by up to 30 percent;**
- **increase productivity by 40 to 70 percent;**
- **increase equipment utilization by a factor of 2 to 3;**
- **reduce work-in-process and lead times by 30 to 60 percent; and**
- **improve quality by a factor of 3 to 4.**

High-Tech Libraries

With Internet search today, libraries may be becoming extinct. Nevertheless, many people still use them. Some libraries use bar code scanners on books to make it easier for customers to check them out, much like a modern supermarket checkout. Others are beginning to use RFID technology. RFID scanners installed in counters at the checkout can identify and check out multiple books faster than using bar codes, and customers are often not aware of it when their receipt is printed. RFID technology is also helping to ensure that books are placed correctly on shelves. Librarians used to do this manually, and it took a lot of time. Such systems increase productivity and allow staff to spend more time answering questions helping their customers.

Perhaps the most common service technology in use today involves the Internet. **E-service** *refers to using the Internet and technology to provide services that create and deliver time, place, information, entertainment, and exchange value to customers and/or support the sale of goods.* Many individuals use airline, hotel, and rental car websites or "one-stop" e-services like Microsoft Expedia in planning a vacation. The boxes that highlight electronic medical record (EMR) systems and library services provide some interesting examples.

5-2 TECHNOLOGY IN VALUE CHAINS

Technology, especially the Internet and e-communications, is changing the operation, speed, and efficiency of the value chain and presents many new challenges to operations managers. In many situations, electronic transaction capability allows all parts of the value chain to immediately know and react to changes in demand and supply. This requires tighter integration of many of the components of the value chain. In some cases, technology provides the capability to eliminate parts of the traditional value chain structure and streamline operations.

With all the new technology that has evolved, a new perspective and capability for the value chain has emerged—the *e-commerce view of the value chain*, shown in Exhibit 5.1. Major e-commerce relationships include B2B—business to business, B2C—business to customer, C2C—customer to customer, G2C—government to customer, G2G—government to government, and G2B—government to business. Here, buyers and sellers are connected by bricks-and-mortar intermediaries such as logistic and transportation services and/or by information technology to share information directly.

E-service refers to using the Internet and technology to provide services that create and deliver time, place, information, entertainment, and exchange value to customers and/or support the sale of goods.

"Technology, especially the Internet and e-communications, is changing the operation, speed, and efficiency of the value chain and presents many new challenges to operations managers."

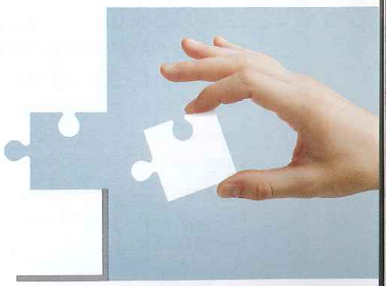
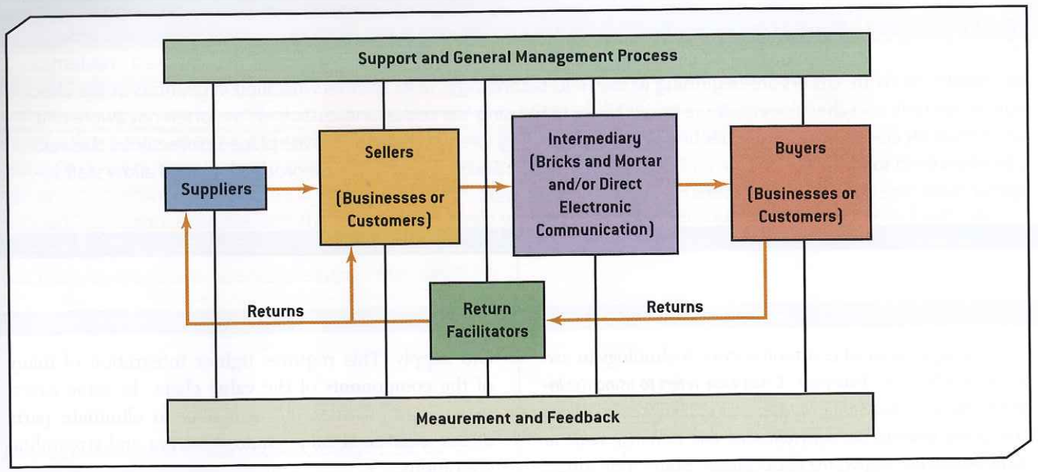


Exhibit 5.1

E-Commerce View of the Value Chain



An **intermediary** is any entity—real or virtual—that coordinates and shares information between buyers and sellers.

Return facilitators specialize in handling all aspects of customers returning a manufactured good or delivered service and requesting their money back, repairing the manufactured good and returning it to the customer, and/or invoking the service guarantee.

An **intermediary** *is any entity—real or virtual—that coordinates and shares information between buyers and sellers.* Some firms, such as General Electric, Walmart, and Procter & Gamble, use e-commerce to communicate directly with suppliers and retail stores, and thereby skip traditional bricks-and-mortar intermediaries. **Return facilitators** *specialize in handling all aspects of customers returning a manufactured good or delivered service and requesting their money back, repairing the manufactured good and returning it to the customer, and/or invoking the service guarantee.*

Some examples of how information technology has enabled companies to build and sustain competitive advantage for e-commerce follow.

- GE Plastics (www.geplastics.com) used the Internet to completely change how plastics are designed, ordered, researched, and delivered for B2B customers. The entire GE Plastics website represents a value-added, information-intensive set of services—e-services—that facilitate the sale of goods—chemicals, plastics, resins, polymers, and the like. GE Polymerland (www.gepolymerland.com) allows other companies to buy, design, interact, research, and participate in a global auction service for many types of chemicals and plastics. The "buy" button reveals many value-added services, such as how to place an order, order status, shipment tracking, pricing, and inventory availability.
- FedEx has a rich history of technology innovation for its B2C value chain. It was the first to install computers in delivery vehicles, providing sophisticated automation for corporate mailing services and developing tracking capabilities and software. In 1994, it was the first to offer package-status tracking for improved customer service via fedex.com. It also pioneered the use of wireless technology for shipping with the introduction of the digitally assisted dispatch system (DADS) over 25 years ago. FedEx developed the FedEx Innovation Labs, an information technology project designed to create an atmosphere of collaborative thinking around critical technologies such as advanced optics for scanning, robotics, pervasive computing, social networking, and more.[8]
- eBay (www.ebay.com) started out as a C2C value chain but quickly incorporated B2C and B2B transactions. The eBay business is built on the values of open communication and honesty, and the vast majority of buyers and sellers at eBay are reliable. eBay fights fraud using customer feedback that keeps track of the trustworthiness of its sellers with a point system and posts this information for all site members to see; it also has its own security monitoring processes. In the event a customer pays for an item and never receives it, eBay will reimburse buyers up to a dollar limit, minus processing costs. eBay provides a variety of services, such as online seminars and interactive tutorials, to help customers learn how to buy and sell on the website, how to search for goods or services on eBay, how to add photos of their goods or services, how to design store fronts and marketing, and so on.
- Federal, state, and local government value chains (i.e., G2C, G2G, and G2B) use e-commerce to provide better service for citizens, control waste and fraud,

IT IN HEALTH CARE

To ensure quality yet dramatically reduce costs, hospitals and health care clinics are adopting electronic medical record (EMR) systems. EMR systems record all the information generated by the health care facility and its patients in electronic form. Instead of a paper-based medical chart for each patient, the doctor uses a wireless PDA or tablet PC. EMR information also is easily integrated with other health care facility information systems, such as billing, patient scheduling, and accounting.

The benefits of an EMR system include:

- **Cost Reduction. At one medical clinic, transcription costs were reduced by 33 percent and transcription turnaround time went from seven days to one day.**
- **Revenue Enhancement. One health maintenance organization (HMO) used the Internet to contact over 600 patients who were overdue for mammograms, resulting in services that generated $670,000 in additional revenue.**
- **Improved Administrative and Support Process Efficiency. In one medical clinic, one full-time employee filed 600 to 700 patient charts per week. With the installation of EMR, these same medical records could be downloaded in 10 minutes.**
- **Improved Clinical Efficiency and Patient Care. An EMR system helps to standardize chart quality across the clinic or hospital and therefore minimizes the problems that result from poor handwriting and other inconsistencies in paper-based systems.**

3D Printing

You have undoubtedly heard of 3D printing, technically called additive manufacturing. This is the process of producing a three-dimensional solid object from a digital model file. "Additive" means that successive layers of material such as plastics, ceramics, or glass are built up, rather than using traditional machining processes such as milling or drilling that remove materials. 3D printing technology has numerous applications. For example, industrial designers can quickly produce a physical model from a digital computer-aided design drawing; this is often called rapid prototyping and is used extensively in architecture and industrial design as well as automotive, aerospace, and other manufacturing industries. It is even used in the dental and medical industries for tooth implants and prosthetics, in the fashion industry (one recent contestant on the TV show *Project Runway* used it to create wearable fashion accessories!). The technology is expanding the customer benefit package, allowing consumers to create custom products. For instance, Nokia introduced 3D printing to make custom cases for mobile phones.

AP Images/Paul Sakuma

and minimize costs. Filing your taxes electronically and the direct deposit monthly Social Security checks are two examples. Food stamps are now in the form of electronic credit cards, and student loan applications must be electronically filed.

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5-2a Analytics in Value Chains

Business analytics plays a critical role in managing value chains, particularly for integrating and analyzing data throughout the value chain within an information systems framework. Netflix, for example, uses analytics everywhere, from marketing to operations to customer service. Netflix collects extensive data using surveys, website user testing, brand awareness studies, and segmentation research. It uses analytics to help decide what price to pay for the rights to distribute new DVDs.[9] Using data on customer preferences, film ratings, and comparisons with people who have similar viewing and preference histories, Netflix predicts movies that a customer is likely to enjoy and creates personalized recommendations. This information also helps to manage its film inventory by recommending older movies to balance demand for newer releases.[10]

Two key information systems that drive value chain management are enterprise resource planning (ERP) and customer relationship management (CRM). **ERP** *systems integrate all aspects of a business—accounting, customer relationship management, supply chain management, manufacturing, sales, human resources—into a unified information system and provide more timely analysis and reporting of sales, customer, inventory, manufacturing, human resource, and accounting data.* Traditionally, each department of a company, such as finance, human resources, and manufacturing, has individual information systems optimized to the needs of that department. If the sales department wants to know the status of a customer's order, for example, someone would typically have to call manufacturing or shipping. ERP combines each department's information into a single, integrated system with a common database so that departments can easily share information and communicate with each other.

ERP systems usually consist of different modules that can be implemented individually so that each department still has a level of autonomy, but they are combined into an integrated operating system. For example, when a customer's order is entered by sales, all information necessary to fulfill the order is built into the ERP system. The finance module would have the customer's order history and credit rating; the warehouse module would have current inventory levels; and the supply chain module would have distribution and shipping information. Not only would sales be able to provide accurate information about product availability and shipping dates, but orders would get processed faster with fewer errors and delays.

Most of the subsystems of ERP systems, such as customer ordering, inventory management, and production scheduling, are *real-time transaction processing systems,* as opposed to *batched processing systems,* in which a day's entire batch of transactions was typically processed during the night. In real-time processing, information is updated continuously, allowing the impacts to be reflected immediately in all other areas of the ERP system.

Enterprise resource planning (ERP) systems integrate all aspects of a business—accounting, customer relationship management, supply chain management, manufacturing, sales, human resources—into a unified information system and provide more timely analysis and reporting of sales, customer, inventory, manufacturing, human resource, and accounting data.

Some business processes, however, such as the weekly payroll, monthly accounting reports, and billing, do not need real-time processing. Two prominent vendors of ERP software are SAP (www.sap.com) and Oracle (www.oracle.com).

Customer relationship management (CRM) *is a business strategy designed to learn more about customers' wants, needs, and behaviors in order to build customer relationships and loyalty and ultimately enhance revenues and profits.* CRM exploits the vast amount of data that can be collected from consumers. For example, using a cell phone to make a voice call leaves behind data on whom you called, how long you talked, what time you called, whether your call was successful or it was dropped, your location, the promotion you may be responding to, and purchase histories.[11] Similarly, supermarkets, drug stores, and retail stores use "loyalty cards" that leave behind a digital trail of data about purchasing patterns. By better understanding these patterns and hidden relationships in data, stores can customize advertisements, promotions, coupons, and so on down to each individual customer and send targeted text messages and e-mail offers.

A typical CRM system includes market segmentation and analysis, customer service and relationship building, effective complaint resolution, cross-selling of goods and services, and pre- and postproduction processes such as preproduction order processing and postproduction field service. Of course, the value chain must be capable of delivering what the customer wants, and that is where sound operational analysis is required.

CRM helps firms gain and maintain competitive advantage by

- segmenting markets based on demographic and behavioral characteristics;
- tracking sales trends and advertising effectiveness by customer and market segment;
- identifying which customers should be the focus of targeted marketing initiatives with predicted high customer response rates;
- forecasting customer retention (and defection) rates and providing feedback as to why customers leave the company;
- identifying which transactions are likely candidates to be fraudulent;
- studying which goods and services are purchased together, and what might be good ways to bundle them (i.e., the customer benefit package);
- studying and predicting what Web characteristics are most attractive to customers and how the website might be improved; and

Terri Miller/E-Visual Communications Inc.

- linking the previous information to competitive priorities by market segment and process and value chain performance.

In recent years, cloud computing has improved the efficiency, productivity, and cost for organizations using information technology (IT) and such systems as ERP and CRM. Many now outsource ERP, CRM, and other IT services; for instance, Netflix outsourced most of its Web technology work to Amazon.

5-3 BENEFITS AND CHALLENGES OF TECHNOLOGY

Technology provides many benefits but at the same time poses some key challenges. A summary of the benefits and challenges of technology is given in Exhibit 5.2. Can you think of others?

One of the major benefits of technology has been its impact on sustainability. In Florida, for example, Card Sound Golf Club in Key Largo had an underground sensor system installed that allowed the club to cut in half the amount of fresh water it used to flush salt out of water used to irrigate the golf course. Many other golf courses are using this advanced sensor technology to reduce water consumption and keep their golf courses green—and not just in color.[12]

Customer relationship management (CRM) is a business strategy designed to learn more about customers' wants, needs, and behaviors in order to build customer relationships and loyalty and ultimately enhance revenues and profits.

Exhibit 5.2

Example Benefits and Challenges of Adopting Technology

Benefits	Challenges
Creates new industries and job opportunities	Higher employee skill levels required, such as information technology and service management skills
Restructures old and less productive industries	Integration of old (legacy) and new technology and systems
Integrates supply and value chain players	Job shift and displacement
Increases marketplace competitiveness and maintains the survival of the firm	Less opportunity for employee creativity and empowerment
Provides the capability to focus on smaller target market segments through mass customization	Protecting the employee's and customer's privacy and security
Improves/increases productivity, quality, customer satisfaction, speed, safety, and flexibility/customization—does more with less	Fewer human service providers, resulting in customer ownership not being assigned, nonhuman service encounters, and inability of the customer to change decisions and return goods easily
Lowers cost	Information overload
Raises world's standard of living	Global outsourcing and impact on domestic job opportunities
Monitors the environment and health of the planet	Enforcement of regulations and laws to support sustainability goals

Intel suggests that the microprocessor is the "ultimate invention for achieving sustainability."[13] Microprocessor-based information and communication technology (ICT) provides sustainable economic, environmental, and social benefits on a national and global basis. One study cited ICT as directly responsible for contributing to two-thirds of the productivity gains in the U.S. economy between 1997 and 2002. These gains have significantly offset carbon usage, enabling more to be done, less miles traveled, and greater operational and material efficiencies. ICT is responsible for a phenomenon known as *dematerialization*, by which the same or an increased quality and quantity of goods and/or services are created using fewer natural resources. ICT has also enabled flexible work options such as telecommuting, which not only yields environmental benefits but social benefits as well.

Scalability is a measure of the contribution margin (revenue minus variable costs) required to deliver a good or service as the business grows and volumes increase.

High scalability is the capability to serve additional customers at zero or extremely low incremental costs.

5-4 TECHNOLOGY DECISIONS AND IMPLEMENTATION

Managers must make good decisions about introducing and using new technology. They must understand the relative advantages and disadvantages of using technologies and their impact on the workforce. Although technology has proven quite useful in eliminating monotony and hazardous work and can help people develop new skills and talents, it can also rob them of empowerment and creativity. The goal of the operations manager is to provide the best synthesis of technology, people, and processes; this interaction is often called the *sociotechnical system*. Designing the sociotechnical system includes making decisions about job specialization versus enlargement, employee empowerment, training, decision support systems, teams and work groups, job design, recognition and reward, career advancement, and facility and equipment layout.

A key factor that affects technology decisions is scalability. **Scalability** *is a measure of the contribution margin (revenue minus variable costs) required to deliver a good or service as the business grows and volumes increase.* Scalability is a key issue in e-commerce. **High scalability** *is the capability to serve additional customers at zero or extremely low incremental costs.* For example, Monster.com is an online job posting and

MANAGING YOUR WAIT
THERE'S AN APP FOR THAT!

You have probably gone to restaurants that have given you a pager that vibrates and lights up when your table is ready. Unfortunately, they generally don't work outside the restaurant. New "wait apps" are changing that. They allow restaurants to send text messages to mobile phones. Customers can shop nearby or hang out elsewhere. Some apps even let customers know where they are in the queue. Restaurants have found that managing expectations in this way reduces walkaways and, of course, increases profit. Cheesecake, anyone?

SOLVED PROBLEM

Maling Manufacturing needs to purchase a new piece of machining equipment. The two choices are a conventional (labor-intensive) machine and an automated (computer-controlled) machine. Profitability will depend on a future unknown event—the demand volume. The following table presents an estimate of the net present value of profit over the next three years.

	Demand Volume	
Decision	**Low**	**High**
Conventional machine	($10,000)	$110,000
Automated machine	($50,000)	$145,000

Given the uncertainty associated with the demand volume, and no other information to work with, how would you make a decision?

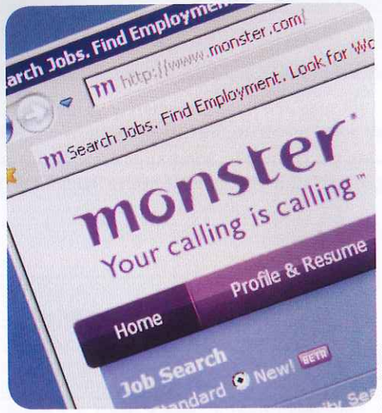
Solution:

Supplementary Chapter (SC) E describes decision criteria for addressing this situation, and Exhibit 5.3 shows the Decision Analysis Excel template from the CourseMate Web site. An aggressive, risk-taking manager would use a "maximax" criterion that would choose the decision that maximizes the maximum profit among all events (cell G9)—in this case, the automated machine. A conservative, risk-averse manager would use a "maximin" criterion that would choose the decision that will maximize the minimum possible profit among all events (cell H8)—in this case, the conventional machine. A third criterion is "minimax regret," which chooses the decision that minimizes the maximum opportunity loss (cell G17). There is no optimal decision; the decision involves determining how much risk one is willing to take.

Exhibit 5.3

Portion of Excel Decision Analysis Template

	A	B	C	D	E	F	G	H	I
1	Decision Analysis								
2	Enter the data only in the yellow cells.								
3	This template is designed to allow up to 5 decision alternatives and future events.								
4	Enter names of decision alternatives and future events in the appropriate cells in column A or K and row 7. Probabilities are optional.								
5									
6	*Profit Payoff Table*	Future Events							
7	Decision Alternative	Low	High				Maximum	Minimum	Expected Value
8	Conventional machine	$15,000.00	$21,000.00				$21,000.00	$15,000.00	
9	Automated machine	$9,000.00	$35,000.00				$35,000.00	$9,000.00	
10									
11									
12									
13	Probability								
14									
15	Opportunity Loss Matrix	Future Events							
16	Decision Alternative	Low	High				Maximum		
17	Conventional machine	$0.00	$14,000.00				$14,000.00		
18	Automated machine	$6,000.00	$0.00				$6,000.00		
19									
20									
21									
22									
23	Maximax Decision	Automated machine							
24	Maximin Decision	Conventional machine							
25	Opportunity Loss Decision	Automated machine							



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placement service that is largely information-intensive. Customers can post their resumes on the Monster.com website and print out job advertisements and opportunities on their office or home computers at their expense. This service is highly scalable because its fixed costs are approximately 80 to 85 percent of total costs. The incremental cost to serve an additional customer is very small, yet the revenue obtained from this customer remains high. If an organization establishes a business where the incremental cost (or variable cost) to serve more customers is zero, then the firm is said to be *infinitely scalable*. Online newspapers, magazines, and encyclopedias; e-banking services; and other information-intensive businesses have the potential to be infinitely scalable.

On the other hand, **low scalability** *implies that serving additional customers requires high incremental variable costs.*

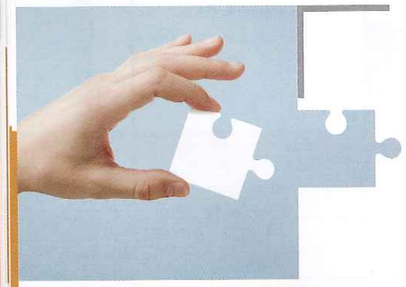
Low scalability implies that serving additional customers requires high incremental variable costs.

WebVan: A Value Chain Failure

One dot.com company with a lot of potential, WebVan, focused on customers' ordering their groceries online and the company then picking up the orders in a warehouse and delivering them to the customers' homes. The idea was to support the order-pick-pack-deliver process of acquiring groceries through an e-service at the front end of the value chain and with delivery vans at the back end of the value chain. This service made several assumptions about customer wants and needs; for example, that customers have perfect knowledge of what they want when they surf the online catalogs; that customers would be home when the delivery arrived; that what the e-catalogue shows is what the customer will get; that the customer doesn't make mistakes when selecting the items; and that time-starved customers are willing to pay a high premium for home delivery. Unfortunately, this was a very high-cost process. The $30 to $40 delivery charge for complex and heterogeneous customer orders and the many opportunities for error doomed WebVan. The founders of WebVan did not clearly define their strategy and target market and properly evaluate the operational and logistical issues associated with their value chain design. WebVan designed its system with low scalability and limited growth potential.[14]

Many of the dot.com companies that failed around the year 2000 had low scalability and unsustainable demand (volumes) created by extraordinary advertising expenses and artificially low prices (see WebVan box).

Many companies do not really understand how to implement technology effectively. The risk of a technology adoption failure is high. For instance, Hershey Foods installed three software packages in the summer of 1999, just as retailers placed orders for Halloween candy. The software was incompatible with other systems, and candy piled up in warehouses because of missed or delayed deliveries. Such experiences are reminiscent of comparable failures of automated manufacturing technology encountered by the automobile and other industries during the 1970s. Reasons include rushing to the wrong technology, buying too much and not implementing it properly, and underestimating the time needed to make it work.



Although technology has proven quite useful in eliminating monotony and hazardous work and can help people develop new skills and talents, it can also rob them of empowerment and creativity.

Discussion Questions

1. Describe at least one application of modern technology in each of these service industries:
   a. financial services
   b. public and government services
   c. transportation services
   d. educational services
   e. hotel and motel services

   How does your example application improve things, or does it?
2. Describe a situation where self-service and technology help create and deliver the customer benefit package to the customer. Provide examples of how such a system can cause a defect, mistake, or service upset.
3. Discuss each of these statements. What might be wrong with each of them?
   a. "We've thought about computer integration of all our manufacturing functions, but when we looked at it, we realized that the labor savings wouldn't justify the cost."
   b. "We've had these computer-controlled robots on the line for several months now, and they're great! We no longer have to reconfigure the whole line to shift to a different product. I just give the robots new instructions, and they change operations. Just wait until this run is done and I'll show you."
   c. "Each of my manufacturing departments is authorized to invest in whatever technologies are necessary to perform its function more effectively. As a result, we have state-of-the-art equipment throughout our factories—from CAD/CAM to automated materials handling to robots on the line. When we're ready to migrate to a CIM environment, we can just tie all these pieces together."
   d. "I'm glad we finally got that CAD system," the designer said, a computer-generated blueprint in hand. "I was able to draw these plans and make modifications right on the computer screen in a fraction of the time it used to take by hand." "They tell me this new computer-aided manufacturing system will do the same for me," the manufacturing engineer replied. "I'll just punch in your specs and find out."
4. Identify one low and one highly scalable organization and explain why each is so.
5. What challenges do companies face when trying to implement e-commerce business plans and strategies? What can they learn from the WebVan experience?

Problems and Activities

Note: An asterisk denotes problems for which an Excel spreadsheet template on the CourseMate Web site may be used.

1. Research and write a short paper (maximum of two typed pages) on the impact of electric cars on the three dimensions of sustainability.
2. Identify and describe (maximum of two typed pages) two apps for your cell phone or electronic reader and how they improve your productivity and quality of life.
3. Identify and describe (maximum of one typed page) a service encounter where technology helps create and deliver the service in total or in part. What hard and soft technology most likely is involved?
4. Research radio-frequency identification devices (RFIDs) and provide examples of how they are or might be used to improve productivity in operations.
5. Find at least two new applications of modern technology in businesses that are not discussed in this chapter. What impacts on productivity and quality do you think these applications have had?

6. Investigate the current technology available for laptop computers, cell phones, iPods, or iPads. Select two different models and compare their features and operational characteristics, as well as the manufacturer's support and service. Briefly explain how you might advise (a) a college student majoring in art, and (b) a salesperson for a high-tech machine tool company in selecting the best device for his or her needs (maximum of two typed pages).
7. Research and write a short paper (maximum of two typed pages) about how business analytics or advances in information systems influence the use of technology and decision making in operations management.
8. Identify and describe (maximum of two typed pages) a business that uses ERP to manage its value chain (if possible, draw a picture of key elements of the value chain, such as sourcing, production, shipping, sales, billing, etc.). What benefits and challenges does ERP bring to this business?
9.* Suzy's Temporary Employee (STE) business, located in a big city, can do an online criminal background check in-house for $1.64 per search with a fixed cost of $24,000. A third-party online security firm offered to do a similar security search for $8.00 per person with an annual service contract with STE. If STE's forecast is 3,000 searches next year, should STE continue to do the search in-house or accept the third-party offer? What other criteria are important in making this decision?
10.* A manager of Paris Manufacturing, which produces computer hard drives, is planning to lease a new automated inspection system. The manager believes the new system will be more accurate than the current manual inspection process. The firm has had problems with hard drive defects in the past and the automated system should help catch these defects before the drives are shipped to the final assembly manufacturer. The relevant information follows.

Current Manual Inspection System

Annual fixed cost = $35,000

Inspection variable cost per unit = $15 per unit

New Automated Inspection System

Annual fixed cost = $165,000

Inspection variable cost per unit = $0.55 per unit

Suppose annual demand is 8,000 units. Should the firm lease the new inspection system?

11.* In problem 10, assume the cost factors given have not changed. A marketing representative of NEWSPEC, a firm that specializes in providing manual inspection processes for other firms, approached Paris Manufacturing and offered to inspect parts for $19 each with no fixed cost. It assured Paris Manufacturing that the accuracy and quality of its manual inspections would equal that of the automated inspection system. Demand for the upcoming year is forecast to be 8,000 units. Should the manufacturer accept the offer?
12.* Edwards Machine Tools needs to purchase a new machine. The basic model is slower but costs less, whereas the advanced model is faster but costs more. Profitability will depend on future demand. The following table presents an estimate of profits over the next three years.

	Demand Volume		
Decision	**Low**	**Medium**	**High**
Basic model	$80,000	$100,000	$150,000
Advanced model	$40,000	$110,000	$220,000

Given the uncertainty associated with the demand volume, and no other information to work with, how would you make a decision? Explain your reasoning.

13.* Suppose that in problem 12, a forecasting study determines that the probabilities of demand volume are Low = 0.4, Medium = 0.1, and High = 0.5. Using the techniques in Supplementary Chapter SC E on decision analysis, determine the expected value decision. How appropriate is it to use this criterion?
14. For the information provided in problem 13, compute the expected value of perfect information (EVPI) as discussed in Supplementary Chapter SC E on decision analysis. Clearly explain how to interpret EVPI for Edwards Machine Tools.
15.* A company is considering three vendors for purchasing a CRM system: Delphi Inc., CRM International, and Murray Analytics. The costs of the system are expected to depend on the length of time required to implement the system, which depends on such factors as the amount of customization required, integration with legacy systems, resistance to change, and so on. Each vendor has different expertise in handling these things, which affect the cost. The costs (in millions of $) are shown below for short, medium, and long implementation durations. Conduct a decision analysis using the techniques in Supplementary Chapter SC E on decision analysis to evaluate the choice of a vendor. Clearly explain your recommendation.

Decision Alternative	**Short**	**Medium**	**Long**
Delphi Inc.	$4.00	$5.50	$8.00
CRM International	$6.00	$4.25	$6.50
Murray Analytics	$4.50	$5.00	$7.20

Bracket International—The RFID Decision Case Study

Jack Bracket, the CEO of Bracket International (BI), has grown his business to sales last year of $78 million with a cost of goods sold of $61 million. Average inventory levels are about $14 million. As a small manufacturer of steel shelving and brackets, the firm operates three small factories in Ohio, Kentucky, and South Carolina. BI's number one competitive priority is "service first," while high product quality and low cost are #2 and #3. Service at BI includes preproduction services such as customized engineering design, production services such as meeting customer promise dates and being flexible to customer-driven changes, and postproduction services such as shipping, distribution, and field service.

The Ohio and Kentucky factories are automated flow shops, whereas the South Carolina factory specializes in small custom orders and is more of a batch-processing job shop. All three factories use bar coding labels and scanning equipment to monitor and control the flow of materials. BI manually scans about 8,850 items per day at all three factories. An item may be an individual part, a roll of sheet steel, a box of 1,000 rivets, a pallet load of brackets, a box of quart oil cans, a finished shelf or bracket set ready for shipment, and so on. That is, whatever a bar code label can be stuck on is bar coded. A factory year consists of 260 days. One full-time BI employee works 2,000 hours per year with an average salary including benefits of $55,000.

Two recent sales calls have Mr. Bracket considering switching from the old bar coding system to a radio-frequency identification device (RFID) system. The RFID vendors kept talking about "on-demand" operational planning and control and how their RFID and software systems could speed up the pace of BI's workflows. One RFID vendor provided the following information:

- Bar code scan times for the sheet metal business (similar to BI) average 10 seconds per item and include employee time to find the bar code, pick up the item and/or position the item or handheld bar code reader so it can read the bar code, and in some cases physically reposition the item. Item orientation is a problem with manual bar coding.
- The 10-second bar code scan time does not include the employee walking to the bar coding spot or equipment. It is assumed that the employee is in position to scan the item. The 10 seconds does not include the time to replace a scratched or defective bar code label. Replacing a damaged bar code tag, including changes to the computer system, may take up to 5 minutes.
- All three BI factories can be fitted with RFID technology (readers, item tags, and hardware-related software) for $620,000. In addition, new supply chain operating system software that takes advantage of the faster pace of RFID information is priced for all three factories at $480,000 and includes substantial training and debugging consulting services.
- RFID scan time is estimated to be 2/100ths of a second, or basically instantaneous.
- For the sheet metal business, bar code misreads average 2 percent (i.e., 0.02) over the year of total reads, and this is estimated to reduce to 0.2 percent (i.e., 0.002) for RFID technology. The 0.2 percent is due to damaged RFID tags or occasional radio-frequency interference or transmission problems. Misreads are a problem because items are lost and not recorded in BI's computer system. The vendor guessed that a single misread could cost a manufacturer on average $4 but noted this estimate could vary quite a bit.
- According to the RFID vendors, other benefits of RFID systems include readily located inventory, fewer required inventory audits, and reduced misplacements and theft. However, they did not have any information quantifying these benefits.

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Bracket International manufactures steel shelving and brackets.

Bracket International recently had problems adapting quickly to changing customer requirements. BI had to deny a Wolf Furniture job order request because it could not react quickly enough to a change in job specifications and order size. Eventually, BI lost the Wolf Furniture business that averaged about $2 million per year. Another BI customer, Home Depot, keeps talking about BI needing to be

more flexible because Home Depot's on-demand point-of-sale systems require frequent changes to BI orders. Home Depot is BI's top customer, so every effort needs to be made to keep Home Depot happy.

Mr. Bracket doesn't think throwing away the bar coding system that works is a good idea. The BI employees are familiar with using bar coding technology, whereas the RFID technology seems hidden from employees. He also doesn't think the return on investment (ROI) on an RFID system is compelling. So why does he feel so guilty when the RFID vendors leave his office? Is he doing the right thing or not? He has an obligation to his trusted employees to do the right thing. Should he adopt RFID based purely on strategic and/or economic benefits? He writes down several questions he needs to investigate.

CASE QUESTIONS FOR DISCUSSION

1. How does RFID compare to bar coding?
2. What is the economic payback in years for this possible RFID adoption? (Hint: There are two benefits that can be quantified—labor savings due to faster scan times and misread savings. Annual benefits divided by economic benefits equals payback.)
3. What are the risks of adopting a new technology too early? Too late?
4. What do you recommend Mr. Bracket do in the short and long terms? Explain your reasoning.

STUDY TOOLS 5

LOCATED AT THE BACK OF THE TEXTBOOK

- ☐ Tear-Out Chapter Review Card

LOCATED AT WWW.CENGAGEBRAIN.COM

- ☐ Key Term Flash Cards
- ☐ Practice Quizzes to prepare for tests
- ☐ "Beat the Clock" and "Quizbowl" to master concepts
- ☐ "Crossword Puzzle" to review key terms
- ☐ Spreadsheet Templates
- ☐ Videos of real-company OM examples