7. Operations management

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Learning objectives:

- understand the role of operations management in organizations
- differentiate between strategic and tactical operations decisions
- describe the key operations management decisions faced by managers
- understand three of the most important operations management practices: Total Quality Management, Supply Chain Management, and Just-in-Time/Lean Operations

What is operations management?

Operations management is the management of processes that transform inputs into goods and services that add value for the customer. The goal of operations management is to maximize efficiency while producing goods and services that effectively fulfill customer needs. For example, if an organization makes furniture, some of the operations management decisions involve the purchasing of wood and fabric, the hiring and training of workers, the location and layout of the furniture factory, and the purchase of cutting tools and other fabrication equipment. If the organization makes good operations decisions, it will be able to produce affordable, functional, and attractive furniture that customers will purchase at a price that will earn profits for the company.

In another example, the owners of a restaurant must make important decisions regarding the location, layout, and seating capacity of the restaurant, the hiring, training, and scheduling of chefs and servers, the suppliers of fresh food at the right prices, and the purchase of stoves, refrigerators, and other food preparation equipment. If the restaurant owners make good operations decisions, they will be able to meet their customers' needs for delicious and affordable food that is served in a pleasing atmosphere. The owners in turn will be able to charge a price that earns a profit and allows the restaurant to stay in business.

One of three strategic functions

Operations is one of the three strategic functions of any organization. This means that it is a vital part of accomplishing the organization's strategy and ensuring its long-term survival. The other two areas of strategic importance to the organization are ***marketing*** and ***finance***. For example, a company that makes team jerseys for sport teams must have strong ***marketing*** ability to identify groups of customers, understand their needs, and communicate with them to win their business. The company must also manage its ***finances*** so it can pay for building and equipment expenses, bank loans, worker wages, and supplies. Finally, the company must have strong ***operations*** skills so it can provide customized team jerseys that are attractive, durable, affordable and delivered on time to the customer.

The operations strategy should support the overall organization strategy. For example, JetBlue airlines is a successful airline that has an organization strategy of providing high-value air transportation service to travelers. JetBlue strives to provide fun, comfortable, and safe air service to popular destinations at a price that middle-income passengers can afford. Given JetBlue's organization strategy, JetBlue features an operations strategy that focuses on low costs, competent and service-oriented employees, and reliable aircraft.

JetBlue's operations strategy is driven by its organization strategy. For example, JetBlue locates ("location" is an operations decision area) its main transportation hub in New York City, a city of 19 million people that helps ensure that JetBlue's planes fly at full capacity. In the area of equipment decisions, JetBlue operates only one type of aircraft, the Airbus 330. The Airbus 330 has high passenger carrying capacity (to maximize revenue), provides good fuel economy and requires only two pilots (versus three) to operate. Having one type of aircraft reduces training costs for pilots and mechanics, reduces investments in parts inventories, and enables JetBlue to negotiate greater discounts on high-volume purchases from Airbus. In another key operations area, JetBlue pays careful attention to hiring, training, and compensating employees who can deliver excellent service, loyalty, and high levels of productivity.

In addition to an operations strategy, JetBlue also has financial and marketing strategies that support its organization strategy. One part of its financial strategy is securing sufficient amounts of capital to help the start-up airline establish reliable service and gain a loyal clientele. JetBlue's marketing strategy keeps advertising costs under control by attracting free media publicity that emphasizes its fun and affordable airline service.

Strategic versus tactical operations decisions

Operations decisions include decisions that are ***strategic*** in nature, meaning that they have long-term consequences and often involve a great deal of expense and resource commitments. ***Strategic*** operations decisions include facility location decisions, the type of technologies that the organization will use, determining how labor and equipment are organized, and how much long-term capacity the organization will provide to meet customer demand.

For example, the leaders of a new hospital must decide where to locate the facility to be accessible to a large number of potential patients. Hospital administrators must evaluate the performance and cost of a wide variety of health equipment. Administrators must also assess and purchase information technologies to keep patient records, fulfill government regulations, provide accurate and timely communications, and track financial performance. Doctors, nurses, and staff must be hired and various departments (x-ray, lab, pharmacy, physical therapy, etc.) must be arranged to maximize both efficiency and effectiveness in patient care.

Tactical operations decisions have short to medium term impact on the organization, often involve less commitment of resources, and can be changed more easily than strategic decisions. Tactical decisions include workforce scheduling, establishing quality assurance procedures, contracting with vendors, and managing inventory. In the hospital example, scheduling the workforce to match patient admissions is critical to both providing quality care and controlling costs. Selecting a food service vendor is important to serving both employees and patients. Ensuring that the right drugs and supplies are on hand is achieved by working closely with vendors in the supply chain.

Operations management provides competitive advantage!

Strategic and tactical operations decisions determine how well the organization can accomplish its goals. They also provide opportunities for the organization to achieve unique competitive advantages that attract and keep customers.

For example, United Parcel Service, an international package delivery service, formed a partnership with its customer, Toshiba computers. Toshiba needs to provide a repair service to its laptop computer customers. The old approach of providing this service was cumbersome and time-consuming: (1) Customers had pick up their computers, (2) delivered the computers to Toshiba, (3) Toshiba repaired the computers, (4) picked up the repaired computers and delivered them back to the customers. Under this traditional approach, the total time to get a laptop computer repaired was two weeks—a long time for people to be without their laptop! Then they came up with an innovative idea for Toshiba to provide better service to its customers. United Parcel Service hired, trained, and certified its own employees to repair Toshiba laptop computers. The new repair process is much more efficient: (1) picks up computers from Toshiba owners, (2) repairs the computers, (3) delivers the computers back to their owners. The total time to get a computer repaired is now about two days. Most Toshiba customers think that Toshiba is doing a great job of repairing their computers, when in fact Toshiba never touches the computers! The result of this operations innovation is better service to Toshiba customers and a strong and profitable strategic partnership between and its customer, Toshiba.

The input/output transformation model

Operations management transforms inputs (labor, capital, equipment, land, buildings, materials and information) into outputs (goods and services) that provide added value to customers. Exhibit 27 summarizes the transformation process. The arrow labeled “Transformation System” is the critical element in the model that will determine how well the organization produces goods and services that meet customer needs. It does not matter whether the organization is a for-profit company, a non-profit organization (religious organizations, hospitals, etc.), or a government agency; all organizations must strive to maximize the quality of their transformation processes to meet customer needs.

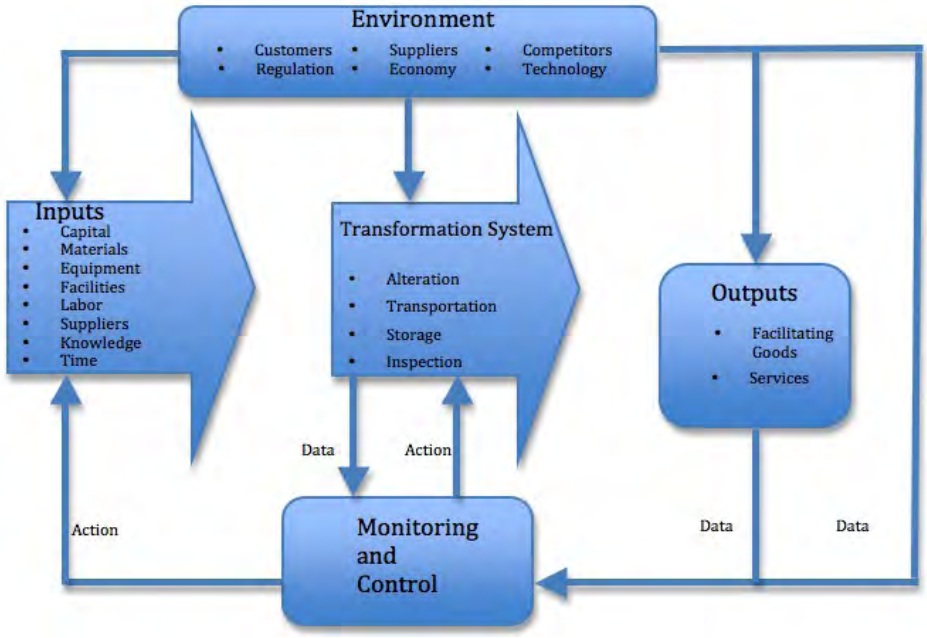

Exhibit 27: Example of typical transformation process

The 3M Company is a good example of the strategic importance of transforming inputs into outputs that provide competitive advantage in the marketplace. 3M manufactures a top-quality adhesive tape called "Magic Tape". Magic Tape is used for everyday taping applications, but it offers attractive features that most other tapes do not, including smooth removal from the tape roll, an adhesive that is sticky enough to hold items in place (but not too sticky that it can not be removed and readjusted if necessary!), and a non-reflective surface. For several decades, 3M has enjoyed a substantial profit margin on its Magic Tape product because 3M engineers make the manufacturing equipment and design the manufacturing processes that produce Magic Tape. In other words, 3M enjoys a commanding competitive advantage by controlling the transformation processes that turn raw material inputs into the high value-added Magic Tape product. Controlling the transformation process makes it extremely difficult for competitors to produce tape of the same quality as Magic Tape, allowing 3M to reap significant profits from this superior product.

An opposite example of the strategic implications of the input/output transformation process is 3M's decision in the 1980s to stop manufacturing VHS tape for video players and recorders. In the VHS tape market 3M had no proprietary manufacturing advantage, as there were many Asian competitors that could produce high-quality VHS tape at lower cost. Since 3M had no proprietary control over the transformation process for VHS tape that would allow the company to protect its profit margins for this product, it dropped VHS tape from its offerings. The two 3M examples of Magic Tape and VHS tape show how important the transformation process and operations management can be to providing and protecting an organization's competitive advantage.

A service example of the strategic importance of the transformation process is ING Bank, a banking company that conducts all banking transactions through the Internet, phone, and mail. ING maintains no traditional bank facilities, except for the buildings that house the employees that execute remote transactions with ING's customers. This strategy results in tremendous cost savings and competitive advantage to ING by not having to spend capital

resources on land and buildings that traditional banks must spend. Consequently, ING can offer its customers higher interest rates on savings accounts and lower interest rates on loans.

Operations decisions

Countless operations decisions that have both long-term and short-term impacts on the organization's ability to produce goods and services that provide added value to customers must be made. If the organization has made mostly good operations decisions in designing and executing its transformation system to meet the needs of customers, its prospects for long-term survival are greatly enhanced. Major operations decisions areas include inventory, capacity, quality, scheduling, process type, technology, location, layout, and supply chain management. Each of these nine decision areas will be discussed in this section.

Inventory decisions

The key question that must be answered for inventory is "How much?" Understanding the best inventory levels to carry is critical to the organization because too much inventory and too little inventory are both costly to the organization. Inventory that exceeds what is needed to satisfy customer demand imposes unnecessary costs such as storage, deterioration, obsolescence, theft, and money tied up in inventory that cannot be used for other purposes. Too little inventory means the organization cannot meet 100 per cent of its customer demand and sales revenues are delayed or lost.

For example, a restaurant that specializes in serving fresh fish needs to make careful purchasing decisions so it has enough fresh fish each day to serve its customers, but not so much that unsold fish must be severely discounted or discarded at the end of the day. Computer companies such as Dell must carefully manage its computer chip inventory so it can meet current customer orders, but not be stuck with too much inventory if a new computer chip comes out or if vendors reduce prices.

Capacity decisions

The question managers must answer for the capacity decision area is the same as the question for inventory: "How much?" Determining the organization's capacity to produce goods and services involves both long-term and short-term decisions. *Long-term* capacity decisions involve facilities and major equipment investments. In 2007, Airbus introduced its Super Jumbo Jet that carries up to 850 passengers and costs USD 3 billion. The Super Jumbo provides huge amounts of passenger carrying capacity, but before an airline purchases this jet, it needs to decide if it has enough passengers to generate the revenue to pay for the plane and earn profits for the airline. A large single airplane like the Super Jumbo may not be the right capacity decision for an airline that serves numerous medium sized cities. On the other hand, an airline that serves passengers traveling between New York City, USA and Shanghai, China might find the Super Jumbo to be a perfect choice for meeting demand because of the large populations in each city.

Capacity decisions also involve *short-term* situations. In a grocery store, the number of customers that need to pay for their groceries at any one point during the day will vary significantly. To provide good customer service, managers must make sure that sufficient cash registers and employees are on hand to meet check-out demand. Similarly, hotels must make sure that they have enough employees to register arriving guests, to clean hotel rooms, and to provide food and beverages to customers. These decisions must be made carefully to avoid excessive labor costs from having too many employees for the number of customers being served.

Quality decisions

The decision relating to quality is not "how much" quality to have. If asked whether they support high quality in their organization, virtually all managers will respond enthusiastically that they fully support high quality! Rather, the quality of goods and services is determined by *numerous* decisions throughout the organization that have both long-term and short-term consequences for the organization's quality performance.

For example, while all managers may say they support quality, how many will support the capital expenditure to purchase new equipment that can meet tighter tolerance requirements more consistently? How many managers will spend money to send their engineers out into the field to talk to customers to better understand necessary product performance standards? How many managers will send teams of quality engineers to supplier facilities to assist suppliers with their quality programs? How much attention and resources does management give to employee skill development and training in the use of quality tools and in the philosophy of defect prevention? The outcome of these decisions will most certainly affect an organization's ability to produce outstanding quality in products and services.

For example, in the air transportation industry, the prevention of crashes is obviously something that everyone supports. Yet, for the past two decades in the United States, the press has reported on the weaknesses and neglect of the US air traffic control technology that plays a critical role in air travel safety. One might conclude that although everyone supports safety in air travel, more investment in modern technology and better decision making is needed to ensure the long-term safety of air transportation. Virtually all organizations are faced with similar decision-making scenarios when it comes to the factors that determine quality performance.

Another example is in the health care industry where one critical measure is the number of surgeries where foreign objects (sponges, instruments, etc.) are left in surgery patients. Such incidents are considered to be a serious oversight and totally unacceptable. In recent years, hospitals have developed processes for preventing these mistakes. In one approach, a member of the surgical staff tracks every object that enters the body cavity during surgery, then checks that object off when it is removed from the cavity. Any object that can not be accounted for triggers an inspection of the cavity, and perhaps an x-ray to help find the item before the incision is closed.

Quality improvement efforts require a great deal of analysis and teamwork, as well as a determined effort to make quality a top priority in the organization. Improving quality requires everyone to adopt a "continuous improvement" philosophy, where everyone approaches their work with the view that there are always opportunities to improve on the organization's key performance measures. Continuous improvement efforts are complex, multidimensional, and require partnerships among workers, management, suppliers, and customers.

Scheduling decisions

Scheduling is an operations decision that strives to provide the right mix of labor and machines to produce goods and services at the right time to achieve both efficiency and customer service goals. For example, a hotel must anticipate the peaks and valleys in demand that may occur during a day, during the week, and at different times of the year. Labor (front desk clerks, room service personnel, housekeepers, bellhops, etc.) must be scheduled carefully to meet customer demand at any given time, without scheduling excess employees that would impose unnecessary costs on the hotel. In a hospital setting, scheduling surgeries is a very important activity. Surgeons, nurses, support staff, equipment, supplies, and operating rooms must be scheduled carefully so patient surgeries

can be conducted effectively and efficiently. At colleges and universities, scheduling the right courses with the right number of classroom seats at the right times is critical to allowing students to graduate on time.

Process decisions

Managers must decide how to organize equipment and labor to achieve the competitive goals of the organization. There are two basic choices for organizing the workplace to produce goods and services: (1) intermittent processes, and (2) repetitive processes.

Intermittent processes organize labor and equipment into departments by similarity of function to serve a wide variety of production requirements. For example, a health care clinic must cater to the individual needs of every patient who enters the clinic for treatment. One patient may have a broken ankle, while another patient may be a pregnant woman who needs a prenatal care checkup. One patient may be a baby with a fever, while another patient may be getting a prescription medication refilled. The primary organizational goal for a health clinic is *effectiveness* in treating the individual needs of each patient, and an intermittent process is often the most suitable way to organize labor and equipment to provide customized treatment for each individual patient. X-ray equipment and technicians are organized into an "X-ray Department". Other departments are created for pediatrics, lab, gynecology, pharmacy, physical therapy, and many more. Patients are routed only to the departments that are needed for their particular treatment requirements. This production process is called an "intermittent" process, because the activity of each department happens intermittently at irregular intervals, depending on the particular needs of different patients (customers) at different points in time.

Intermittent processes are also used in manufacturing operations where a wide variety of products are manufactured, or where products are made to customer specifications. Equipment and labor can be organized into departments such as drilling, punch press, lathe, machining, painting, heat treating, molding, etc. Raw materials and components are routed through the facility according to the type and order of manufacturing activities necessary to produce the finished items. Exhibit 28 illustrates how two different products, "A63" and "B5" make their way through an intermittent process layout.

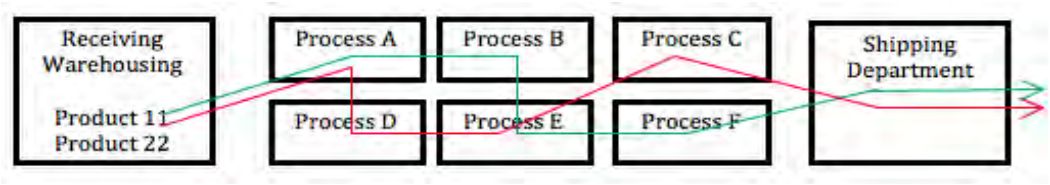

Exhibit 28: Intermittent process flows

Repetitive processes are used to produce identical or very similar products in high volumes. Equipment and labor are organized in a line flow arrangement to meet very specific customer or product processing requirements. Examples include assembly lines that produce products such as computers, cars, hamburgers, automatic car washes, and cafeteria lines. In all of these cases, the products or customers follow the same production steps to produce a standardized outcome. Since the production requirements to produce each unit of output are so well understood, there are many opportunities to achieve high levels of efficiency in repetitive process environments. *Efficiency* is a key goal in repetitive process environments. Investments in automation and technology are

financially justified because the high volume of production spreads out the investment cost over more items/customers.

A paper mill is a good example of a repetitive process. The manufacturing requirements are well-understood, capital investment in automation is high, and production volume is extremely high to keep unit production costs as low as possible.

Exhibit 29 represents an example of a repetitive process for producing a product such as a small appliance, where raw materials and components are assembled to each unit at different stages of production. The units flow through the facility in a uniform pattern until they are completed and shipped to the customer.

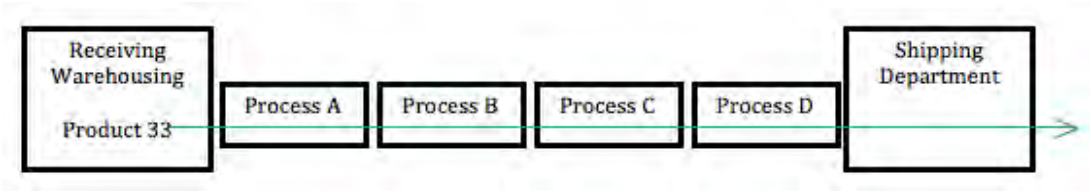

Exhibit 29: Product flow in a repetitive process

The two main differences between the intermittent and repetitive processes are product variety and product volume.

Intermittent processes are very flexible in meeting the individual requirements of different products or customers, but they tend to be very inefficient, with high amounts of waiting time, work in process inventories, and space requirements. Repetitive processes are very efficient at reducing unit production costs, waiting time, and inventories, but they are not very flexible in accommodating high product/customer variety. A compromise solution is the ***cellular*** process layout that captures the advantages of both intermittent and repetitive processes.

A cellular process arranges dissimilar machines and equipment together in a line that is dedicated to producing a specific family of products that have similar processing requirements. By setting up multiple dedicated cells, the facility can efficiently produce a wide variety of products (Exhibit 30). Since the products within a family have similar production requirements, equipment setup times, inventories, and lot sizes can be kept to a minimum. The cellular approach allows each product to be sent through the manufacturing process one piece at a time, according to the immediate set of customer orders. It provides workers the flexibility to change a product or customize it in some way in response to specific customer requirements. The cells are usually arranged in a U shape. This enables one worker to view multiple machines simultaneously and puts all machines within easy reaching distance. Cellular processes minimize cycle times and enable the organization to maintain higher levels of product volumes, variety, and customization.

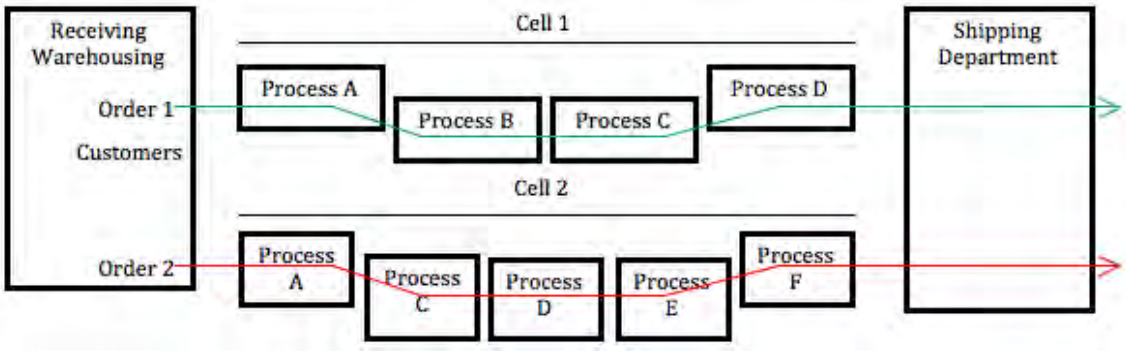

Exhibit 30: Cellular Layouts

Technology decisions

There are many benefits that technology can bring to an operations environment. Automated machinery, programmable equipment, and management information systems can provide speed, low unit processing costs, labor cost savings, increased accuracy and consistency, and sophisticated tracking and decision support systems to increase operations efficiency and effectiveness for both manufacturing and service environments. The main drawback in many technology decisions is the high fixed cost of purchasing and implementing the new systems. If mistakes are made in technology purchases, it can severely impact the fortunes of the company.

Managers are often biased in favor of adopting leading edge technology, especially if they see their competitors adopting it. Financial justifications for purchasing new technology are often overly optimistic in estimations of payback periods, the costs of implementation, and the actual gains in overall productivity the firm will enjoy.

The challenge for managers in technology is selecting the right technology for the right application. For example, if a manufacturing company believes that automation will increase the firm's flexibility to adapt to a changing competitive environment, questions should be asked, such as:

- What type of flexibility does the company need to thrive?
- Does it need to quickly switch production across a wide variety of products (product mix flexibility)?
- Does it need to quickly produce new products for a rapidly changing marketplace (product development flexibility)?
- Does it need to be able to quickly ramp up production during times of high demand, and quickly scale down production when cyclical or seasonal demand hits downturns (volume flexibility)?

Deere & Co manufactures machinery for the highly cyclical agricultural and construction industries. One of the reasons for Deere's success over the many decades is its ability to keep its technology expenditures under control so it can weather the inevitable declines in demand for its products. Deere managers use a mix of low technology/labor intensive production methods and automated/programmable technologies in its manufacturing plants. Careful technology decision making is a major reason why Deere & Co continues to thrive in spite of its highly volatile markets.

Location decisions

There are many factors that can determine where an organization will locate its facilities. For any given situation, some factors become more important than others in how facility location affects an organization's efficiency and effectiveness.

- **Proximity to sources of supply:** Firms that process bulk raw materials usually locate close to the source of supply to reduce transportation costs. Paper mills locate close to forests, canneries are built close to farming areas, and fish processing plants are located close to the harbors where the fishing vessels dock.
- **Proximity to customers:** There are several reasons why an organization would locate close to end customers. Service firms need to be close to customers to be convenient, as is the case for grocery stores, gas stations, fast food restaurants, and hospitals. Transportation costs can also require proximity to customers, as in the case of concrete manufacturing. Perishable products often require that they be produced close to the final market, as is the case for bakeries and fresh flowers.
- **Community factors:** Communities may offer a number of incentives to entice companies, including waiving or reducing taxes, and providing access roads, water and sewer connections, and utilities. Community attitudes can also play a role in an organization's location decision. Some communities may actively discourage companies that might bring more pollution, noise, and traffic to the area. Some communities may not want a prison to be located in their community. Other communities may welcome such firms because of the jobs, tax revenues, and economic diversity they promise.
- **Labor factors:** Research shows that the majority of location decisions are largely based on labor factors, since labor is a critical variable for many firms. Labor factors include the prevailing wage rate in a community for similar jobs, the supply of qualified workers, and the average education level of the local population (percentage of high school graduates, etc.). Other labor factors can include the degree of union organizing and the general work ethic of a community, as well as other measures of absenteeism and worker longevity in a job can play strong roles when a firm makes a location decision.
- **Other factors:** Many other factors can play a role in the location decision, including quality of life (crime rates, good schools, climate, and recreation options), access to major transportation arteries, construction costs, proximity of the competition, and opportunities for future expansion. As mentioned earlier, the importance of any location factor can vary greatly, depending on the circumstances of the decision.

In the 1990s, MCI, a major US telecommunications company, decided to relocate its engineering services division from MCI's headquarters in Washington DC to Colorado Springs, Colorado to reduce labor and facility costs. The decision was largely unsuccessful due to the high costs of employee relocation and the fact that much of the ethnically diverse engineering workforce did not want to live in Colorado Springs. Unlike Washington DC, Colorado Springs did not have cultural diversity to match with its diverse and highly educated workforce, it lacked employment options for spouses, and the work ethic was more relaxed due to the beautiful natural setting that provided unlimited options for outdoor recreation. In short, if MCI had put more effort into researching how well the Colorado Springs location matched its strategic requirements, it probably could have saved itself millions of dollars and a great deal of internal disruption to the organization.

Chapter summary

Operations management is a strategic function of the organization that produces the goods and services that are offered to the customer. Operations decisions determine how well these goods and services meet the needs of the organization's target market, and consequently, whether the organization will be able to survive over the long term.

This chapter concludes with discussions of three "Special topics" in operations management that deserve special attention because they are widely acknowledged as "best practices" for successful organizations. They include Total Quality Management, Supply Chain Management, and Just-In-Time/Lean Operations.

Special topic: Total Quality Management

Total Quality Management (TQM) is the organization-wide management of quality that includes facilities, equipment, labor, suppliers, customers, policies, and procedures. TQM promotes the view that quality improvement never ends, quality provides a strategic advantage to the organization, and zero defects is the quality goal that will minimize total quality costs. While this special topic on TQM is not a comprehensive discussion of all aspects of TQM, several key concepts will be discussed.

Quality costs

An important basis for justifying TQM practice is understanding its impact on total quality costs. TQM is rooted in the belief that preventing defects is cheaper than dealing with the costs of quality failures. In other words, total quality costs are minimized when managers strive to reach zero defects in the organization. The four major types of quality costs are prevention, appraisal, internal failure, and external failure.

Prevention costs are the costs created from the effort to reduce poor quality. Examples are designing the products so that they will be durable, training employees so they do a good job, certifying suppliers to ensure that suppliers provide quality in products and services, conducting preventive maintenance on equipment, and documenting quality procedures and improvements. In a traditional organization that does not practice TQM, prevention costs typically comprise the smallest percentage of total quality costs.

A good example of good product design occurs in all Honda products. Honda produces a wide variety of items including automobiles, ATVs, engines, generators, motorcycles, outboard motors, snow blowers, lawn and garden equipment, and even more items. To say the least, Honda engines last a long time. For example, Honda Accords typically run for well over 200,000 miles.

Employee training is also a very important prevention cost. For instance, employees in a vegetable/fruit packaging warehouse need to know what a bad vegetable/fruit looks like, since customers will not want to find spoiled produce in the store. Lifeguards at a swimming pool must know proper procedures for keeping swimmers safe. In many circumstances in both manufacturing and service businesses, the training of employees can make an enormous difference in preventing defects.

Supplier selection and certification are critical prevention activities. A product or service is only as good as the suppliers who partner with an organization to provide the raw materials, parts and components, and supporting services that make up the final products and services that the end customers receive. For example, a home furnishings store might use an outside subcontractor to install carpeting, but if the subcontractor fails to show up on time, tracks mud into the customer's home, or behaves in a rude manner, the store's reputation will suffer.

Similarly, a car manufacturer who purchases defective tires from a supplier risks incurring high costs of recalls and lawsuits when the defects are discovered.

Preventive maintenance is necessary for preventing equipment breakdowns. Many manufacturing companies use sophisticated software to track machine usage, and determine optimal schedules for regular machine maintenance, overhauls, and replacement.

Documenting quality is a necessary prevention cost because it helps the organization track quality performance, identify quality problems, collect data, and specify procedures that contribute to the pursuit of zero defects. Documentation is important to communicating good quality practice to all employees and suppliers.

Appraisal costs are a second major type of quality cost. Appraisal costs include the inspection and testing of raw materials, work-in-process, and finished goods. In addition, quality audits, sampling, and statistical process control also fall under the umbrella of appraisal costs.

Inspection and testing of raw materials is very important, since substandard raw materials lead to substandard products. Raw materials used for a bridge determine the strength of the bridge. For example, soft steel will erode away faster than hardened steel. Moreover, the concrete bridge decking needs to be solid, as concrete with air pockets will erode and crumble faster creating an unsafe bridge.

Finished goods and work-in-process inventory also need inspecting and testing. For example, worker error is quite common in the home construction industry, and this is why inspections occur frequently on newly constructed homes during and after the construction process is complete. Building inspectors ensure that the house has the proper framing, electrical, plumbing, heating, and so forth.

Quality audits and sampling are also important appraisal costs. Quality audits are checks of quality procedures to ensure that employees and suppliers are following proper quality practices. With sampling, a company can ensure with confidence that a batch of products is fit for use. For example, a wooden baseball bat manufacturer may test 10 out of every 100 bats to check that they meet strength standards. One weak bat can signal that quality problems are present.

Statistical process control (SPC) is the final type of appraisal cost. SPC tracks on-going processes in manufacturing or service environments to make sure that they are producing the desired performance. For example, a restaurant might statistically track customer survey results to make sure that customer satisfaction is maintained over time. In manufacturing windshields for automobiles, SPC might be used to track the number of microscopic air bubbles in the glass to make sure the process is performing to standard.

Internal failure costs are a third category of quality costs. This cost occurs when quality defects are discovered before they reach the customer. Examples of internal failure costs include scrapping a product, reworking the product, and lost productivity due to machine breakdowns or labor errors. Internal failure costs are typically more expensive than both prevention and appraisal costs because a great deal of material and labor often has been invested prior to the discovery of the defect. If a book publisher prints 10,000 books, then discovers that one of the chapters is missing from every copy, the cost of reworking or scrapping the books represents a major loss to the company. It would have been much cheaper to have procedures in place to prevent such a mistake from happening in the first place.

In the case of internal failure cost due to machine failures, FedEx, and other courier services cannot keep up with demand when a conveyor belt breaks down in the package distribution center. Major delays and costs occur when such incidents occur. Other examples include a road construction company having a road grader break down, a tool and die shop having a CNC machine break down, and a farmer having a combine break down during harvest time.

External failure costs are the fourth major cost of quality. External failure costs when the defect is discovered after it has reached the customer. This is the most expensive category of quality costs. Examples include product returns, repairs, warranty claims, lost reputation, and lost business. One spectacular example of external failure cost was when the Hubbell telescope was launched into space with mirrors that were ground improperly. When the telescope was turned on, instead of a magnificent view of stars, planets, and galaxies, the scientists could see only blurred images. The price of correcting the problem was over USD 1 billion.

External failure costs also occur when the wrong meal is delivered to a restaurant customer, when a computer breaks down shortly after it was purchased, when the wrong kidney is removed from a patient, and when a poorly designed automobile causes the death of drivers and passengers. Because of the enormous costs of internal and external failures, all companies should strive for zero defects. Successful TQM practice dictates that pursuing zero defects will result in the minimization of total quality costs by spending more on prevention and appraisal activities in order to reduce the much higher costs of internal and external failure.

TQM's seven basic elements

Successful practice of Total Quality Management involves both technical and people aspects that cover the entire organization and extend to relationships with suppliers and customers. Seven basic elements capture the essence of the TQM philosophy: customer focus, continuous improvement, employee empowerment, quality tools, product design, process management, and supplier quality.

- **Customer focus:** Decisions of how to organize resources to best serve customers starts with a clear understanding of customer needs and the measurement of customer satisfaction. For example, the Red Cross surveys its blood donors to determine how it can make the blood donation experience more pleasant and convenient. It collects information on the place, date and time donors came in, and asks donors questions of whether the donation time was convenient, whether they were treated with respect and gratitude, how long they had to wait to donate, and whether parking was adequate. By understanding donors' needs and experiences, Red Cross managers can determine strengths and weaknesses of the donation service process and make adjustments if necessary.
- **Continuous improvement:** An organizational culture that promotes continuous learning and problem solving is essential in the pursuit of zero defects. The Toyota Production System (TPS) is a universal continuous improvement system that has been effectively applied to many different types of organizations, including the health care industry. Essential elements of the TPS culture include studying process flow, collecting data, driving out wasteful non-value-added activities, and making everyone responsible for quality improvement. In the case of health care, the TPS approach enabled one hospital to analyze the causes of patient infections from catheters and pneumonia in patients on ventilators. With simple changes

in procedures that prevented patients from getting these secondary illnesses, the hospital was able to save USD 40,000 per patient in these cases.

- **Employee involvement:** Employees in a TQM environment have very different roles and responsibilities than in a traditional organization. They are given responsibility, training, and authority to measure and control the quality of the work they produce, they work together in teams to address quality issues, they are cross-trained to be able to perform multiple tasks and have a greater understanding of the total production process, and they have a more intimate understanding of the operation and maintenance of their equipment. Employees are essential to the building of a continuous improvement organization.
- **Quality tools:** Discussion of the details of quality tools extends beyond the scope of this chapter, but there are seven basic quality tools that are used by front-line workers and managers in monitoring quality performance and gathering data for quality improvement activities. These tools include: cause-and-effect (fishbone) diagrams, flowcharts, checklists, control charts, scatter diagrams, Pareto analysis, and histograms. The beauty of these tools is that they are easy to understand and apply in on-going quality efforts.
- **Product design:** Product design is a key activity to avoid costly internal and external failure costs. For example, when a dental office designs the service process, it might have patients fill out a form that covers important information on general health issues, allergies, and medications. This helps to avoid future complications and problems. Staff, hygienists, and dentists are highly trained to follow proper procedures, the facility is both functional and pleasant, and the equipment and tools are state of the art to ensure that the patient's desired outcome is achieved. In a manufacturing setting, products should be designed to maximize product functionality, reliability, and manufacturability.
- **Process management:** "Quality at the Source" is an important concept in TQM. It means that managers and employees should be focused on the detailed activities in a process where good or bad quality is created. For example, in a Toyota plant in the United States in Georgetown, Kentucky, one of the work stations was responsible for installing seat belts and visors in every vehicle that came along the assembly line. There were 12 possible combinations of visors and seat belts that would go into any particular vehicle and the worker had to select the right combination and install the items in the vehicle in 55 seconds. Even the best workers made several errors during a shift on this activity. After studying the process, the workers came up with an idea to put all the items for a particular vehicle model in a blue plastic tote. With this change, the worker only had to make one decision per vehicle. Almost all the errors from the previous system were eliminated with this simple solution.
- **Supplier quality:** The focus on quality at the source extends to suppliers' processes as well, since the quality of a finished product is only as good as the quality of its individual parts and components, regardless of whether they come from internal or external sources. Sharing your quality and engineering expertise with your suppliers, having a formal supplier certification program, and including your suppliers in the product design stage are important measures to take to ensure that quality at the source extends to the supplier network.

Quality awards and standards

There are several quality awards and standards that are available for organizations to access. The large majority of organizations that use these programs use them as tools to help improve their quality processes and move toward implementing and successfully practicing TQM. The Malcolm Baldrige Award is a United States quality award that covers an extensive list of criteria that are evaluated by independent judges if an organization chooses to compete for the award. In many cases, organizations use the Baldrige criteria as a guide for their internal quality efforts rather than compete directly for the award. The criteria can be accessed from the Internet at: http://www.baldrige.nist.gov/rnet.

The International Organization for Standardization (ISO) sponsors a certification process for organizations that seek to learn and adopt superior methods for quality practice (ISO 9000) and environmentally responsible products and methods of production (ISO 14000). These certifications are increasingly used by organizations of all sizes to compete more effectively in a global marketplace due to the wide acceptance of ISO certification as a criterion for supplier selection. ISO 9000 and ISO 14000 are described on the ISO web page at: http://www.iso.org/iso/home.htm .

> *"The ISO 9000 family addresses "quality management". This means what the organization does to fulfill:*
>
> *the customer's quality requirements, and*
>
> *applicable regulatory requirements, while aiming to*
>
> *enhance customer satisfaction, and*
>
> *achieve continual improvement of its performance in pursuit of these objectives.*
>
> *The ISO 14000 family addresses "environmental management". This means what the organization does to:*
>
> *minimize harmful effects on the environment caused by its activities, and to*
>
> *achieve continual improvement of its environmental performance."*

Another popular quality award is the Deming Prize, which is a Japanese quality award for which organizations from any country can apply. The Deming Prize was named after W. Edwards Deming, an American statistician, author, and consultant who helped improve United States production capabilities during World War II, but is best known for his work in post-war Japan. He is widely credited with assisting the Japanese in rebuilding their nation's production infrastructure in the areas of product design, product quality, and testing through the application of statistical methods. Florida Power and Electric was the first American company to win the Deming Prize, due to its meticulous use of formal approaches to quality improvement, data-based decision making, quality improvement teams, and the careful documentation of processes and procedures. More information on the Deming Prize can be found at:

http://www.juse.or.jp/e/deming/index.html

Special topic: supply chain management

Supply chain management is the business function that coordinates and manages all the activities of the supply chain, including suppliers of raw materials, components and services, transportation providers, internal departments, and information systems. Exhibit 31 illustrates a supply chain for providing packaged milk to consumers.

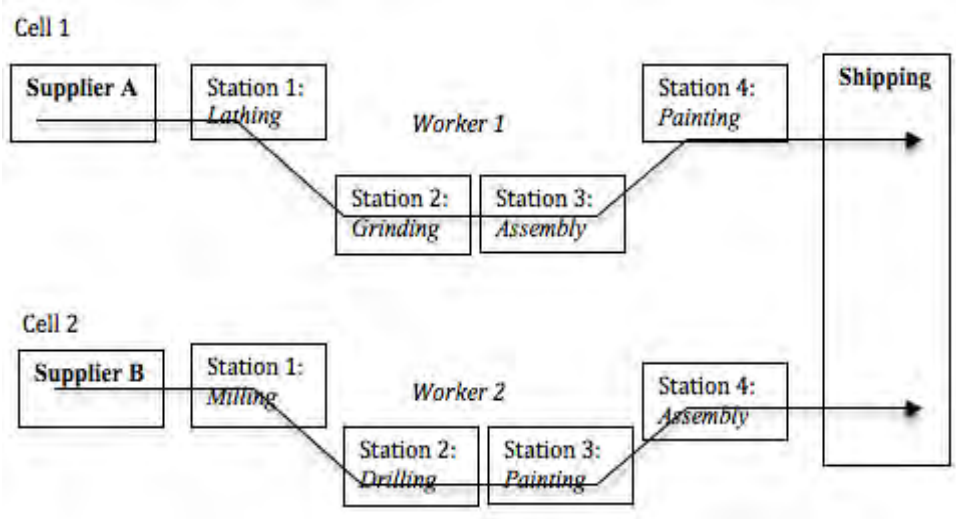

Exhibit 31: Illustration of a supply chain

In the manufacturing sector, supply chain management addresses the movement of goods through the supply chain from the supplier to the manufacturer, to wholesalers or warehouse distribution centers, to retailers and finally to the consumer. For example, Apple, Inc uses sophisticated information systems to accept orders for custom-built computers from individual customers all over the world. Apple assembles the computers in Shanghai, China, to the customers' specifications. It uses parts and components that are provided by outside suppliers who can deliver the right parts in the right quantity in a timely way to satisfy the immediate production schedule. The completed computers are flown from Shanghai by FedEx, reaching the end-user customers only a few days after the orders were placed. Apple's supply chain allows it to provide fast delivery of high-quality custom computers at competitive prices.

Supply chain concepts also apply to the service sector, where service firms must coordinate equipment, materials, and human resources to provide services to their customers in a timely manner. For example, a retail store that sells electronic products may contract with an outside business to provide installation services to its customers. In many cases, the customer does not even know the installation was done by an outside contractor. Information and communication technologies such as global positioning systems (GPS), barcode technology, customer relationship management (CRM) databases, and the Internet allow service businesses to coordinate external and internal service suppliers to efficiently and effectively respond to customer demand.

The supply chain is not just a one way process that runs from raw materials to the end customer. Although goods tend to flow this way, important data such as forecasts, inventory status, shipping schedules, and sales data are examples of information that is constantly being conveyed to different links in the supply chain. Money also tends to flow "upstream" in the supply chain so goods and service providers can be paid.

Bullwhip effect

A major goal in supply chain management strategy is to minimize the bullwhip effect. The bullwhip effect occurs when inaccurate or distorted information is passed on through the links in the supply chain. As the bad information gets passed from one party to the next, the distortions worsen and cause poor ordering decisions by upstream parties in the supply chain that have little apparent link to the final end-item product demand. As information gets farther from the end customer, the worse the quality of information gets as the supply chain members base their guesses on the bad guesses of their partners. The results are wasteful inventory investments, poor customer service, inefficient distribution, misused manufacturing capacity, and lost revenues for all parties in the supply chain.

For example, Open Range Jeans (a fictitious company) are sold in a popular retail store chain. The retail chain decides to promote Open Range Jeans and reduce the price to boost customer traffic in its stores, but the chain does not tell the Open Range manufacturer of this promotion plan. The manufacturer sees an increase in retail orders, forecasts a long-term growth in demand for its jeans, and places orders with its suppliers for more fabric, zippers, and dye.

Suppliers of fabric, zippers and dye see the increase in orders from the jeans manufacturer and boost their orders for raw cotton, chemicals, etc. Meanwhile, the retail chain has ended its Open Range promotion, and sales of the jeans plummet below normal levels because customers have stocked up to take advantage of the promotion prices. Just as end-customer demand falls, new jeans are being manufactured, and raw materials are being sent to the jeans factory. When the falling end-customer demand is finally realized, manufacturers rush to slash production, cancel orders, and discount inventories.

Not wanting to get burned twice, manufacturers wait until finished goods jean inventories are drawn down to minimal levels. When seasonal demand increases jeans purchases, the retail stores order more Open Range jeans, but the manufacturers cannot respond quickly enough. A stockout occurs at the retail store level just as customers are purchasing jeans during the back-to-school sales season. Retail customers respond to the stockout by purchasing the jeans of a major competitor, causing long-term damage to Open Range's market share.

Causes of the bullwhip effect

The bullwhip effect is caused by demand forecast updating, order batching, price fluctuation, and rationing and gaming.

- ***Demand forecast updating*** is done individually by all members of a supply chain. Each member updates its own demand forecast based on orders received from its "downstream" customer. The more members in the chain, the less these forecast updates reflect actual end-customer demand.
- ***Order batching*** occurs when each member takes order quantities it receives from its downstream customer and rounds up or down to suit production constraints such as equipment setup times or truckload quantities. The more members who conduct such rounding of order quantities, the more distortion occurs of the original quantities that were demanded.
- ***Price fluctuations*** due to inflationary factors, quantity discounts, or sales tend to encourage customers to buy larger quantities than they require. This behavior tends to add variability to quantities ordered and uncertainty to forecasts.

- ***Rationing and gaming*** is when a seller attempts to limit order quantities by delivering only a percentage of the order placed by the buyer. The buyer, knowing that the seller is delivering only a fraction of the order placed, attempts to "game" the system by making an upward adjustment to the order quantity. Rationing and gaming create distortions in the ordering information that is being received by the supply chain.

Counteracting the bullwhip effect

To improve the responsiveness, accuracy, and efficiency of the supply chain, a number of actions must be taken to combat the bullwhip effect:

- Make real-time end-item demand information available to all members of the supply chain. Information technologies such as electronic data interchange (EDI), bar codes, and scanning equipment can assist in providing all supply chain members with accurate and current demand information.
- Eliminate order batching by driving down the costs of placing orders, by reducing setup costs to make an ordered item, and by locating supply chain members closer to one another to ease transportation restrictions.
- Stabilize prices by replacing sales and discounts with consistent "every-day low prices" at the consumer stage and uniform wholesale pricing at upstream stages. Such actions remove price as a variable in determining order quantities.
- Discourage gaming in rationing situations by using past sales records to determine the quantities that will be delivered to customers.

Other factors affecting supply chain management

In addition to managing the bullwhip effect, supply chain managers must also contend with a variety of factors that pose on-going challenges:

- Increased demands from customers for better performance on cost, quality, delivery, and flexibility. Customers are better informed and have a broader array of options for how they conduct business. This puts added pressure on supply chain managers to continually improve performance.
- Globalization imposes challenges such as greater geographic dispersion among supply chain members. Greater distances create longer lead times and higher transportation costs. Cultural differences, time zones, and exchange rates make communication and decision-making more difficult. Boeing and Airbus have discovered the downside of sourcing from global suppliers. Much smaller suppliers of kitchen galleys, lavatories, and passenger seats have been unable to fulfill orders from Boeing and Airbus, leaving the latter unable to deliver planes to its airline customers.
- Government regulations, tariffs, and environmental rules provide challenges as well. For example, many countries require that products have a minimum percentage of local content. Being environmentally responsible by minimizing waste, properly disposing of dangerous chemicals, and using recyclable materials is rapidly becoming a requirement for doing business.

Supplier selection

Choosing suppliers is one of the most important decisions made by a company. The efficiency and value a supplier provides to an organization is reflected in the end product the organization produces. The supplier must not only provide goods and services that are consistent with the company's mission, it must also provide good value. The three most important factors in choosing a supplier are price, quality, and on-time delivery.

A company must not only choose who it wants as a supplier, it must also decide how many suppliers to use for a given good or service. There are advantages to using multiple suppliers and there are advantages to using one supplier. Whether to single-source or multiple-source often depends on the supply chain structure of the company and the character of the goods or services it produces.

If a company uses a single supplier, it can form a partnership with that supplier. A partnership is a long-term relationship between a supplier and a company that involves trust, information sharing, and financial benefits for both parties. When both parties benefit from a partnership, it is called a "win-win situation". It is easy to see how choosing suppliers is one of the most important decisions a company makes.

There are advantages and disadvantages to using one supplier. One advantage is that the supplier might own patents or processes and be the only source for the product. With one supplier, pricing discounts may be granted because purchases over the long-term are large and unit production costs for the supplier are lower. The supplier may be more responsive if you are the only purchaser of an item, resulting in better supplier relations. Just-in-time ordering is easier to implement, and deliveries may be scheduled more easily. Finally, using a single supplier is necessary to form a partnership. One disadvantage is that if that one supplier experiences a disaster at its warehouse like a fire or a tornado, or its workers go on strike, there is no other ready source for the product. Another possible disadvantage is that a single supplier may not be able to supply a very large quantity if it is suddenly needed. Also, sometimes the government requires the use of multiple suppliers for government projects.

There are also advantages and disadvantages to using multiple suppliers. Suppliers might provide better products and services over time if they know they are competing with other suppliers. Also, if a disaster happens at one supplier's warehouse, other suppliers can make up the loss. If a company uses multiple suppliers, there is more flexibility of volume to match demand fluctuations. One disadvantage with multiple suppliers is that it is more difficult to forge long-term partnerships. Information sharing becomes riskier, lower volumes for each supplier provide fewer opportunities for cost savings, and suppliers tend to be less responsive to emergency situations.

Partnerships are long-term relationships between a supplier and a company that involve trust and sharing and result in benefits for both parties. A good example of a partnership is the partnering between a Deere & Co. farm equipment factory and its suppliers. Deere decided to outsource its sheet metal, bar stock, and castings part families.

When Deere sent requests for bids to 120 companies, 24 companies responded to say they were interested. Deere then sent a team of engineers, quality specialists, and supply chain managers to evaluate each company. One supplier was chosen for each of the three part families. All three of the suppliers that were chosen were located less than two hours of driving time from the Deere plant.

For many years, all three suppliers have continued to provide outstanding quality, delivery, and cost performance to Deere. The suppliers benefited by gaining a long-term customer with a large amount of profitable business. Deere realized a 50 per cent drop in production costs on the three part families and was able to better focus on its mission of manufacturing farm equipment.

Conclusion

Supply chain management concerns the development of communication and information systems to link suppliers together in cooperative partnerships that promote advantage for all participants. Benefits include faster response times, reduced inventory costs, increased accuracy, and improved quality.

Special topic: just-in-time and lean systems

Just-in-time (JIT) is a management philosophy that originated in the 1970s. Taiichi Ohno is credited with developing JIT and perfected it for Toyota's manufacturing plants in Japan. The main goal of JIT is to eliminate anything that does not add value from the customer's perspective. Non-value-added activities are referred to as "waste" in JIT. Examples of waste include:

- overproduction beyond what is needed to satisfy immediate demand
- waiting time (work-in-process, customer waiting)
- unnecessary transportation (material handling, customer travel through a facility, etc.)
- processing waste (yield rates, start-up costs)
- inventory storage waste (space, deterioration, obsolescence, etc.)
- unnecessary motion and activity (waste in work techniques, etc.)
- waste from product and service defects (rework, scrap, warranty, etc.)

There are three essential elements that contribute to the successful practice of JIT:

- JIT manufacturing principles
- Total Quality Management (TQM)
- employee empowerment

JIT manufacturing principles

In a manufacturing setting, there are six major ways to pursue JIT goals: inventory reduction to expose waste, use of a "demand-pull" production system, quick setups to reduce lot sizes, uniform plant loading, flexible resources, and cellular flow layouts.

Inventory reduction to expose waste

Inventory covers up a lot of wasteful practices (poor equipment, weak vendors, bad quality, long setup times, etc.). By gradually lowering inventory, the weaknesses of the production system can be revealed and addressed one by one. Machines can be replaced or better maintained, vendors quality and delivery can be improved, machine setup procedures can be streamlined, quality practices can be implemented, and labor and equipment can be laid

out more efficiently. These improvements permit the organization to operate with less inventory, less costs, and faster response times in meeting customer needs.

Demand-pull production system

The traditional approach to manufacturing management promotes a strong focus on machine and labor utilization. The view was that if managers make sure that workers and machines are always busy, then surely the factory will be productive and efficient. This approach is called the "push" system of manufacturing, where raw material and work-in-process is continuously pushed through the factory in the pursuit of high utilization. The problem with this approach is that it usually produces high levels of inventories, long lead times, overtime costs, high levels of potential rework, and workers who are competing with one another rather than working cooperatively.

In contrast to the push system, JIT espouses a "demand-pull" system that operates on the rule that work should flow to a work center only if that work center needs more work. If a work center is already occupied with work activity, the upstream work center should stop production until the downstream work center communicates a need for more material. The emphasis on maintaining high utilization is removed in a JIT environment. The focus of a JIT environment is on addressing the challenges that affect the overall effectiveness of the factory (setup time reduction, quality improvement, enhanced production techniques, waste elimination, etc.) in meeting its strategic goals, rather than allowing excess inventory to cover up inefficiencies that reduce the factory's competitiveness.

Quick setups to reduce lot sizes

The longer it takes, and the more expensive it is to setup equipment and labor to produce an item, the greater the quantity of items that have to be produced in a given production run. Traditional production management philosophy promoted the notion that long production runs of the same item were the key to driving down unit costs. The problem was that large production runs created large quantities of WIP and finished goods inventory that far exceeded the demand. These items would consequently cause high levels of inventory costs, long lead times, high potential rework, low flexibility in responding to customer needs, etc.

Driving down setup costs and setup times are key to dramatically improving factory competitiveness in a JIT environment. In the 1980s, the 3M company converted a factory that made a few adhesive products in long production runs into a factory that made over 500 adhesive products in small production runs. To keep unit production costs under control, 3M studied the setups on its coating machines. Since the cost of chemical waste disposal was a major part of the cost of changing over a coating machine to make another product, 3M shortened the length of hoses that needed purging and redesigned the shape of the adhesive solution holding pan on the coating machine to be shallower. 3M also used quick-connect devices, disposable filters, and work teams to speed up setups. The result was that 3M could maintain low unit costs on its coating machines while producing small lots of hundreds of products to meet market demand quickly.

Uniform plant loading

The successful practice of JIT means having the right quantities of the right products in the right place at the right time. Driving down setup times enables the company to produce the product mix and quantities that are demanded in the present time period.

Flexible resources

The enemy of JIT is uncertainty. A JIT environment thrives on predictability in customer demand, production processes, suppliers, and workers. Of course, uncertainty cannot be completely eliminated in most organizational environments.

The defense against uncertainty that cannot be driven out is to implement flexible resources that can adapt easily to changing circumstances. General-purpose, moveable equipment that can fulfill a wide variety of production requirements is one way to improve flexibility. For example, drilling machines with quick-change bits which can be wheeled into position to form new work cells allows the factory to maximize efficiency while producing exactly what is needed to satisfy immediate demand. Another example is Toyota's use of paint canisters that attach to paint sprayers. Any car can be painted any color without having to purge hoses in switching from one color to another.

Multifunctional workers are another way to bring flexibility to the work environment. At Honeywell's heating and cooling controls plant, workers are trained to operate all the machines on their work line. The flexibility that comes from multifunctional workers changes the nature of how work gets done. Instead of workers being trained on one machine and working independently of one another, multifunctional workers have a "big picture" view of the production line, where every worker understands all aspects of the line and how to work together to meet quality and schedule goals regardless of the circumstances.

Line/cellular flow layouts

Earlier in this chapter, we described the efficiencies that repetitive process layouts provide. Repetitive process layouts are perfectly suited for driving out non-value-added activities and transitioning to a JIT environment. Intermittent layouts feature dozens or even hundreds of different paths through the facility. They are filled with complexity, uncertainty, and low visibility. Workers tend to have specialized skills, work independently of other departments, and have little sense of "ownership" of the products they work on.

In contrast, cell layouts promote JIT goals by featuring unidirectional product flows, high visibility, and fast throughput times. Workers with multifunctional skills are assigned to individual cells and have responsibility and control of the products they produce. Workers in a cell environment tend to have a greater sense of ownership and pride in their work because they have a "big picture" view of the product as it is converted from raw material to a finished good. This deeper understanding of the production process increases the opportunities for workers to contribute ideas for process improvements.

Total Quality Management

TQM was discussed in detail earlier. TQM goes hand in hand with the JIT philosophy because quality is a major source of uncertainty and non-value-added activities in an organization with poor quality practices. TQM promotes continuous improvement, doing it right the first time, designing quality into products and processes, and establishing an overall focus on prevention as the primary quality activity.

Employee empowerment

Front-line employees play a critical role in successful JIT practice. They work in partnership with management and each other in the continuous pursuit of excellence. There are several ways in which front-line employees contribute to JIT success:

- Employees work together in problem-solving teams to gather data and build consensus on how to improve work processes.
- Employees are responsible for understanding the quality measures of their work and what they need to do to meet the needs of internal and external customers.
- Each employee is empowered to take action to correct problems.
- Employees have cross-functional skill sets that allow them to be assigned to areas which need help, and to help them adopt a broader ("big picture") view of the production process.
- Unlike a traditional "push" environment where line workers are relatively independent of one another in their work activities, JIT employees are connected by the "demand pull" discipline, where work is not produced unless the downstream work center needs it. Demand-pull promotes the inter-connectedness of workers.
- Front-line employees are responsible for the basic maintenance of their machines. This helps employees have a better understanding of the condition of their equipment and its ability to meet quality and production requirements.

Management works with employees by being coaches and facilitators rather than authoritative supervisors. Managers are charged with hiring employees who can work in a proactive team environment, and provide the training and incentives to build a work culture that is focused on continuous improvement.

Conclusion: The evolution of JIT into "lean operations"

The JIT philosophy has evolved from a manufacturing-focused management approach to a set of management principles that can be applied to any organization. "Lean operations" is a term that is replacing JIT, especially in service environments. "Lean operations" captures the true essence and power of how a culture built around continuous improvement and the pursuit of value-added activities leads directly to competitive advantage in the marketplace. Lean operations is a management philosophy for any organization to achieve higher quality, increased productivity, improved delivery speed, greater responsiveness to changing markets, and increased customer satisfaction.