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20. Operations and quality management

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Table of Content

CHAPTER 1.

1.1 Definition and examples of operations

Operations is that part of a business organization that is responsible for producing goods and/or services. Goods are physical items that include raw materials, parts, subassemblies such as motherboards that go into computers, and final products such as cell phones and automobiles. Services are activities that provide some combination of time, location, form, or psychological value. Operations is responsible for producing the goods or providing the services offered by the organization. To put this into perspective, if a business organization were a car, operations would be its engine. And just as the engine is the core of what a car does, in a business organization, operations is the core of what the organization does. Operations management is responsible for managing that core. Hence operations management is the management of systems or processes that create goods and/or provide services.

Operations management uses the organization's resources to create outputs that fulfill defined market requirements. This is the fundamental activity of any type of enterprise.

From goods producing to entertainment or communications, there are many types of operations that are needed to be managed.

All operations can be modelled as input–transformation–output processes. They all have inputs of transforming resources, which are usually divided into 'facilities' and 'staff', and transformed resources, which are some mixture of materials, information and customers.

Most operations create and deliver a combination of services and products, rather than being a 'pure' service or 'product' product operation.

The success of operations management is often expressed in the rate of productivity. Productivity is the quantitative relation between what we produce and we use as a resource to produce them, i.e., arithmetic ratio of amount produced (output) to the amount of resources (input). Productivity can be expressed as:

Productivity =Output/Input

Productivity refers to the efficiency of the production system. It is the concept that guides the management of production system. It is an indicator to how well the factors of production (land, capital, labor and energy) are utilized.

1.2 The scope of operations management

In some types of organizations it is relatively easy to visualize the operations function and what it does, even if we have never seen it. For example, most people have seen images of an automobile assembly.

But what about an airline? There are many operations at an airline most people do not see or think about, so let us go through these:

– Forecasting such things as weather and landing conditions, seat demand for flights, and the growth in air travel.

– Capacity planning, essential for the airline to maintain cash flow and make a reasonable profit. (Too few or too many planes, or even the right number of planes but in the wrong places, will hurt profits.)

– Locating facilities according to managers' decisions on which cities to provide service for, where to locate maintenance facilities, and where to locate major and minor hubs. Facilities and layout, important in achieving effective use of workers and equipment.

– Scheduling of planes for flights and for routine maintenance; scheduling of pilots and flight attendants; and scheduling of ground crews, counter staff, and baggage handlers.

– Managing inventories of such items as foods and beverages, first-aid equipment, inflight magazines, pillows and blankets, and life preservers.

– Assuring quality, essential in flying and maintenance operations, where the emphasis is on safety, and important in dealing with customers at ticket counters, check-in, telephone and electronic reservations, and curb service, where the emphasis is on efficiency and courtesy.

– Motivating and training employees in all phases of operations.

A primary function of an operations manager is to guide the system by decision making. Certain decisions affect the design of the system, and others affect the operation of the system. System design involves decisions that relate to system capacity, the geographic location of facilities, arrangement of departments and placement of equipment within physical structures, product and service planning, and acquisition of equipment. These decisions usually, but not always, require long-term commitments. Moreover, they are typically strategic decisions. System operation involves management of personnel, inventory planning and control, scheduling, project management, and quality assurance. These are generally tactical and operational decisions.

Feedback on these decisions involves measurement and control. In many instances, the operations manager is more involved in day-to-day operating decisions than with decisions relating to system design. However, the operations manager has a vital stake in system design because system design essentially determines many of the parameters of system operation. For example, costs, space, capacities, and quality are directly affected by design decisions. Even though the operations manager is not responsible for making all design decisions, he or she can provide those decision makers with a wide range of information that will have a bearing on their decisions. A number of other areas are part of, or support, the operations function. They include purchasing, industrial engineering, distribution, and maintenance. Purchasing has responsibility for procurement of materials, supplies, and equipment. Close contact with operations is necessary to ensure correct quantities and timing of purchases. The purchasing department is often called on to evaluate vendors for quality, reliability, service, price, and ability to adjust to changing demand. Purchasing is also involved in receiving and inspecting the purchased goods. Industrial engineering is often concerned with scheduling, performance standards, work methods, quality control, and material handling.

Distribution involves the shipping of goods to warehouses, retail outlets, or final customers. Maintenance is responsible for general upkeep and repair of equipment, buildings and grounds, heating and air-conditioning; removing toxic wastes; parking; and perhaps security.

1.3 History of operations management

Systems for production have existed since ancient times. The construction of pyramids and management of war operations all involved operations management skills. The production of goods for sale, at least in the modern sense, and the modern factory system had their roots in the Industrial Revolution.

The Industrial Revolution began in the 1770s in England and spread to the rest of Europe and to the United States during the 19th century. Prior to that time, goods were produced in small shops by craftsmen and their apprentices. That time, it was common for one person to be responsible for making a product, such as a piece of furniture, from start to finish. Only simple tools were available; the machines in use today had not been invented. Then, a number of innovations in the 18th century changed the face of production forever by substituting machine power for human power. The most significant of these was the steam engine, because it provided a source of power to operate machines in factories. That time, goods were produced using craft production: highly skilled workers using simple, flexible tools produced goods according to customer specifications, but this had major shortcomings, as production was slow and costly. Another shortcoming was that production costs did not decrease as volume increased; there were no economies of scale, which would have provided a major incentive for companies to expand. Later, as standardized machines were invented, factories began to spring up and grow rapidly.

Despite the major changes that were taking place, management theory and practice had not progressed much from early days, up until 1911.

From 1911, the scientific management era brought widespread changes to the management of factories. The movement was lead by the efficiency engineer and inventor Frederick Winslow Taylor, who is often referred to as the father of scientific management. Taylor believed in a "science of management" based on observation, measurement, analysis and improvement of work methods, and economic incentives. He studied work methods in great detail to identify the best method for doing each job.

– Taylor's methods emphasized maximizing output. They were not always popular with workers, who sometimes thought the methods were used to unfairly increase output without a corresponding increase in compensation. Besides Taylor, other pioneers also contributed heavily to this movement:

– Frank Gilbreth was an industrial engineer who is often referred to as the father of motion study. He developed principles of motion economy that could be applied to incredibly small portions of a task.

– Henry Gantt recognized the value of nonmonetary rewards to motivate workers, and developed a widely used system for scheduling, called Gantt charts.

– Harrington Emerson applied Taylor's ideas to organization structure and encouraged the use of experts to improve organizational efficiency.

– Henry Ford, the great industrialist, employed scientific management techniques in his factories. Ford's Model T was such a success that the company had trouble keeping up with orders for the cars, so Ford adopted the scientific management principles and invented the assembly line.

– Lillian Gilbreth, a psychologist and the wife of Frank Gilbreth, worked with her husband, focusing on the human factor in work.

– Elton Mayo conducted studies at the Hawthorne division of Western Electric. His studies revealed that in addition to the physical and technical aspects of work, worker motivation is critical for improving productivity.

– Abraham Maslow developed motivational theories, which Frederick Hertzberg refined.

– Douglas McGregor added Theory X and Theory Y. These theories represented the two ends of the spectrum of how employees view work. Theory X, on the negative end, assumed that workers do not like to work, and have to be controlled—rewarded and punished—to get them to do good work. Theory Y, on the other end of the spectrum, assumed that workers enjoy the physical and mental aspects of work and become committed to work. William Ouchi added Theory Z, which combined the Japanese approach with such features as lifetime employment, employee problem solving, and consensus building, and the traditional Western approach that features short-term employment, specialists, and individual decision making and responsibility.

– H. F. Dodge, H. G. Romig, and W. Shewhart—developed statistical procedures for sampling and quality control.

– L.H.C. Tippett conducted studies that provided the groundwork for statistical sampling theory. At first, these quantitative models were not widely used in industry, but during World War II. specialists from many disciplines combined efforts to achieve advancements in the military and in manufacturing. After the war, efforts to develop and refine quantitative tools for decision making continued, resulting in decision models for forecasting, inventory management, project management, and other areas of operations management.

– George Dantzig invented linear programming in 1947, a mathematical method for determining a way to achieve the best outcome (such as maximum profit or lowest cost) in a given mathematical model for some list of requirements represented as linear relationships.

– In the 1970s, Stafford Beer was working on Management cybernetics, the application of cybernetics to management and organizations.

– During the 1960s and 1970s, management science techniques were highly regarded; in the 1980s, they lost some favor. However, the widespread use of personal computers and user-friendly software in the workplace contributed to a resurgence in the popularity of these techniques.

– The Influence of Japanese Manufacturers A number of Japanese manufacturers developed or refined management practices that increased the productivity of their operations and the quality of their products, due in part to the influence of Americans W. Edwards Deming and Joseph Juran.

– Japanese had a very big influence on the operations management processes, mainly because of the lack of resources in their island. They needed to be just as accurate, and just as effective as they could be, as they have no other option but to bring resources from other parts of the world and use them as effectively as possible. So they have refined and developed operations management practices that increased the productivity of their plants and their processes. They created the just in time production system that enabled the companies to schedule processes to that point when materials and shipments only arrive when they are needed at the plant.

– Taiichi Ohno, one of the lead engineers (later president), of Toyota, went to the United States, and based on what he saw there in the 1940s, he believed that he can create a system that can make Toyota, one of the best car manufacturers in the world, that later became the Toyota method, that is today the foundation of the lean manufacturing.

– Continuous Improvement came with total quality management and at the middle of the 1980s Flexible specialization, was introduced by Prior and Sable.

– And then we have arrived to the Information Age. The information age, brought the lean manufacturing in the 1990s, it brought mass customization, agile manufacturing. Quality standards have been introduced, just like the ISO or the IATF systems. Six Sigma, industry 4.0 and Internet of Things came as a result of all these previous approaches.

– Industry 4.0 and then internet of thing came with the information age, as companies had a lot of new opportunities because of the internet, because of the interconnections between different devices, different systems. Now it is possible to follow, check and intervene in production processes real time.

But there are a lot of key issues, a lot of challenges that today's business operations, need to face. One of them is the economic conditions that are changing very rapidly. Just look at what happened during the COVID epidemic. There is a huge need for innovation, there are a lot of quality problems and there are a lot of quality conditions, that, that companies need to be able to answer. There is the topic of risk management cybersecurity and of course something that we cannot deny, and something that we cannot just overcome that is globalization.

When it comes to economic conditions, there are recessions, and after every recession, just like in 2008 or 2020, there is a slow recovery in every sector, so it makes the managers cautious about investing or about rehiring workers. There are a lot of unsure factors in every system so everybody is a little cautious about what to do and how to do it. During the recession of the COVID crisis, a lot of companies needed to go out of practice. A lot of companies needed to shut down temporary or overall, because they (or their suppliers) were not able to organize their processes or to make make them feasible in the long run.

The second thing that is a huge challenge for operations managers is innovation, because there is a constant need and industry expectation to find new ways to improve the product - they need to make it nicer better, bigger, and cheaper. There is a lot of pressure, and they need to somehow answer that pressure through and with innovation.

Quality problems are, again, a huge challenge to operations management today. There are a lot of expectations towards product design and testing – for example in the automotive industry, where expectations and standars are extremely high. We can imagine that how big of a challenge it is to provide a production system that doesn't make a failure in 1 million parts

They also need to manage risks in a very unstable environment. There are many types of risks, and being able to handle and manage it, especially when the conditions and the market conditions are very unstable is a challenge for operations managers.

With the beginning of the information age, cybersecurity became a very important thing for many companies as they need to be able to protect their data, their databases, and they need to have reliable sources through which they can communicate and store sensitive information. We cannot deny that globalization is everywhere. It has an effect on almost every aspect of our life, and not just on us as consumers but also on companies.

Many of them need to manage operations that are going around the globe, one factory is in Mexico, the other one is in the United States, the third one is in Japan the fourth is in China, and they need to be able to harmonize all the things that are going on between the locations.

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CHAPTER 2.

2.1 Competitiveness

Companies must be competitive to sell their goods and services in the marketplace. Competitiveness is an important factor in determining whether a company prospers, barely gets by, or fails. Business organizations compete through some combination of price, delivery time, and product or service differentiation.

Marketing influences competitiveness in several ways, including identifying consumer wants and needs, pricing, and advertising and promotion.

– Identifying consumer wants and/or needs is a basic input in an organization's decision-making process, and central to competitiveness. The ideal is to achieve a perfect match between those wants and needs and the organization's goods and/or services.

– Price and quality are key factors in consumer buying decisions. It is important to understand the trade-off decision consumers make between price and quality.

– Advertising and promotion are ways organizations can inform potential customers about features of their products or services, and attract buyers.

Operations has a major influence on competitiveness through product and service design, cost, location, quality, response time, flexibility, inventory and supply chain management, and service.

– Product and service design should reflect joint efforts of many areas of the firm to achieve a match between financial resources, operations capabilities, supply chain capabilities, and consumer wants and needs. Special characteristics or features of a product or service can be a key factor in consumer buying decisions.

– Cost of an organization's output is a key variable that affects pricing decisions and profits. Costreduction efforts are generally ongoing in business organizations. Productivity (discussed later in the chapter) is an important determinant of cost. Organizations with higher productivity rates than their competitors have a competitive cost advantage.

– Location can be important in terms of cost and convenience for customers. Location near inputs can result in lower input costs. Location near markets can result in lower transportation costs and quicker delivery times. Convenient location is particularly important in the retail sector.

– Quality refers to materials, workmanship, design, and service. Consumers judge quality in terms of how well they think a product or service will satisfy its intended purpose. Customers are generally willing to pay more for a product or service if they perceive the product or service has a higher quality than that of a competitor.

– Quick response can be a competitive advantage. One way is quickly bringing new or improved products or services to the market. Another is being able to quickly deliver existing products and services to a customer after they are ordered, and still another is quickly handling customer complaints.

– Flexibility is the ability to respond to changes. Changes might relate to alterations in design features of a product or service, or to the volume demanded by customers, or the mix of products or services offered by an organization. High flexibility can be a competitive advantage in a changeable environment.

– Inventory management can be a competitive advantage by effectively matching supplies of goods with demand.

– Supply chain management involves coordinating internal and external operations (buyers and suppliers) to achieve timely and cost-effective delivery of goods throughout the system.

– Service might involve after-sale activities customers perceive as value-added, such as delivery, setup, warranty work, and technical support. Or it might involve extra attention while work is in progress, such as courtesy, keeping the customer informed, and attention to details. Service quality can be a key differentiator; and it is one that is often sustainable. Moreover, businesses rated highly by their customers for service quality tend to be more profitable, and grow faster, than businesses that are not rated highly.

Organizations fail, or perform poorly, for a variety of reasons. Being aware of those reasons can help managers avoid making similar mistakes.

Among the chief reasons are the following:

– Neglecting operations strategy.

– Failing to take advantage of strengths and opportunities, and/or failing to recognize competitive threats.

– Putting too much emphasis on short-term financial performance at the expense of research and development.

– Placing too much emphasis on product and service design and not enough on process design and improvement.

– Neglecting investments in capital and human resources.

– Failing to establish good internal communications and cooperation among different functional areas.

– Failing to consider customer wants and needs.

The key to successfully competing is to determine what customers want and then directing efforts toward meeting (or even exceeding) customer expectations. Two basic issues must be addressed. First: What do the customers want? (Which items on the preceding list of the ways business organizations compete are important to customers?) Second: What is the best way to satisfy those wants? Operations must work with marketing to obtain information on the relative importance of the various items to each major customer or target market.

2.2 Strategy

In the pursuit of bigger profits and healthier margins, a business can often lose sight of what really matters. When the first business plan is drawn up, it all looks so straightforward on paper – the ultimate purpose of the business, sitting atop the organizational pyramid, trickles down into the strategic, tactical and operational approaches of the business, all aligned in perfect harmony.

An organization's mission is the reason for its existence. It is expressed in its mission statement. For a business organization, the mission statement should answer the question "What business are we in?" Missions vary from organization to organization, depending on the nature of their business. Table 2.1 provides several examples of mission statements. A mission statement serves as the basis for organizational goals, which provide more detail and describe the scope of the mission. The mission and goals often relate to how an organization wants to be perceived by the general public, and by its employees, suppliers, and customers. Goals serve as a foundation for the development of organizational strategies. These, in turn, provide the basis for strategies and tactics of the functional units of the organization. Organizational strategy is important because it guides the organization by providing direction for, and alignment of, the goals and strategies of the functional units. Moreover, strategies can be the main reason for the success or failure of an organization.

There are three basic business strategies:

– Low cost: Maintaining low costs either by keeping wages or raw material cost low, or by providing technology that enables costs to be kept low.

– Responsiveness: Being able to respond to changes in technology or customer expectations

– Differentiation from competitors: Providing products and services that are easy to differentiate from the competitiors'

The combination of these basic strategies enable companies many competitive opportunities. Some of these strategies can be:

– Low cost. Outsource operations to third-world countries that have low labor costs.

– Scale-based strategies. Use capital-intensive methods to achieve high output volume and low unit costs.

– Specialization. Focus on narrow product lines or limited service to achieve higher quality.

– Newness. Focus on innovation to create new products or services. Flexible operations. Focus on quick response and/or customization.

– High quality. Focus on achieving higher quality than competitors.

– Service. Focus on various aspects of service (e.g., helpful, courteous, reliable, etc.).

– Sustainability. Focus on environmental-friendly and energy-efficient operations.

2.3 Operations strategy

The organization strategy provides the overall direction for the organization. It is broad in scope, covering the entire organization. Operations strategy is narrower in scope, dealing primarily with the operations aspect of the organization. It is also important to differentiate between operational efficiency and strategy, as operational efficiency deals with performing tasks well (in best case scenario, better than the competition), while operations strategy ensures that the tasks performed are the right tasks, by the right people, at the right time and place.

Besides being accurate and tailored to the organization's needs, operations strategy must be consistent with the overall strategy of the organization, and with the other functional units of the organization.

No operation that fails to serve its markets adequately is likely to survive in the long term. Without an understanding of what markets require, it is impossible to ensure that the operation is achieving the right priority between its performance objectives (quality, speed, dependability, flexibility and cost).

Operations seek to satisfy customers through developing their five performance objectives. For example, if customers particularly value low-priced products or services, the operation will place emphasis on its cost performance. Alternatively, a customer emphasis on fast delivery will make speed important to the operation. When it is important that products or services are delivered exactly when they are promised, the performance objective of dependability will be essential for the operation. When customers value products or services that have been adapted or designed specifically for them, flexibility will be vital – so whatever competitive factors are important to customers should influence the priority of each performance objective. Therefore, it is inevitable that companies need to harmonize operations resources with market requirements.

When companies are developing their operations strategies, it is important that is made after – thefeore, builds upon and supports- the business strategy, and focuses on those competitive priorities, that can provide the company with long term competitive advantage.

2.4 Competitive priorities and operations strategies

In 1984 Hayes and Wheelwright suggested that companies compete in the marketplace by virtue of one or more of the following competitive priorities:

– Quality

– Lead-time

– Cost

– Flexibility

Operations managers must work closely with marketing in order to understand the competitive situation in the company's market before they can determine which competitive priorities are important. There are four broad categories of competitive priorities:

1. Cost

Competing based on cost means offering a product at a low price relative to the prices of competing products. The need for this type of competition emerges from the business strategy. The role of the operations strategy is to develop a plan for the use of resources to support this type of competition. Note that a low-cost strategy can result in a higher profit margin, even at a competitive price. Also, low cost does not imply low quality.

2. Quality

Many companies claim that quality is their top priority, and many customers say that they look for quality in the products they buy. Yet quality has a subjective meaning; it depends on who is defining it. For example, to one person quality could mean that the product lasts a long time, such as with a Volvo, a car known for its longevity. To another person quality might mean high performance, such as a BMW. When companies focus on quality as a competitive priority, they are focusing on the dimensions of quality that are considered important by their customers.

3. Time

Time or speed is one of the most important competitive priorities today. Making time a competitive priority means competing based on all time-related issues, such as rapid delivery and on-time delivery. Rapid delivery refers to how quickly an order is received; on-time delivery refers to how often deliveries are made on time. Another time-competitive priority is development speed, which is the time needed to take an idea to the marketplace.

4. Flexibility

As a company's environment changes rapidly, including customer needs and expectations, the ability to readily accommodate these changes can be a winning strategy. This is flexibility. There are two dimensions of flexibility. One is the ability to offer a wide variety of goods or services and customize them to the unique needs of clients. This is called product flexibility. A flexible system can quickly add new products that may be important to customers or easily drop a product that is not doing well. Another aspect of flexibility is the ability to rapidly increase or decrease the amount produced in order to accommodate changes in the demand. This is called volume flexibility

The operations function must place emphasis on those priorities that directly support the business strategy. Therefore, it needs to make trade-offs between the different priorities. For example, consider a company that competes on using the highest quality component parts in its products. Due to the high quality of parts, the company may not be able to offer the final product at the lowest price. In this case, the company has made a trade-off between quality and price. Similarly, a company that competes on making each product individually based on customer specifications will likely not be able to compete on speed. Here, the trade-off has been made between flexibility and speed. It is important to know that every business must achieve a basic level of each of the priorities, even though its primary focus is only on some.

2.5 Productivity

One of the primary responsibilities of a manager is to achieve productive use of an organization's resources. The term productivity is used to describe this. Productivity is an index that measures output (goods and services) relative to the input (labor, materials, energy, and other resources) used to produce it. It is usually expressed as the ratio of output to input:

Productivity = Output ______ Input (2–1)

Although productivity is important for all business organizations, it is particularly important for organizations that use a strategy of low cost, because the higher the productivity, the lower the cost of the output. A productivity ratio can be computed for a single operation, a department, an organization, or an entire country. In business organizations, productivity ratios are used for planning workforce requirements, scheduling equipment, financial analysis, and other important tasks. Productivity has important implications for business organizations and for entire nations. For nonprofit organizations, higher productivity means lower costs; for profit-based organizations, productivity is an important factor in determining how competitive a company is. For a nation, the rate of productivity growth is of great importance. Productivity growth is the increase in productivity from one period to the next relative to the productivity in the preceding period.

There are several factors that affect productivity, such as equipment breakdowns and shortages of parts or materials. The education level and training of workers and their health can greatly affect productivity as well. The opportunity to obtain lower costs due to higher productivity elsewhere is a key reason many organizations turn to outsourcing. Hence, an alternative to outsourcing can be improved productivity. Moreover, as a part of their strategy for quality, the best organizations strive for continuous improvement. Productivity improvements can be an important aspect of that approach.

Productivity improvements (PI) can happen in various scenarios, with various changes in inputs and outputs. PI can occur when the company achieves more output with less input, for example by developing new technology. Another scenario of PI is achieving more outputs with the same input level, for example by reengineering or eliminating non-value creating processes.

Productivity measures can be based on a single input factor(partial productivity), or more than one input (multifactor productivity), or on all inputs (total productivity). The choice of productivity measure depends primarily on the purpose of the measurement. If the purpose is to track improvements in labor productivity, then labor becomes the obvious input measure. Partial measures are often of greatest use in operations management. The units of output used in productivity measures depend on the type of job performed.

There are two approached to study productivity: Static productivity describes the level of productivity at one point in time. Dynamic productivity is concerned with new technology and increases in productivity, which causes efficiency to increase over a period of time.

Productivity measures usually aim for simplicity, therefore, a wide variety of products or services, too many input resources, price/cost changes of inputs or outputs or redesigned products/services can cause measurement problems and inaccuracies.

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CHAPTER 3.

3.1 Selecting the processes

Process selection refers to deciding on the way production of goods or services will be organized. It has major implications for capacity planning, layout of facilities, equipment, and design of work systems. Process selection occurs when new products or services are being planned, and also occurs periodically due to technological changes in products or equipment, as well as competitive pressures. Forecasts, product and service design, and technological considerations all influence capacity planning and process selection. Moreover, capacity and process selection are interrelated, and are often done in concert. They, in turn, affect facility and equipment choices, layout, and work design. How an organization approaches process selection is determined by the organization's process strategy.

Key aspects include:

– Capital intensity: The mix of equipment and labor that will be used by the organization.

– Process flexibility: The degree to which the system can be adjusted to changes in processing requirements due to such factors as changes in product or service design, changes in volume processed, and changes in technology.

Process choice is demand driven. The two key questions in process selection are: 1. How much variety will the process need to be able to handle? 2. How much volume will the process need to be able to handle? Answers to these questions will serve as a guide to selecting an appropriate process. Usually, volume and variety are inversely related; a higher level of one means a lower level of the other. However, the need for flexibility of personnel and equipment is directly related to the level of variety the process will need to handle: the lower the variety, the less the need for flexibility, while the higher the variety, the greater the need for flexibility. There is another aspect of variety that is important. Variety means either having separate operations for each product or service, with a steady demand for each, or being willing to live with some idle time, or to get equipment ready every time there is the need to change the product being produced or the service being provided.

3.2 Process types

Job Shop.

A job shop usually operates on a relatively small scale. It is used when a low volume of high-variety goods or services will be needed. Processing is intermittent; work includes small jobs, each with somewhat different processing requirements. High flexibility using general-purpose equipment and skilled workers are important characteristics of a job shop. A manufacturing example of a job shop is a tool and die shop that is able to produce one-of-a-kind tools. A service example is a veterinarian's office, which is able to process a variety of animals and a variety of injuries and diseases.

Batch.

Batch processing is used when a moderate volume of goods or services is desired, and it can handle a moderate variety in products or services. The equipment need not be as flexible as in a job shop, but processing is still intermittent. The skill level of workers doesn't need to be as high as in a job shop because there is less variety in the jobs being processed. Examples of batch systems include bakeries, which make bread, cakes, or cookies in batches; movie theaters, which show movies to groups (batches) of people; and airlines, which carry planeloads (batches) of people from airport to airport. Other examples of products that lend themselves to batch production are paint, ice cream, soft drinks, beer, magazines, and books. Other examples of services include plays, concerts, music videos, radio and television programs, and public address announcements.

Repetitive.

When higher volumes of more standardized goods or services are needed, repetitive processing is used. The standardized output means only slight flexibility of equipment is needed. Skill of workers is generally low. Examples of this type of system include production lines and assembly lines. In fact, this type of process is sometimes referred to as assembly. Familiar products made by these systems include automobiles, television sets, pencils, and computers. An example of a service system is an automatic carwash. Other examples of service include cafeteria lines and ticket collectors at sports events and concerts. Also, mass customization is an option.

Continuous.

When a high volume of nondiscrete, highly standardized output is desired, a continuous system is used. These systems have almost no variety in output and, hence, no need for equipment flexibility. Workers' skill requirements can range from low to high, depending on the complexity of the system and the expertise workers need. Generally, if equipment is highly specialized, worker skills can be lower. Examples of products made in continuous systems include petroleum products, steel, sugar, flour, and salt. Continuous services include air monitoring, supplying electricity to homes and businesses, and the Internet. These process types are found in a wide range of manufacturing and service settings. The ideal is to have process capabilities match product or service requirements. Failure to do so can result in inefficiencies and higher costs than are necessary, perhaps creating a competitive disadvantage.

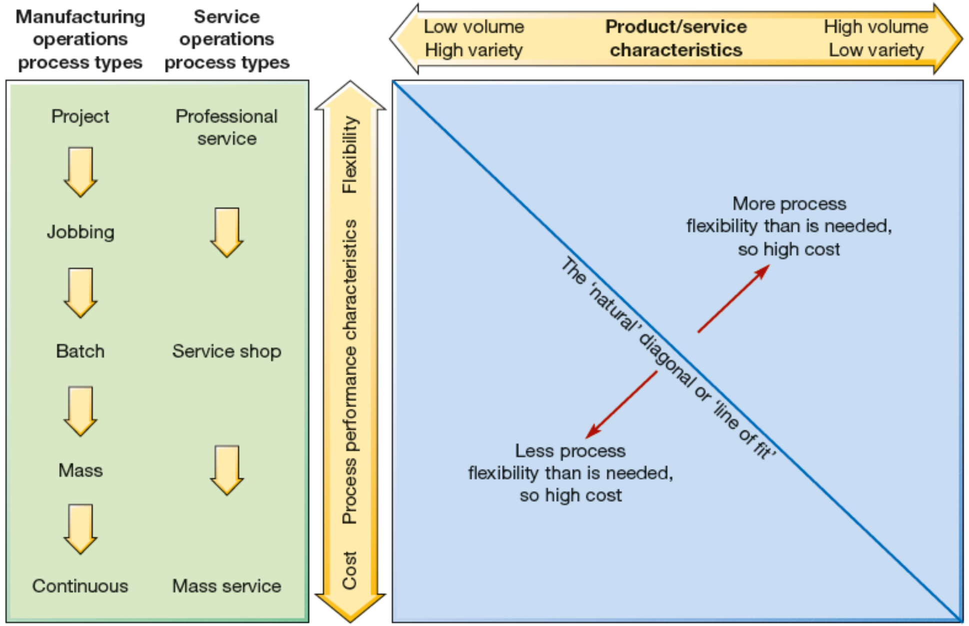
Project. Some situations are not ongoing but instead are of limited duration. In such instances, the work is often organized as a project. A project is used for work that is nonroutine, with a unique set of objectives to be accomplished in a limited time frame. Examples range from simple to complicated, including such things as putting on a play, consulting, making a motion picture, launching a new product or service, publishing a book, building a dam, and building a bridge. Equipment flexibility and worker skills can range from low to high.

Job variety, process flexibility, and unit cost are highest for a job shop and get progressively lower moving from job shop to continuous processing. Conversely, volume of output is lowest for a job shop and gets progressively higher moving from job shop to continuous processing. Note, too, that the examples fall along the diagonal. The implication is that the diagonal represents the ideal choice of processing system for a given set of circumstances. For example, if the goal is to be able to process a small volume of jobs that will involve high variety, job shop processing is most appropriate. For less variety and a higher volume, a batch system would be most appropriate, and so on. Note that combinations far from the diagonal would not even be considered, such as using a job shop for high-volume, low-variety jobs, or continuous processing for low-volume, high-variety jobs, because that would result in either higher than necessary costs or lost opportunities.

Another consideration is that products and services often go through life cycles that begin with low volume, which increases as products or services become better known. When that happens, a manager must know when to shift from one type of process (e.g., job shop) to the next (e.g., batch). Of course, some operations remain at a certain level (e.g., magazine publishing), while others increase (or decrease as markets become saturated) over time.

3.3 Product and service profiling

The most common method of illustrating the relationship between a process's volume– variety position and its design characteristics is the product-process matrix. it can in fact be used for any type of process whether producing products or services. The underlying idea of the product–process matrix is that many of the more important elements of process design are strongly related to the volume–variety position of the process. So, for any process, the tasks that it undertakes, the flow of items through the process, the layout of its resources, the technology it uses, and the design of jobs are all strongly influenced by its volume–variety position. This means that most processes should lie close to the diagonal of the matrix that represents the 'fit' between the process and its volume–variety position. This is called the 'natural' diagonal, or the 'line of fit'.



Source: Slack et. al (2010): *Operations management.* Wiley and Sons. P. 194.

A process lying on the natural diagonal of the matrix will normally have lower operating costs than one with the same volume–variety position that lies off the diagonal. This is because the diagonal represents the most appropriate process design for any volume–variety position. Processes that are on the right of the 'natural' diagonal would normally be associated with lower volumes and higher variety. This means that they are likely to be more flexible than seems to be warranted by their actual volume– variety position. That is, they are not taking advantage of their ability to standardize their activities. Because of this, their costs are likely to be high. Process selection can involve substantial investment in equipment and have a very specific influence on the layout of facilities, which also require heavy investment. Moreover, mismatches between operations capabilities and market demand and pricing or cost strategies can have a significant negative impact on the ability of the organization to compete or, in government agencies, to effectively service clients. Therefore, it is highly desirable to assess the degree of correlation between various process choices and market conditions before making process choices in order to achieve an appropriate matching. Product or service profiling can be used to avoid any inconsistencies by identifying key product or service dimensions and then selecting appropriate processes. Key dimensions often relate to the range of products or services that will be processed, expected order sizes, pricing strategies, expected frequency of schedule changes, and order-winning requirements.

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CHAPTER 4.

4.1 Importance of layout design

Layout refers to the configuration of departments, work centers, and equipment, with particular emphasis on movement of work (customers or materials) through the system.

As in other areas of system design, layout decisions are important for three basic reasons:

(1) they require substantial investments of money and effort;

(2) they involve long-term commitments, which makes mistakes difficult to overcome; and

(3) they have a significant impact on the cost and efficiency of operations.

The need for layout planning arises both in the process of designing new facilities and in redesigning existing facilities.

The most common reasons for redesign of layouts include

– inefficient operations (e.g., high cost, bottlenecks)

– accidents or safety hazards

– changes in the design of products or services

– introduction of new products or services

– changes in the volume of output or mix of outputs

– changes in methods or equipment

– changes in environmental or other legal requirement

– and morale problems (e.g., lack of face-to-face contact).

Poor layout design can adversely affect system performance.

The basic objective of layout design is to facilitate a smooth flow of work, material, and information through the system.

Supporting objectives generally involve the following:

1. To facilitate attainment of product or service quality.

2. To use workers and space efficiently.

3. To avoid bottlenecks.

4. To minimize material handling costs.

5. To eliminate unnecessary movements of workers or materials.

6. To minimize production time or customer service time.

7. To design for safety.

The three basic types of layout are product, process, and fixed-position. Product layouts are most conducive to repetitive processing, process layouts are used for intermittent processing, and fixedposition layouts are used when projects require layouts. The characteristics, advantages, and disadvantages of each layout type are described in this section, along with hybrid layouts, which are combinations of these pure types. These include cellular layouts and flexible manufacturing systems.

Layout planning is deciding on the best physical arrangement of all resources that consume space within a facility. These resources might include a desk, a work center, a cabinet, a person, an entire office, or even a department. Decisions about the arrangement of resources in a business are not made only when a new facility is being designed; they are made any time there is a change in the arrangement of resources, such as a new worker being added, a machine being moved, or a change in procedure being implemented. Also, layout planning is performed any time there is an expansion in the facility or a space reduction. The arrangement of resources in a facility can significantly affect the productivity of a business.

4.2 Product layouts

Product layouts are used to achieve a smooth and rapid flow of large volumes of goods or customers through a system. This is made possible by highly standardized goods or services that allow highly standardized, repetitive processing. The work is divided into a series of standardized tasks, permitting specialization of equipment and division of labor.

The large volumes handled by these systems usually make it economical to invest substantial sums of money in equipment and job design. Because only one or a few very similar items are involved, it is feasible to arrange an entire layout to correspond to the technological processing requirements of the product or service. For instance, if a portion of a manufacturing operation required the sequence of cutting, sanding, and painting, the appropriate pieces of equipment would be arranged in that same sequence. And because each item follows the same sequence of operations, it is often possible to utilize fixed-path material-handling equipment such as conveyors to transport items between operations.

Examples of this type of layout are less plentiful in service environments because processing requirements usually exhibit too much variability to make standardization feasible. Without high standardization, many of the benefits of repetitive processing are lost. When lines are used, certain compromises may be made. For instance, an automatic car wash provides equal treatment to all cars—the same amount of soap, water, and scrubbing—even though cars may differ considerably in cleaning needs.

Product layouts achieve a high degree of labor and equipment utilization, which tends to offset their high equipment costs. Because items move quickly from operation to operation, the amount of work-inprocess is often minimal. Consequently, operations are so closely tied to each other that the entire system is highly vulnerable to being shut down because of mechanical failure or high absenteeism. Maintenance procedures are geared to this. Preventive maintenance—periodic inspection and replacement of worn parts or those with high failure rates—reduces the probability of breakdowns during the operations. Of course, no amount of preventive activity can completely eliminate failures, so management must take measures to provide quick repair. These include maintaining an inventory of spare parts and having repair personnel available to quickly restore equipment to normal operation.

Repetitive processing can be machine paced (e.g., automatic car wash, automobile assembly), worker paced (e.g., fast-food restaurants such as McDonald's, Burger King), or even customer paced (e.g., cafeteria line).

The main advantages of product layouts are:

– A high rate of output.

– Low unit cost due to high volume. The high cost of specialized equipment is spread over many units.

– Labor specialization, which reduces training costs and time, and results in a wide span of supervision.

– Low material-handling cost per unit. Material handling is simplified because units follow the same sequence of operations. Material handling is often automated.

– A high utilization of labor and equipment.

– The establishment of routing and scheduling in the initial design of the system. These activities do not require much attention once the system is operating.

– Fairly routine accounting, purchasing, and inventory control.

The primary disadvantages of product layouts include the following:

– The intensive division of labor usually creates dull, repetitive jobs that provide little opportunity for advancement and may lead to morale problems and to repetitive stress injuries.

– Poorly skilled workers may exhibit little interest in maintaining equipment or in the quality of output.

– The system is fairly inflexible in response to changes in the volume of output or changes in product or process design.

– The system is highly susceptible to shutdowns caused by equipment breakdowns or excessive absenteeism because workstations are highly interdependent.

– Preventive maintenance, the capacity for quick repairs, and spare-parts inventories are necessary expenses.

– Incentive plans tied to individual output are impractical since they would cause variations among outputs of individual workers, which would adversely affect the smooth flow of work through the system.

U-Shaped Layouts. Although a straight production line may have intuitive appeal, a U-shaped line (has a number of advantages that make it worthy of consideration. One disadvantage of a long, straight line is that it interferes with cross-travel of workers and vehicles. A U-shaped line is more compact; it often requires approximately half the length of a straight production line. In addition, a U-shaped line permits increased communication among workers on the line because workers are clustered, thus facilitating teamwork. Flexibility in work assignments is increased because workers can handle not only adjacent stations but also stations on opposite sides of the line. Moreover, if materials enter the plant at the same point that finished products leave it, a U-shaped line minimizes material handling. Of course, not all situations lend themselves to U-shaped layouts: On highly automated lines there is less need for teamwork and communication. And entry and exit points may be on opposite sides of the building. Also, operations may need to be separated because of noise or contamination factors, so then, applying an Ushape layout is not practical or possible.

4.3 Process layouts

Process layouts (functional layouts) are designed to process items or provide services that involve a variety of processing requirements. The variety of jobs that are processed requires frequent adjustments to equipment. This causes a discontinuous workflow, which is referred to as intermittent processing.

The layouts feature departments or other functional groupings in which similar kinds of activities are performed. A manufacturing example of a process layout is the machine shop, which has separate departments for milling, grinding, drilling, and so on. Items that require those operations are frequently moved in lots or batches to the departments in a sequence that varies from job to job. Consequently, variable-path material handling equipment (forklift trucks, jeeps, tote boxes) is needed to handle the variety of routes and items. Workers who operate the equipment are usually skilled or semiskilled.

Process layouts are quite common in service environments. Examples include hospitals, colleges and universities, banks, auto repair shops, airlines, and public libraries. For instance, hospitals have departments or other units that specifically handle surgery, maternity, pediatrics, psychiatric, emergency, and geriatric care. And universities have separate schools or departments that concentrate on one area of study such as business, engineering, science, or math.

Because equipment in a process layout is arranged by type rather than by processing sequence, the system is much less vulnerable to shutdown caused by mechanical failure or absenteeism. In manufacturing systems especially, idle equipment is usually available to replace machines that are temporarily out of service. Moreover, because items are often processed in lots (batches), there is considerably less interdependence between successive operations than with a product layout. Maintenance costs tend to be lower because the equipment is less specialized than that of product layouts, and the grouping of machinery permits repair personnel to become skilled in handling that type of equipment. Machine similarity reduces the necessary investment in spare parts. On the negative side, routing and scheduling must be done on a continual basis to accommodate the variety of processing demands typically imposed on these systems. Material handling is inefficient, and unit handling costs are generally much higher than in product layouts. In-process inventories can be substantial due to batch processing and capacity mismatches.

The advantages of process layouts include the following:

– The systems can handle a variety of processing requirements.

– The systems are not particularly vulnerable to equipment failures.

– General-purpose equipment is often less costly than the specialized equipment used in product layouts and is easier and less costly to maintain.

– It is possible to use individual incentive systems.

The disadvantages of process layouts include the following:

– In-process inventory costs can be high if batch processing is used in manufacturing systems.

– Routing and scheduling pose continual challenges.

– Equipment utilization rates are low.

– Material handling is slow and inefficient, and more costly per unit than in product layouts.

– Job complexities often reduce the span of supervision and result in higher supervisory costs than with product layouts.

– Special attention necessary for each product or customer (e.g., routing, scheduling, machine setups) and low volumes result in higher unit costs than with product layouts.

– Accounting, inventory control, and purchasing are much more involved than with product layouts.

4.4 Fixed-position and combination layouts

In fixed-position layouts, the item being worked on remains stationary, and workers, materials, and equipment are moved about as needed. This is in marked contrast to product and process layouts. Almost always, the nature of the product dictates this kind of arrangement: Weight, size, bulk, or some other factor makes it undesirable or extremely difficult to move the product. Fixed-position layouts are used in large construction projects (buildings, power plants, dams), shipbuilding, and production of large aircraft and space mission rockets. In those instances, attention is focused on timing of material and equipment deliveries so as not to clog up the work site and to avoid having to relocate materials and equipment around the work site. Lack of storage space can present significant problems, for example, at construction sites in crowded urban locations.

Because of the many diverse activities carried out on large projects and because of the wide range of skills required, special efforts are needed to coordinate the activities, and the span of control can be quite narrow. For these reasons, the administrative burden is often much higher than it would be under either of the other layout types. Material handling may or may not be a factor; in many cases, there is no tangible product involved (e.g., designing a computerized inventory system). When goods and materials are involved, material handling often resembles process-type, variable-path, general-purpose equipment. Projects might require use of earth-moving equipment and trucks to haul materials to, from, and around the work site, for example.

Fixed-position layouts are widely used in farming, firefighting, road building, home building, remodeling and repair, and drilling for oil. In each case, compelling reasons bring workers, materials, and equipment to the product's location instead of the other way around.

The three basic layout types are ideal models, which may be altered to satisfy the needs of a particular situation. It is not hard to find layouts that represent some combination of these pure types. For instance, supermarket layouts are essentially process layouts, yet we find that most use fixed-path materialhandling devices such as roller-type conveyors in the stockroom and belt-type conveyors at the cash registers. Hospitals also use the basic process arrangement, although frequently patient care involves more of a fixed-position approach, in which nurses, doctors, medicines, and special equipment are brought to the patient. By the same token, faulty parts made in a product layout may require off-line reworking, which involves customized processing. Moreover, conveyors are frequently observed in both farming and construction activities. Process layouts and product layouts represent two ends of a continuum from small jobs to continuous production. Process layouts are conducive to the production of a wider range of products or services than product layouts, which is desirable from a customer standpoint where customized products are often in demand. However, process layouts tend to be less efficient and have higher unit production costs than product layouts. Some manufacturers are moving away from process layouts in an effort to capture some of the benefits of product layouts. Ideally, a system is flexible and yet efficient, with low unit production costs.

4.5. Combination and Service layouts

Service layouts can often be categorized as product, process, or fixed-position layouts. In a fixed-position service layout (e.g., appliance repair, roofing, landscaping, home remodeling, copier service), materials, labor, and equipment are brought to the customer's residence or office.

Process layouts are common in services due mainly to the high degree of variety in customer processing requirements. Examples include hospitals, supermarkets and department stores, vehicle repair centers, and banks.

If the service is organized sequentially, with all customers or work following the same or similar sequence, as it is in a car wash or a cafeteria line, a product layout is used, however, the degree of customer contact and the degree of customization are two key factors in service layout design.

If contact and customization are both high, as in health care and personal care, the service environment is a job shop, usually with high labor content and flexible equipment, and a layout that supports this. If customization is high but contact low (e.g., picture framing, tailoring), the layout can be arranged to facilitate workers and equipment.

If contact is high but customization is low (e.g., supermarkets, gas stations), self-service is a possibility, in which case layout must take into account ease of obtaining the service as well as customer safety.

If the degree of contact and the need for customization are low, the core service and the customer can be separated, making it easier to achieve a high degree of efficiency in operations. Highly standardized services may lend themselves to automation.

The most commonly used layout types are:

Warehouse and Storage Layouts. The design of storage facilities presents a different set of factors than the design of factory layouts. Frequency of order is an important consideration; items that are ordered frequently should be placed near the entrance to the facility, and those ordered infrequently should be placed toward the rear of the facility.

Retail Layouts. The objectives that guide design of manufacturing layouts often pertain to cost minimization and product flow. However, with retail layouts such as department stores, supermarkets, and specialty stores, designers must take into account the presence of customers and the opportunity to influence sales volume and customer attitudes through carefully designed layouts.

Office Layouts. Office layouts are undergoing transformations as the flow of paperwork is replaced with the increasing use of electronic communications. This lessens the need to place office workers in a layout that optimizes the physical transfer of information or paperwork.

Another trend is to create an image of openness; office walls are giving way to low-rise partitions, which also facilitate communication among workers.

Restaurant layouts.

In restaurant layouts, the single most important element is process workflow.

Food and non-food products should transition easily through the operation from the receiving door to the customer with all phases of storage, pre-preparation, cooking, holding, and service, unimpaired or minimized due to good design

Hospital Layouts.

Key elements of hospital layout design are patient care and safety, with easy access to critical resources such as machines, diagnostic equipment and different departments of the facility.

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CHAPTER 5.

5.1 The importance of location decisions

Existing organizations may need to make location decisions for a variety of reasons. Firms such as banks, fast-food chains, supermarkets, and retail stores view locations as part of marketing strategy, and they look for locations that will help them to expand their markets. Basically, the location decisions in those cases reflect the addition of new locations to an existing system. A similar situation occurs when an organization experiences a growth in demand for its products or services that cannot be satisfied by expansion at an existing location. The addition of a new location to complement an existing system is often a realistic alternative.

Location decisions are closely tied to an organization's strategies. For example, a strategy of being a low-cost producer might result in locating where labor or material costs are low, or locating near markets or raw materials to reduce transportation costs.

Location choices can impact capacity and flexibility. Certain locations may be subject to space constraints that limit future expansion options. Moreover, local restrictions may restrict the types of products or services that can be offered, thus limiting future options for new products or services. Location decisions are strategically important for other reasons as well. One is that they entail a long-term commitment, which makes mistakes difficult to overcome. Another is that location decisions often have an impact on investment requirements, operating costs and revenues, and operations. A poor choice of location might result in excessive transportation costs, a shortage of qualified labor, loss of competitive advantage, inadequate supplies of raw materials, or some similar condition that is detrimental to operations. For services, a poor location could result in lack of customers and/or high operating costs. For both manufacturing and services, location decisions can have a significant impact on competitive advantage. And another reason for the importance of location decisions is their strategic importance to supply chains.

Profit-oriented organizations base their decisions on profit potential, whereas nonprofit organizations strive to achieve a balance between cost and the level of customer service they provide. It would seem to follow that all organizations attempt to identify the "best" location available. However, this is not necessarily the case. Most organizations do not set out with the intention of identifying the one best location; rather, they hope to find a number of acceptable locations from which to choose. Location criteria can depend on where a business is in the supply chain. For instance, at the retail end of a chain, site selection tends to focus more on accessibility, consumer demographics (population density, age distribution, average buyer income), traffic patterns, and local customs. Businesses at the beginning of a supply chain, if they are involved in supplying raw materials, are often located near the source of the raw materials. Businesses in the middle of the chain may locate near suppliers or near their markets, depending on a variety of circumstances.

The location of factories, warehouses and distribution centers can involve a long-term commitment of resources, so known risks and benefits should be considered carefully. A related issue is whether to have centralized or decentralized distribution. Centralized distribution generally yields scale economies as well as tighter control than decentralized distribution, but it sometimes incurs higher transportation costs. Decentralized distribution tends to be more responsive to local needs.

Managers of existing companies generally consider four options in location planning:

– Expand an existing facility. This option can be attractive if there is adequate room for expansion, especially if the location has desirable features that are not readily available elsewhere. Expansion costs are often less than those of other alternatives.

– Add new locations while retaining existing ones. This is done in many retail operations. In such cases, it is essential to take into account what the impact will be on the total system. Opening a new store in a shopping mall may simply draw customers who already patronize an existing store in the same chain, rather than expand the market. On the other hand, adding locations can be a defensive strategy designed to maintain a market share or to prevent competitors from entering a market.

– Shut down at one location and move to another. An organization must weigh the costs of a move and the resulting benefits against the costs and benefits of remaining in an existing location. A shift in markets, exhaustion of raw materials, and the cost of operations often cause firms to consider this option seriously.

– Do nothing. If a detailed analysis of potential locations fails to uncover benefits that make one of the previous three alternatives attractive, a firm may decide to maintain the status quo, at least for the time being.

5.2 Location decision factors

The way an organization approaches location decisions often depends on its size and the nature or scope of its operations. New or small organizations tend to adopt a rather informal approach to location decisions. New firms typically locate in a certain area simply because the owner lives there. Similarly, managers of small firms often want to keep operations in their backyard, so they tend to focus almost exclusively on local alternatives. Large established companies, particularly those that already operate in more than one location, tend to take a more formal approach.

The general procedure for making location decisions usually consists of the following steps:

1. Decide on the criteria to use for evaluating location alternatives, such as increased revenues, decreased cost, or community service.

2. Identify important factors, such as location of markets or raw materials. The factors will differ depending on the type of facility. For example, retail, manufacturing, distribution, health-care, and transportation all have differing factors that guide their location decisions.

3. Develop location alternatives: a. Identify a country or countries for location. b. Identify the general region for a location. c. Identify a small number of community alternatives. d. Identify site alternatives among the community alternatives.

4. Evaluate the alternatives and make a selection.

Many factors influence location decisions. However, it often happens that one or a few factors are so important that they dominate the decision. For example, in manufacturing, the potentially dominating factors usually include availability of an abundant energy and water supply and proximity to raw materials.

Regional factors to consider include the location of raw materials, the location of markets, labor factors or other factors like climate and taxes.

– Firms locate near or at the source of raw materials for three primary reasons: necessity, perishability, and transportation costs.

– Profit-oriented firms frequently locate near the markets they intend to serve as part of their competitive strategy, whereas nonprofit organizations choose locations relative to the needs of the users of their services Primary labor considerations are the cost and availability of labor, wage rates in an area, labor productivity and attitudes toward work, and whether unions are a serious potential problem.

Community considerations

Many communities actively try to attract new businesses, offering financial and other incentives, because they are viewed as potential sources of future tax revenues and new job opportunities. However, communities do not, as a rule, want firms that will create pollution problems or otherwise lessen the quality of life in the community.

From a company standpoint, a number of factors determine the desirability of a community as a place for its workers and managers to live. They include facilities for education, shopping, recreation, transportation, religious worship, and entertainment; the quality of police, fire, and medical services; local attitudes toward the company; and the size of the community. Community size can be particularly important if a firm will be a major employer in the community; a future decision to terminate or reduce operations in that location could have a serious impact on the economy of a small community. Other community-related factors are the cost and availability of utilities, environmental regulations, taxes (state and local, direct and indirect), and often a laundry list of enticements offered by state or local governments that can include bond issues, tax abatements, low-cost loans, grants, and worker training.

Site related factors

The primary considerations related to sites are land, transportation, and zoning or other restrictions. Evaluation of potential sites may require consulting with engineers or architects, especially in the case of heavy manufacturing or the erection of large buildings or facilities with special requirements. Soil conditions, load factors, and drainage rates can be critical and often necessitate certain kinds of expertise in evaluation. Because of the long-term commitment usually required, land costs may be secondary to other site-related factors, such as room for future expansion, current utility and sewer capacities—and any limitations on these that could hinder future growth.

Multiple plant strategies

When companies have multiple manufacturing facilities, they can organize operations in several ways.

– Product Plant Strategy. With this strategy, entire products or product lines are produced in separate plants, and each plant usually supplies the entire domestic market. This is essentially a decentralized approach, with each plant focusing on a narrow set of requirements that entails specialization of labor, materials, and equipment along product lines.

– Market Area Plant Strategy. With this strategy, plants are designed to serve a particular geographic segment of a market (e.g., Europe or Middle-East). Individual plants produce most if not all of a company's products and supply a limited geographical area.

– Process Plant Strategy. With this strategy, different plants concentrate on different aspects of a process. Automobile manufacturers often use this approach, with different plants for engines, transmissions, body stamping, and even radiators. This approach is best suited to products that have numerous components; separating the production of components results in less confusion than if all production were carried out at the same location.

– General-Purpose Plant Strategy. With this strategy, plants are flexible and capable of handling a range of products. This allows for quick response to product or market changes, although it can be less productive than a more focused approach

Service and retail are typically governed by somewhat different considerations than manufacturing organizations in making location decisions. For one thing, nearness to raw materials is usually not a factor, nor is concern about processing requirements. Customer access is sometimes a prime consideration, as it is with banks and supermarkets, but not a consideration in others, such as call centers, catalog sales, and online services. Manufacturers tend to be cost-focused, concerned with labor, energy, and material costs and availability, as well as distribution costs.

Service and retail businesses tend to be profit or revenue focused, concerned with demographics such as age, income, and education, population/drawing area, competition, traffic volume/patterns, and customer access/parking. Retail sales and services are usually found near the center of the markets they serve. Examples include fast-food restaurants, service stations, dry cleaners, and supermarkets. Quite often their products and those of their competitors are so similar that they rely on convenience to attract customers. Hence, these businesses seek locations with high population densities or high traffic. The competition/convenience factor is also important in locating banks, hotels and motels, auto repair shops, drugstores, newspaper kiosks, and shopping centers

5.3 Globalization and global locations

There are a number of factors that have made globalization attractive and feasible for business organizations.

Two key factors are trade agreements and technological advances.

– Trade Agreements. Barriers to international trade such as tariffs and quotas have been reduced or eliminated with trade agreements such as the North American Free Trade Agreement (NAFTA), the General Agreement on Tariffs and Trade (GATT), and the U.S.–China Trade Relations Act. Also, the European Union has dropped many trade barriers, and the World Trade Organization is helping to facilitate free trade.

– Technology. Technological advances in communication and information sharing have been very helpful. These include faxing capability, e-mail, cell phones, teleconferencing, and the Internet.

The benefits of global locations

– Markets. Companies often seek opportunities for expanding markets for their goods and services, as well as better serving existing customers by being more attuned to local needs and having a quicker response time when problems occur.

– Cost savings. Among the areas for potential cost saving are transportation costs, labor costs, raw material costs, and taxes. High production costs in Germany have contributed to a number of German companies locating some of their production facilities in lower cost countries.

– Legal and regulatory. There may be more favorable liability and labor laws, and less restrictive environmental and other regulations.

– Financial. Companies can avoid the impact of currency changes that can occur when goods are produced in one country and sold in other countries. Also, a variety of incentives may be offered by national, regional, or local governments to attract businesses that will create jobs and boost the local economy.

The disadvantages of global locations

Transportation costs. High transportation costs can occur due to poor infrastructure or having to ship over great distances, and the resulting costs can offset savings in labor and materials costs.

Security costs. Increased security risks and theft can increase costs. Also, security at international borders can slow shipments to other countries.

Unskilled labor. Low labor skills may negatively impact quality and productivity, and the work ethic may differ from that in the home country. Additional employee training may be required.

Import restrictions. Some countries place restrictions on the importation of manufactured goods, so having local suppliers avoids those issues.

Criticisms. Critics may argue that cost savings are being generated through unfair practices such as using sweatshops, in which employees are paid low wages and made to work in poor conditions; using child labor; and operating in countries that have less stringent environmental requirements. Others might criticize migrating jobs and tax incomes from the home country to other countries.

Productivity. Low labor productivity may offset low labor costs or other advantages.

The risks of global locations:

– Opportunity cost: The loss of value or benefit that would be incurred by engaging in one activity/investment over another, meaning that the company loses certain benefits by choosing one location over an other.

– Political. Political instability and political unrest can create risks for personnel safety and the safety of assets. Moreover, a government might decide to nationalize facilities, taking them over.

– Economic. Economic instability might create inflation or deflation, either of which can negatively impact profitability.

– Legal. Laws and regulations may change, reducing or eliminating what may have been key benefits.

– Ethical. Corruption and bribery, differences in laws and legistlations.

– Cultural. Cultural differences in work morale, attention, religion or other socio-cultural factors might pose a risk on building successful and productive work communities.

Although global operations offer many benefits, these operations often create new issues for management to deal with. For example, language and cultural differences increase the risk of miscommunication and may also interfere with developing trust that is important in business relationships. Management styles may be quite different, so tactics that work well in one country may not work in another. Increased travel distances and related travel times and costs may result in a decreased tendency for face-to-face meetings and management site visits.

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CHAPTER 6.

6.1 The aim of product and service design

The various activities and responsibilities of product and service design include the following (functional interactions are shown in parentheses):

1. Translate customer wants and needs into product and service requirements operations)
2. Refine existing products and services (marketing)
3. Develop new products and/or services (marketing, operations)
4. Formulate quality goals (marketing, operations)
5. Formulate cost targets (accounting, finance, operations)
6. Construct and test prototypes (operations, marketing, engineering)
7. Document specifications
8. Translate product and service specifications into process specifications (engineering, operations)

Product and service design involves or affects nearly every functional area of an organization. However, marketing and operations have major involvement.

From a buyer's standpoint, most purchasing decisions bring two fundamental considerations:

1. cost
2. quality or performance

From the organization's standpoint, the key questions are:

1. Is there demand for it? What is the potential size of the market, and what is the expected demand profile (will demand be long term or short term, will it grow slowly or quickly)?

2. Can we do it? Do we have the necessary knowledge, skills, equipment, capacity, and supply chain capability? For products, this is known as manufacturability; for services, this is known as serviceability. Also, is outsourcing some or all of the work an option?

3. What level of quality is appropriate? What do customers expect? What level of quality do competitors provide for similar items? How would it fit with our current offerings?

4. Does it make sense from an economic standpoint? What are the potential liability issues, ethical considerations, sustainability issues, costs, and profits? For nonprofits, is the cost within budget?

Product and service design has typically had strategic implications for the success and prosperity of an organization. Furthermore, it has an impact on future activities. Consequently, decisions in this area are some of the most fundamental that managers must make. Organizations become involved in product and service design or redesign for a variety of reasons. The main forces that initiate design or redesign are market opportunities and threats.

The factors that give rise to market opportunities and threats can be one or more changes:

– Economic (e.g., low demand, excessive warranty claims, the need to reduce costs)

– Social and demographic (e.g., aging baby boomers, population shifts)

– Political, liability, or legal (e.g., government changes, safety issues, new regulations) – Competitive (e.g., new or changed products or services, new advertising/promotions)

– Cost or availability (e.g., of raw materials, components, labor, water, energy)

– Technological (e.g., in product components, processes)

Because of rapidly changing customer expectations, operations managers today are concerned by and influenced by trends related to achieving as many satisfied customers, as possible. The foundation of customer satisfaction is designing products that are needed by the customers, and are user friendly in terms of ease of use, design and costs.

Customization and mass customization are also approached supporting customer satisfaction.

Pressure,however, does not come only from the side of the customers but also from the side of the competitors. That's why there is a big need in reducing time to introduce a product or service, to as soon as possibl, by rather launching an MVP or a product that is not completely finished than lose competitive advantage.

There is also a need from the organization to produce or deliver the right item on the right time, that is made possible by monitoring trends and fluctuations on demand, markets and suppliers.

There are also a lot of environmental concerns when it comes to product and service design. Of course, sustainability is a trend nowadays that many companies wants to, or have to be able to cope with, by redesigning their packaging, redesigning their processes or redesigning their products.

6.2 Product and service design processes

The product design process is a vital part of the life of every company.

It always starts with

1. Idea generation, where

2. Feasibility analysis entails market analysis (demand), economic analysis (development cost and production cost, profit potential), and technical analysis (capacity requirements and availability, and the skills needed)

3. Product specifications involves detailed descriptions of what is needed to meet (or exceed) customer wants, and requires collaboration between legal, marketing, and operations.

4. Process specifications. Once product specifications have been set, attention turns to specifications for the process that will be needed to produce the product. Alternatives must be weighed in terms of cost, availability of resources, profit potential, and quality.

5. Prototype development. With product and process specifications complete, one (or a few) units are made to see if there are any problems with the product or process specifications.

6. Design review. At this stage, any necessary changes are made or the project is abandoned. Marketing, finance, engineering, design, and operations collaborate to determine whether to proceed or abandon.

7. Market test. A market test is used to determine the extent of consumer acceptance. If unsuccessful, the product returns to the design review phase.

8. Product introduction. The new product is promoted.

9. Follow-up evaluation. Based on user feedback, changes may be made or forecasts refined.

Service design is very similar to product design, except that the delivery system also must be designed.

1. Conceptualize.

   – Idea generation

   – Assessment of customer wants/needs

   – Assessment of demand potential

2. Identify service package components needed

3. Determine performance specifications

4. Translate performance specifications into design specifications.

5. Translate design specifications into delivery specifications.

Service operations managers must contend with issues that may be insignificant or nonexistent for managers in a production setting.

These include the following:

1. Products are generally tangible; services are generally intangible. Consequently, service design often focuses more on intangible factors (e.g., peace of mind, ambiance) than does product design.

2. In many instances services are created and delivered at the same time (e.g., a haircut, a car wash). In such instances there is less latitude in finding and correcting errors before the cus tomer has a chance to discover them.

3. Services cannot be inventoried. This poses restrictions on flexibility and makes capacity issues very important.

4. Services are highly visible to consumers and must be designed with that in mind; this adds an extra dimension to process design, one that usually is not present in product design.

5. Some services have low barriers to entry and exit. This places additional pressures on service design to be innovative and cost-effective.

6. Location is often important to service design, with convenience as a major factor. Hence, design of services and choice of location are often closely linked.

7. Service systems range from those with little or no customer contact to those that have a very high degree of customer contact.

8. Demand variability alternately creates waiting lines or idle service resources.

6.3 Forthcoming aspects of product design

The product lifecycle

Products, like people, have life cycles. A product begins with an idea, and within the confines of modern business, it isn't likely to go further until it undergoes research and development (R&D) and is found to be feasible and potentially profitable. At that point, the product is produced, marketed, and rolled out.

As mentioned above, there are four generally accepted stages in the life cycle of a product—introduction, growth, maturity, and decline.

1. Introduction: This phase generally includes a substantial investment in advertising and a marketing campaign focused on making consumers aware of the product and its benefits.

2. Growth: If the product is successful, it then moves to the growth stage. This is characterized by growing demand, an increase in production, and expansion in its availability.

3. Maturity: This is the most profitable stage, while the costs of producing and marketing decline.

4. Decline: A product takes on increased competition as other companies emulate its successsometimes with enhancements or lower prices. The product may lose market share and begin its decline.

When a product is successfully introduced into the market, demand increases, therefore increasing its popularity. These newer products end up pushing older ones out of the market, effectively replacing them. Companies tend to curb their marketing efforts as a new product grows. That's because the cost to produce and market the product drop. When demand for the product wanes, it may be taken off the market completely.

Standardization

An important issue that often arises in both product/service design and process design is the degree of standardization. Standardization refers to the extent to which there is absence of variety in a product, service, or process. Standardized products are made in large quantities of identical items; calculators, computers, and 2 percent milk are examples. Standardized service implies that every customer or item processed receives essentially the same service. Standardized processes deliver standardized service or produce standardized goods. Standardization carries a number of important benefits as well as certain disadvantages. Standardized products are immediately available to customers. Standardized products mean interchangeable parts, which greatly lower the cost of production while increasing productivity and making replacement or repair relatively easy compared with that of customized parts. Design costs are generally lower. By reducing variety, companies save time and money while increasing quality and reliability of their products.

Mass Customization

Mass customization is a strategy of producing standardized goods or services, but incorporating some degree of customization in the final product or service. Several tactics make this possible. One is delayed differentiation, and another is modular design.

– Delayed differentiation is a postponement tactic: the process of producing, but not quite completing, a product or service, postponing completion until customer preferences or specifications are know.

– Modular design is a form of standardization. Modules represent groupings of component parts into subassemblies, usually to the point where the individual parts lose their separate identity

Reliability

Reliability Reliability is a measure of the ability of a product, a part, a service, or an entire system to perform its intended function under a prescribed set of conditions. The importance of reliability is underscored by its use by prospective buyers in comparing alternatives and by sellers as one determinant of price. Reliability also can have an impact on repeat sales, reflect on the product's image, and, if it is too low, create legal implications.

Concurrent engineering

To achieve a smoother transition from product design to production, and to decrease product development time, many companies are using simultaneous development, or concurrent engineering. Concurrent engineering means bringing design and manufacturing engineering people together early in the design phase to simultaneously develop the product and the processes for creating the product. More recently, this concept has been enlarged to include manufacturing personnel (e.g., materials specialists) and marketing and purchasing personnel in loosely integrated, cross-functional teams.

CAD

Computer-aided design (CAD) uses computer graphics for product design. The designer can modify an existing design or create a new one on a monitor by means of a light pen, a keyboard, a joystick, or a similar device. Once the design is entered into the computer, the designer can maneuver it on the screen: It can be rotated to provide the designer with different perspectives, it can be split apart to give the designer a view of the inside, and a portion of it can be enlarged for closer examination.

QFD

Quality function deployment (QFD) is a structured approach for integrating the "voice of the customer" into both the product and service development process. The purpose is to ensure that customer requirements are factored into every aspect of the process. Listening to and understanding the customer is the central feature of QFD.

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CHAPTER 7.

7.1 The role of capacity decisions

Capacity refers to an upper limit or ceiling on the load that an operating unit can handle. The load might be in terms of the number of physical units produced (e.g., bicycles assembled per hour) or the number of services performed (e.g., computers upgraded per hour). The operating unit might be a plant, department, machine, store, or worker. Capacity needs include equipment, space, and employee skills.

The goal of strategic capacity planning is to achieve a match between the long-term supply capabilities of an organization and the predicted level of long-term demand. Organizations become involved in capacity planning for various reasons. Among the chief reasons are changes in demand, changes in technology, changes in the environment, and perceived threats or opportunities. A gap between current and desired capacity will result in capacity that is out of balance. Overcapacity causes operating costs that are too high, while undercapacity causes strained resources and possible loss of customers.

The key questions in capacity planning are the following:

1. What kind of capacity is needed?

2. How much is needed to match demand?

3. When is it needed?

Where only one product or service is involved, the capacity of the productive unit may be expressed in terms of that item. However, when multiple products or services are involved, as is often the case, using a simple measure of capacity based on units of output can be misleading. An appliance manufacturer may produce both refrigerators and freezers. If the output rates for these two products are different, it would not make sense to simply state capacity in units without reference to either refrigerators or freezers. The problem is compounded if the firm has other products. One possible solution is to state capacities in terms of each product. Thus, the firm may be able to produce 100 refrigerators per day or 80 freezers per day. Sometimes this approach is helpful, sometimes not. For instance, if an organization has many different products or services, it may not be practical to list all of the relevant capacities. This is especially true if there are frequent changes in the mix of output, because this would necessitate a frequently changing composite index of capacity. The preferred alternative in such cases is to use a measure of capacity that refers to availability of inputs. Thus, a hospital has a certain number of beds, a factory has a certain number of machine hours available, and a bus has a certain number of seats and a certain amount of standing room.

Design capacity is the maximum rate of output achieved under ideal conditions. Effective capacity is always less than design capacity owing to realities of changing product mix, the need for periodic maintenance of equipment, lunch breaks, coffee breaks, problems in scheduling and balancing operations, and similar circumstances. Actual output cannot exceed effective capacity and is often less because of machine breakdowns, absenteeism, shortages of materials, and quality problems, as well as factors that are outside the control of the operations managers.

For a number of reasons, capacity decisions are among the most fundamental of all the design decisions that managers must make. In fact, capacity decisions can be critical for an organization.

1. Capacity decisions have a real impact on the ability of the organization to meet future demands for products and services; capacity essentially limits the rate of output possible. Having capacity to satisfy demand can often allow a company to take advantage of tremendous benefits.

2. Capacity decisions affect operating costs. Ideally, capacity and demand requirements will be matched, which will tend to minimize operating costs. In practice, this is not always achieved because actual demand either differs from expected demand or tends to vary (e.g., cyclically). In such cases, a decision might be made to attempt to balance the costs of over- and undercapacity.

3. Capacity is usually a major determinant of initial cost. Typically, the greater the capacity of a productive unit, the greater its cost. This does not necessarily imply a one-for-one relationship; larger units tend to cost proportionately less than smaller units.

4. Capacity decisions often involve long-term commitment of resources and the fact that, once they are implemented, those decisions may be difficult or impossible to modify without incurring major costs.

5. Capacity decisions can affect competitiveness. If a firm has excess capacity, or can quickly add capacity, that fact may serve as a barrier to entry by other firms. Then, too, capacity can affect delivery speed, which can be a competitive advantage.

6. Capacity affects the ease of management; having appropriate capacity makes management easier than when capacity is mismatched.

7. Globalization has increased the importance and the complexity of capacity decisions. Far-flung supply chains and distant markets add to the uncertainty about capacity needs.

8. Because capacity decisions often involve substantial financial and other resources, it is necessary to plan for them far in advance. For example, it may take years for a new power-generating plant to be constructed and become operational. However, this increases the risk that the designated amount of capacity will not match actual demand when the capacity becomes available.

7.2 Determinants of effective capacity

1. *Facilities.* The design of facilities, including size and provision for expansion, is key. Locational factors, such as transportation costs, distance to market, labor supply, energy sources, and room for expansion, are also important. Likewise, layout of the work area often determines how smoothly work can be performed, and environmental factors such as heating, lighting, and ventilation also play a significant role in determining whether personnel can perform effectively or whether they must struggle to overcome poor design characteristics.

2. *Product and Service Factors.* Product or service design can have a tremendous influence on capacity. For example, when items are similar, the ability of the system to produce those items is generally much greater than when successive items differ. Thus, a restaurant that offers a limited menu can usually prepare and serve meals at a faster rate than a restaurant with an extensive menu. Generally speaking, the more uniform the output, the more opportunities there are for standardization of methods and materials, which leads to greater capacity. The particular mix of products or services rendered also must be considered since different items will have different rates of output.

3. *Process Factors.* The quantity capability of a process is an obvious determinant of capacity. A more subtle determinant is the influence of output quality. For instance, if quality of output does not meet standards, the rate of output will be slowed by the need for inspection and rework activities. Productivity also affects capacity. Process improvements that increase quality and productivity can result in increased capacity. Also, if multiple products or multiple services are processed in batches, the time to change over equipment settings must be taken into account.

4. *Human Factors.* The tasks that make up a job, the variety of activities involved, and the training, skill, and experience required to perform a job all have an impact on the potential and actual output. In addition, employee motivation has a very basic relationship to capacity, as do absenteeism and labor turnover.

5. *Operational Factors.* Scheduling problems may occur when an organization has differences in equipment capabilities among alternative pieces of equipment or differences in job requirements. Inventory stocking decisions, late deliveries, purchasing requirements, acceptability of purchased materials and parts, and quality inspection and control procedures also can have an impact on effective capacity. Inventory shortages of even one component of an assembled item (e.g., computers, refrigerators, automobiles) can cause a temporary halt to assembly operations until the components become available. This can have a major impact on effective capacity. Thus, insufficient capacity in one area can affect overall capacity.

6. *Supply Chain Factors.* Supply chain factors must be taken into account in capacity planning if substantial capacity changes are involved. Key questions include: What impact will the changes have on suppliers, warehousing, transportation, and distributors? If capacity will be increased, will these elements of the supply chain be able to handle the increase? Conversely, if capacity is to be decreased, what impact will the loss of business have on these elements of the supply chain?

7. External Factors. Product standards, especially minimum quality and performance standards, can restrict management's options for increasing and using capacity. Thus, pollution standards on products and equipment often reduce effective capacity, as does paperwork required by government regulatory agencies by engaging employees in nonproductive activities. A similar effect occurs when a union contract limits the number of hours and type of work an employee may do.

7.3 Capacity planning

A leading capacity strategy builds capacity in anticipation of future demand increases. If capacity increases involve a long lead time, this strategy may be the best option. A following strategy builds capacity when demand exceeds current capacity.

A tracking strategy is similar to a following strategy, but it adds capacity in relatively small increments to keep pace with increasing demand. long-term demand patterns, technological changes, and the behavior of its competitors. These typically involve (1) the growth rate and variability of demand, (2) the costs of building and operating facilities of various sizes, (3) the rate and direction of technological innovation, (4) the likely behavior of competitors, and (5) availability of capital and other inputs.

In some instances a decision may be made to incorporate a capacity cushion, which is an amount of capacity in excess of expected demand when there is some uncertainty about demand. Capacity cushion = capacity – expected demand. Typically, the greater the degree of demand uncertainty, the greater the amount of cushion used. Organizations that have standard products or services generally have smaller capacity cushions. Cost and competitive priorities are also key factors.

Steps in the Capacity Planning Process

1. Estimate future capacity requirements.

2. Evaluate existing capacity and facilities and identify gaps.

3. Identify alternatives for meeting requirements.

4. Conduct financial analyses of each alternative.

5. Assess key qualitative issues for each alternative.

6. Select the alternative to pursue that will be best in the long term.

7. Implement the selected alternative.

8. Monitor results.

Capacity planning can be difficult at times due to the complex influence of market forces and technology. Capacity planning decisions involve both long-term and short-term considerations.

Long-term considerations relate to overall level of capacity, such as facility size; short-term considerations relate to probable variations in capacity requirements created by such things as seasonal, random, and irregular fluctuations in demand. Because the time intervals covered by each of these categories can vary significantly from industry to industry, it would be misleading to put times on the intervals. However, the distinction will serve as a framework within which to discuss capacity planning. Long-term capacity needs require forecasting demand over a time horizon and then converting those forecasts into capacity requirements. When trends are identified, the fundamental issues are (1) how long the trend might persist, because few things last forever, and (2) the slope of the trend. If cycles are identified, interest focuses on (1) the approximate length of the cycles and (2) the amplitude of the cycles (i.e., deviation from average).

Short-term capacity needs are less concerned with cycles or trends than with seasonal variations and other variations from average. These deviations are particularly important because they can place a severe strain on a system's ability to satisfy demand at some times and yet result in idle capacity at other times.

7.4 Bottleneck operations

Capacity changes inevitably affect an organization's supply chain. Suppliers may need time to adjust to their capacity, so collaborating with supply chain partners on plans for capacity increases is essential. That includes not only suppliers, but also distributors and transporters. The risk in not taking a big-picture approach is that the system will be unbalanced. Evidence of an unbalanced system is the existence of a bottleneck operation. A bottleneck operation is an operation in a sequence of operations whose capacity is lower than the capacities of other operations in the sequence. As a consequence, the capacity of the bottleneck operation limits the system capacity; the capacity of the system is reduced to the capacity of the bottleneck operation.

Bottlenecks tend to have different causes and usually have more severe implications in the process industries. In parts manufacturing and assembly, the workers tend to be the rate-limiting factor across various steps, and therefore managing bottleneck operations in manufacturing is often a matter of managing people – by appropriate staffing and task leveling. In process plants, the throughput in most operational steps is limited by equipment capability and not necessarily by labor. And with equipment rather than operating labor being the bottleneck, throughput limitations can't be resolved by bringing in additional labor or by scheduling overtime.

Listed below are few things to be kept in mind to understand the causes:

– Most often the root cause is generally in the equipment capacity and performance, not labor staffing.

– Outdated equipment, unscheduled downtime, and inaccurate supply chain forecasting are also to be blamed as factors.

– Root causes also include yield losses, reliability problems, and the inherent capacity.

– Sometimes, non-bottlenecks can become bottlenecks owing to variability in operationsal factors.

– Bottlenecks can vary with the product mix.

– At times, bottlenecks may not be obvious as the resulting inventory or waste is frequently hidden from sight.

Signs that companies may have a bottleneck include:

– Long wait times– Work is getting delayed because there is a waiting for a product, a report, or more information

– Delayed movement- Materials are moving slowly from one step to another

– Backlogged work– There is a lot of work being piled up continuously at one end of a process, and not enough at the other end

– Missing delivery schedules- Company constantly missing expected delivery schedules resulting in dissatisfied customers

– Irregular maintenance frequency- Unable to keep a tab on the equipment maintenance frequencies due to unexpected breakdowns

– Lead-time unpredictability- Challenges in accurately estimating production lead times

Overcoming and resolving bottlenecks, however, is not impossible, and can be achieved by following the guidelines below:

– Identify root-cause effects

– Apply AI-driven or automated data analytics if possible instead of manual work

– Support real-time and end-to-end visibility

– Avoid data scattering and aim for transparency

– Bring decision that is based on data

– Know your system from the ground up

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CHAPTER 8.

8.1 Job design

Job design involves specifying the content and methods of jobs. Job designers focus on what will be done in a job, who will do the job, how the job will be done, and where the job will be done. The objectives of job design include productivity, safety, and quality of work life. Current practice in job design contains elements of two basic schools of thought. One might be called the efficiency school because it emphasizes a systematic, logical approach to job design; the other is called the behavioral school because it emphasizes satisfaction of wants and needs. The efficiency approach, a refinement of Frederick Winslow Taylor's scientific management concepts, received considerable emphasis in the past. The behavioral approach followed and has continued to make inroads into many aspects of job design. It is noteworthy that specialization is a primary issue of disagreement between the efficiency and behavioral approaches.

1. Specialization

The term specialization describes jobs that have a very narrow scope. Examples range from assembly lines to medical specialties. College professors often specialize in teaching certain courses, some auto mechanics specialize in transmission repair, and some bakers specialize in wedding cakes. The main rationale for specialization is the ability to concentrate one's efforts and thereby become proficient at that type of work. Sometimes the amount of knowledge or training required of a specialist and the complexity of the work suggest that individuals who choose such work are very happy with their jobs. This seems to be especially true in the "professions" (e.g., doctors, lawyers, professors). At the other end of the scale are assembly-line workers, who are also specialists, although much less glamorous. The advantage of these highly specialized jobs is that they yield high productivity and relatively low unit costs, and they are largely responsible for the high standard of living that exists today in industrialized nations. Unfortunately, many of the lower-level jobs can be described as monotonous or downright boring, and are the source of much of the dissatisfaction among many industrial workers. While some workers undoubtedly prefer a job with limited requirements and responsibility for making decisions, others are not capable of handling jobs with greater scopes.

2. Behavioral Approaches to Job Design

In an effort to make jobs more interesting and meaningful, job designers frequently consider job enlargement, job rotation, job enrichment, and increased use of mechanization Job enlargement means giving a worker a larger portion of the total task. This constitutes horizontal loading—the additional work is on the same level of skill and responsibility as the original job. The goal is to make the job more interesting by increasing the variety of skills required and by providing the worker with a more recognizable contribution to the overall output. For example, a production worker's job might be expanded so that he or she is responsible for a sequence of activities instead of only one activity. Job rotation means having workers periodically exchange jobs. A firm can use this approach to avoid having one or a few employees stuck in monotonous jobs. It works best when workers can be transferred to more interesting jobs; there is little advantage in having workers exchange one boring job for another. Job rotation allows workers to broaden their learning experience and enables them to fill in for others in the event of sickness or absenteeism. Job enrichment involves an increase in the level of responsibility for planning and coordination tasks. It is sometimes referred to as vertical loading. An example of this is to have stock clerks in supermarkets handle reordering of goods, thus increasing their responsibilities. The job enrichment approach focuses on the motivating potential of worker satisfaction.

3. Motivation

Motivation is a key factor in many aspects of work life. Not only can it influence quality and productivity, it also contributes to the work environment. People work for a variety of reasons in addition to compensation. Other reasons include socialization, self-actualization, status, the physiological aspects of work, and a sense of purpose and accomplishment. Awareness of these factors can help management to develop a motivational framework that encourages workers to respond in a positive manner to the goals of the organization.

4. Teams

The efforts of business organizations to become more productive, competitive, and customeroriented have caused them to rethink how work is accomplished. Significant changes in the structure of some work environments have been the increasing use of teams and the way workers are paid, particularly in lean production systems. There are a number of different forms of teams. One is a short-term team formed to collaborate on a topic such as quality improvement, product or service design, or solving a problem. Team members may be drawn from the same functional area or from several functional areas, depending on the scope of the problem. Other teams are more long term. One form of long-term team that is increasingly being used, especially in lean production settings, is the self-directed team.

5. Ergonomics

Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design in order to optimize human well-being and overall system performance. “Ergonomists contribute to the design and evaluation of tasks, jobs, products, environments and systems in order to make them compatible with the needs, abilities and limitations of people.” 2 In the work environment, ergonomics also helps to increase productivity by reducing worker discomfort and fatigue.

8.2 Quality of work life

The success of any organisation is highly dependant on how it attracts, recruits, motivates, and retains its workforce. Today's organisations need to be more flexible so that they are equipped to develop their workforce and enjoy their commitment. Therefore, organisations are required to adopt a strategy to improve the employees' quality of work life to satisfy both the organisational objectives and employee needs.

Quality of Working Life is a term that had been used to describe the broader job-related experience an individual has. It has been differentiated from the broader concept of quality of life. To some degree, this may be overly simplistic, as Elizur and Shye concluded that quality of work performance is affected by quality of life as well as quality of working life. However, it will be argued here that the specific attention to work-related aspects of quality of life is valid.

Working conditions are an important aspect of job design. Physical factors such as temperature, humidity, ventilation, illumination, and noise can have a significant impact on worker performance in terms of productivity, quality of output, and accidents. In many instances, government regulations apply.

Temperature and Humidity. Although human beings can function under a fairly wide range of temperatures and humidity, work performance tends to be adversely affected if temperatures or humidities are outside a very narrow comfort band. That comfort band depends on how strenuous the work is; the more strenuous the work, the lower the comfort range.

Ventilation. Unpleasant and noxious odors can be distracting and dangerous to workers. Moreover, unless smoke and dust are periodically removed, the air can quickly become stale and annoying.

Illumination. The amount of illumination required depends largely on the type of work being performed; the more detailed the work, the higher the level of illumination needed for adequate performance. Other important considerations are the amount of glare and contrast. From a safety standpoint, good lighting in halls, stairways, and other dangerous points is important. However, because illumination is expensive, high illumination in all areas is not generally desirable.

Noise and Vibrations. Noise is unwanted sound. It is caused by both equipment and humans. Noise can be annoying or distracting, leading to errors and accidents. It also can damage or impair hearing if it is loud enough. Vibrations can be a factor in job design even without a noise component, so merely eliminating sound may not be sufficient in every case. Vibrations can come from tools, machines, vehicles, human activity, air-conditioning systems, pumps, and other sources. Corrective measures include padding, stabilizers, shock absorbers, cushioning, and rubber mountings.

Work Time and Work Breaks. Reasonable (and sometimes flexible) work hours can provide a sense of freedom and control over one's work. This is useful in situations where the emphasis is on completing work on a timely basis and meeting performance objectives rather than being "on duty" for a given time interval, as is the case for most retail and manufacturing operations. Work breaks are also important. Long work intervals tend to generate boredom and fatigue. Productivity and quality can both deteriorate. Similarly, periodic vacation breaks can give workers something to look forward to, a change of pace, and a chance to recharge themselves. Occupational Health Care. Good worker health contributes to productivity, minimizes health care costs, and enhances workers' sense of well-being. Many organizations have exercise and healthy-eating programs designed to improve or maintain employees' fitness and general health.

Safety. Worker safety is one of the most basic issues in job design. This area needs constant attention from management, employees, and designers. Workers cannot be effectively motivated if they feel they are in physical danger. From an employer standpoint, accidents are undesirable because they are expensive (insurance and compensation); they usually involve damage to equipment and/or products; they require hiring, training, and makeup work; and they generally interrupt work. From a worker standpoint, accidents mean physical suffering, mental anguish, potential loss of earnings, and disruption of the work routine.

8.3 Methods analysis

One of the techniques used by self-directed teams and work analysts is methods analysis, which focuses on how a job is done. Job design often begins with an analysis of the overall operation. It then moves from general to specific details of the job, concentrating on arrangement of the workplace and movements of materials and/or workers. Methods analysis can be a good source of productivity improvements. The need for methods analysis can come from a number of different sources: Changes in tools and equipment, changes in product design or introduction of new products, changes in materials or procedures, government regulations or contractual agreements, and incidents such as accidents and quality problems. Methods analysis is done for both existing jobs and new jobs. For a new job it is needed to establish a method. For an existing job the procedure usually is to have the analyst observe the job as it is currently being performed and then devise improvements. For a new job, the analyst must rely on a job description and an ability to visualize the operation.

The basic procedure in methods analysis is as follows:

1. Identify the operation to be studied, and gather all pertinent facts about tools, equipment, materials, and so on.

2. For existing jobs, discuss the job with the operator and supervisor to get their input.

3. Study and document the present method of an existing job using process charts. For new jobs, develop charts based on information about the activities involved.

4. Analyze the job.

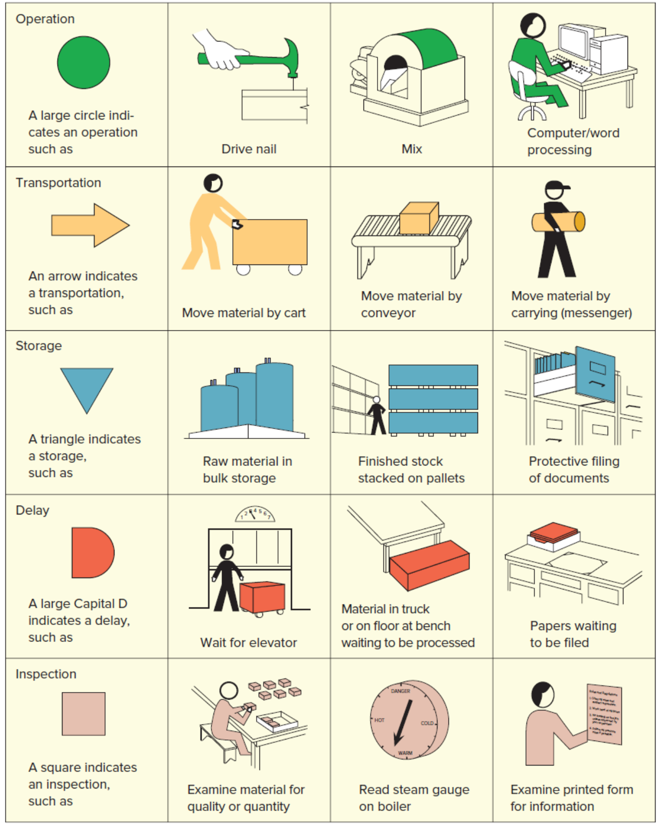
5. Propose new methods.

6. Install the new methods.

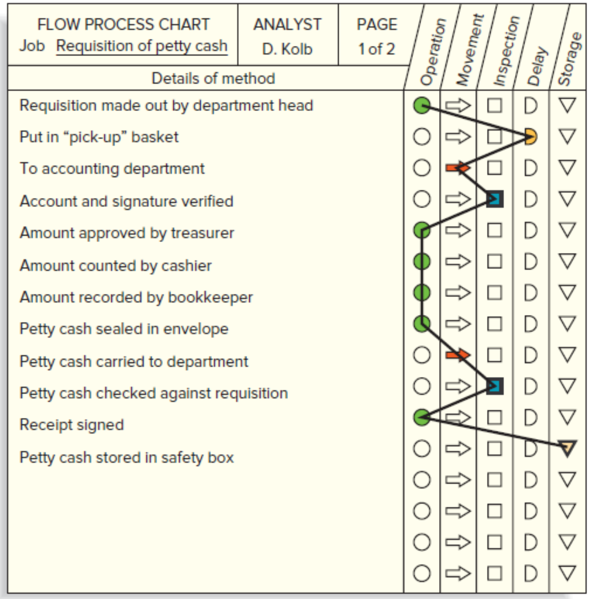
7. Follow up implementation to assure that improvements have been achieved

Job analysis requires careful thought about the what, why, when, where, and who of the job. Often, simply going through these questions will clarify the review process by encouraging the analyst to take a devil's advocate attitude toward both present and proposed methods. Analyzing and improving methods is facilitated by the use of various charts such as flow process charts and worker-machine charts. Flow process charts are used to review and critically examine the overall sequence of an operation by focusing on the movements of the operator or the flow of materials. These charts are helpful in identifying nonproductive parts of the process (e.g., delays, temporary storages, distances traveled).

The uses for flow process charts include studying the flow of material through a department, studying the sequence that documents or forms take, analyzing movement and care of surgical patients, studying layout of department and grocery stores, and handling mail.

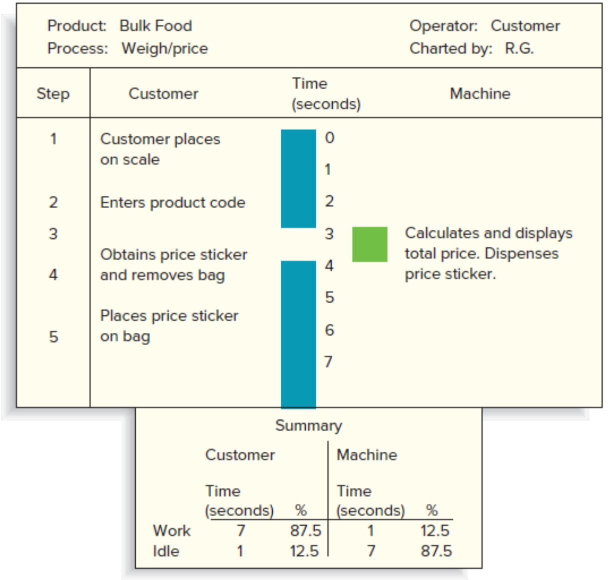


Symbols and actions of a Flow process chart (Source: Stevenson (2018): *Operations management.* McGraw Hill Education. P. 308.



A flow process chart. Source: Stevenson (2018) Operations management, McGraw Hill Education, p.309.

A worker-machine chart is helpful in visualizing the portions of a work cycle during which an operator and equipment are busy or idle. The analyst can easily see when the operator and machine are working independently and when their work overlaps or is interdependent. One use of this type of chart is to determine how many machines or how much equipment the operator can manage.



A worker-machine chart: Stevenson (2018): *Operations management.* McGraw Hill Education. P. 310.

8.4 Measurement

Job design determines the content of a job, and methods analysis determines how a job is to be performed. Work measurement is concerned with determining the length of time it should take to complete the job. Job times are vital inputs for capacity planning, workforce planning, estimating labor costs, scheduling, budgeting, and designing incentive systems. Moreover, from the workers' standpoint, time standards reflect the amount of time it should take to do a given job working under typical conditions. The standards include expected activity time plus allowances for probable delays. A standard time is the amount of time it should take a qualified worker to complete a specified task, working at a sustainable rate, using given methods, tools and equipment, raw material inputs, and workplace arrangement. Whenever a time standard is developed for a job, it is essential to provide a complete description of the parameters of the job because the actual time to do the job is sensitive to all of these factors; changes in any one of the factors can materially affect time requirements. For instance, changes in product design or changes in job performance brought about by a methods study should trigger a new time study to update the standard time. As a practical matter, though, minor changes are occasionally made that do not justify the expense of restudying the job. Consequently, the standards for many jobs may be slightly inaccurate. Periodic time studies may be used to update the standards.

The two most widely used methods to job measurement are stopwatch time studies and applying standard elemental times.

1. Stopwatch time study

Stopwatch time study was first introduced over a hundred years ago by Frederick Winslow Taylor to set times for manufacturing and construction activities. It was met with much resistance from workers, who felt they were being taken advantage of. Nonetheless, over time, this measurement tool gained acceptance, and it is now a common practice to conduct time studies on a wide range of activities in distribution and warehousing, janitorial services, waste management, call centers, hospitals, data processing, retail operations, sales, and service and repair operations. It is especially appropriate for short, repetitive tasks. Stopwatch time study is used to develop a time standard based on observations of one worker taken over a number of cycles. That is then applied to the work of all others in the organization who perform the same task.

The basic steps in a time study are the following:

1. Define the task to be studied, and inform the worker who will be studied.

2. Determine the number of cycles to observe.

3. Time the job and rate the worker's performance.

4. Compute the standard time.

The analyst who studies the job should be thoroughly familiar with it since it is not unusual for workers to attempt to include extra motions during the study in hope of gaining a standard that allows more time per piece (i.e., the worker will be able to work at a slower pace and still meet the standard). Furthermore, the analyst will need to check that the job is being performed efficiently before setting the time standard. In most instances, an analyst will break all but very short jobs down into basic elemental motions (e.g., reach, grasp) and obtain times for each element. There are several reasons for this: One is that some elements are not performed in every cycle, and the breakdown enables the analyst to get a better perspective on them. Another is that the worker's proficiency may not be the same for all elements of the job. A third reason is to build a file of elemental times that can be used to set times for other jobs.

2. Standard elemental times

Standard elemental times are derived from a firm's own historical time study data. Over the years, a time study department can accumulate a file of elemental times that are common to many jobs. After a while, many elemental times can be simply retrieved from the file, eliminating the need for analysts to go through a complete time study to obtain them.

The procedure for using standard elemental times consists of the following steps:

1. Analyze the job to identify the standard elements.

2. Check the file for elements that have historical times, and record them. Use time study to obtain others, if necessary.

3. Modify the file times if necessary (explained as follows).

4. Sum the elemental times to obtain the normal time, and factor in allowances to obtain the standard time.

In some cases, the file times may not pertain exactly to a specific task. For instance, standard elemental times might be on file for "move the tool 3 centimeters" and "move the tool 9 centimeters," when the task in question involves a move of 6 centimeters. However, it is often possible to interpolate between values on file to obtain the desired time estimate. One obvious advantage of this approach is the potential savings in cost and effort created by not having to conduct a complete time study for each job. A second advantage is that there is less disruption of work, again because the analyst does not have to time the worker. A third advantage is that performance ratings do not have to be done; they are generally averaged in the file times. The main disadvantage of this approach is that times may not exist for enough standard elements to make it worthwhile, and the file times may be biased or inaccurate.

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CHAPTER 9.

9.1. The evolution of quality management

Prior to the Industrial Revolution, skilled craftsmen performed all stages of production. Pride of workmanship and reputation often provided the motivation to see that a job was done right. Lengthy guild apprenticeships caused this attitude to carry over to new workers. Moreover, one person or a small group of people were responsible for an entire product.

A division of labor accompanied the Industrial Revolution; each worker was then responsible for only a small portion of each product. Pride of workmanship became less meaningful because workers could no longer identify readily with the final product. The responsibility for quality shifted to the foremen. Inspection was either nonexistent or haphazard, although in some instances 100 percent inspection was used. Frederick Winslow Taylor, the "Father of Scientific Management," gave new emphasis to quality by including product inspection and gauging in his list of fundamental areas of manufacturing management. G. S. Radford improved Taylor's methods. Two of his most significant contributions were the notions of involving quality considerations early in the product design stage and making connections among high quality, increased productivity, and lower costs.

In 1924, Bell Telephone Laboratories introduced statistical control charts that could be used to monitor production. Around 1930, H. F. Dodge and H. G. Romig, also of Bell Labs, introduced tables for sampling. Nevertheless, statistical quality control procedures were not widely used until World War II, when the U.S. government began to require vendors to use them. World War II caused a dramatic increase in emphasis on quality control. The U.S. Army refined sampling techniques for dealing with large shipments of arms from many suppliers. By the end of the 1940s, the U.S. Army, Bell Labs, and major universities were training engineers in other industries in the use of statistical sampling techniques. About the same time, professional quality organizations were emerging throughout the country. One of these organizations was the American Society for Quality Control (ASQC, now known as ASQ).

Over the years, the society has promoted quality with its publications, seminars and conferences, and training programs. During the 1950s, the quality movement evolved into quality assurance. In the mid1950s, total quality control efforts enlarged the realm of quality efforts from its primary focus on manufacturing to include product design and incoming raw materials. One important feature of this work was greater involvement of upper management in quality.

During the 1960s, the concept of "zero defects" gained favor. This approach focused on employee motivation and awareness, and the expectation of perfection from each employee. It evolved from the success of the Martin Company in producing a "perfect" missile for the U.S. Army. In the 1970s, quality assurance methods gained increasing emphasis in services including government operations, health care, banking, and the travel industry. Something else happened in the 1970s that had a global impact on quality. An embargo on oil sales instituted by the Organization of Petroleum Exporting Countries (OPEC) caused an increase in energy costs, and automobile buyers became more interested in fuel-efficient, lower-cost vehicles. Japanese auto producers, who had been improving their products, were poised to take advantage of these changes, and they captured an increased share of the automobile market. The quality of their automobiles enhanced the reputation of Japanese producers, opening the door for a wide array of Japanese-produced goods. American producers, alarmed by their loss of market share, spent much of the late 1970s and the 1980s trying to improve the quality of their goods while lowering their costs. The evolution of quality took a dramatic shift from quality assurance to a strategic approach to quality in the late 1970s. Up until that time, the main emphasis had been on finding and correcting defective products before they reached the market. It was still a reactive approach.

The strategic approach is proactive, focusing on preventing mistakes from occurring in the first place. The idea is to design quality into products, rather than to find and correct defects after the fact.

This approach has now expanded to include processes and services. Quality and profits are more closely linked. This approach also places greater emphasis on customer satisfaction, and it involves all levels of management as well as workers in a continuing effort to increase quality.

9.2 Dimensions of quality

One way to think about quality is the degree to which performance of a product or service meets or exceeds customer expectations. The difference between these two, that is Performance—Expectations, is of great interest. If these two measures are equal, the difference is zero, and expectations have been met. If the difference is negative, expectations have not been met, whereas if the difference is positive, performance has exceeded customer expectations. Customer expectations can be broken down into a number of categories, or dimensions, that customers use to judge the quality of a product or service. Understanding these helps organizations in their efforts to meet or exceed customer expectations. The dimensions used for goods are somewhat different from those used for services.

Product Quality

Product quality is often judged on nine dimensions of quality:

– Performance—main characteristics of the product

– Aesthetics—appearance, feel, smell, taste

– Special features—extra characteristics

– Conformance—how well a product corresponds to design specifications

– Reliability—dependable performance

– Durability—ability to perform over time

– Perceived quality—indirect evaluation of quality (e.g., reputation)

– Serviceability—handling of complaints or repairs

– Consistency—quality doesn’t vary

Notice that price is not a dimension of quality.

Service Quality

The dimensions of product quality don't adequately describe service quality.

Instead, service quality is often described using the following dimensions:

– Convenience—the availability and accessibility of the service

– Reliability—the ability to perform a service dependably, consistently, and accurately

– Responsiveness—the willingness of service providers to help customers in unusual situations and to deal with problems

– Time—the speed with which service is delivered

– Assurance—the knowledge exhibited by personnel who come into contact with a customer and their ability to convey trust and confidence

– Courtesy—the way customers are treated by employees who come into contact with them

– Tangibles—the physical appearance of facilities, equipment, personnel, and communication materials

– Consistency—the ability to provide the same level of good quality repeatedly

– Expectations—meet (or exceed) customer expectations

The dimensions of both product and service quality establish a conceptual framework for thinking about quality, but even they are too abstract to be applied operationally for purposes of product or service design, or actually producing a product or delivering a service. They must be stated in terms of specific, measurable characteristics. For example, when buying a car, a customer would naturally be interested in the car's performance. But what does that mean? In more specific terms, it might refer to a car's estimated miles per gallon, how quickly it can go from 0 to 60 miles per hour, or its stopping distance when traveling at 60 mph. Each of these can be stated in measurable terms (e.g., estimated miles per gallon: city = 25, highway = 30). Similar measurable characteristics can often be identified for each of the other product dimensions, as well as for the service dimensions. This is the sort of detailed information that is needed to both design and produce high-quality goods and services.

It is important for management to recognize the different ways in which the quality of a firm's products or services can affect the organization and to take these into account in developing and maintaining a quality assurance program. Some of the major areas affected by quality are:

1. Loss of business

2. Liability

3. Productivity

4. Costs

Poor designs or defective products or services can result in loss of business. Failure to devote adequate attention to quality can damage a profit-oriented organization's reputation and lead to a decreased share of the market, or it can lead to increased criticism and/or controls for a government agency or nonprofit organization.

On the other hand, business organizations with good or excellent quality typically benefit in a variety of ways:

an enhanced reputation for quality, the ability to command premium prices, an increased market share, greater customer loyalty, lower liability costs, and fewer production or service problems—which yields higher productivity, fewer complaints from customers, lower production costs, and higher profits

9.3 Quality certifications

Quality assurance system standards, including ISO 9001, are defined as frameworks that provide regulations to organisations to ensure that their processes, inputs, products, and services are capable of meeting every customer requirement.

Organisations chiefly seek regulatory standards and frameworks that define specific practices because they help them to achieve many objectives.

The key objectives are:

Ensuring maximum satisfaction of clients by meeting their quality requirements Safety of products and services during usage Complying with international regulations and local legislative rules Being environmentally responsible Confidentiality of stakeholders including customers, employees, partners, and investors Assuring a safer workplace for employees Optimum allocation of resources and minimisation of waste While obtaining the standards for their quality assurance systems is voluntary for organisations, many need to achieve them to establish their credibility and gain confidence of their stakeholders.

The International Organization for Standardization (ISO) promotes worldwide standards for the improvement of quality, productivity, and operating efficiency through a series of standards and guidelines.

Used by industrial and business organizations, regulatory agencies, governments, and trade organizations, the standards have important economic and social benefits.

ISO certification certifies that a management system, manufacturing process, service, or documentation procedure has all the requirements for standardization and quality assurance. ISO (International Organization for Standardization) is an independent, non-governmental, international organization that develops standards to ensure the quality, safety, and efficiency of products, services, and systems.

ISO certifications exist in many areas of industry, from energy management and social responsibility to medical devices and energy management. ISO standards are in place to ensure consistency. Each certification has separate standards and criteria and is classified numerically.

Two of the most well-known of these are ISO 9000 and ISO 14000.

The ISO 9000 family: Set of international standards on quality management and quality assurance, critical to international business

– A systems approach to management

– Continual improvement

– Factual approach to decision making

– Mutually beneficial supplier relationships

– Customer focus

– Leadership

– People involvement

– Process approach

The ISO 14000 family: A set of international standards for assessing a company's environmental performance

– Management systems: Systems development and integration of environmental responsibilities into business planning

– Operations: Consumption of natural resources and energy

– Environmental systems: Measuring, assessing and managing emissions, effluents, and other waste Certification means the organization has met the requirements designated under ISO standards.

For example, ISO 9001 requires organizations to define and follow a quality management system that is both appropriate and effective while also requiring them to identify areas for improvement and take action toward those improvements.

As a result, it's typically understood that an organization claiming ISO 9001 certification is an organization with products and services that meet quality standards.

9.4 Total Quality Management

Total Quality Management (TQM) is a management approach that originated in the 1950s and has steadily become more popular since the early 1980s. Total quality is a description of the culture, attitude and organization of a company that strives to provide customers with products and services that satisfy their needs. The culture requires quality in all aspects of the company's operations, with processes being done right the first time and defects and waste eradicated from operations.

TQM can be summarized as a management system for a customer-focused organization that involves all employees in continual improvement. It uses strategy, data, and effective communications to integrate the quality discipline into the culture and activities of the organization. Many of these concepts are present in modern quality management systems, the successor to TQM. Here are the 8 principles of total quality management:

Customer-focused: The customer ultimately determines the level of quality. No matter what an organization does to foster quality improvement—training employees, integrating quality into the design process, or upgrading computers or software—the customer determines whether the efforts were worthwhile.

Total employee involvement: All employees participate in working toward common goals. Total employee commitment can only be obtained after fear has been driven from the workplace, when empowerment has occurred, and when management has provided the proper environment. High-performance work systems integrate continuous improvement efforts with normal business operations. Self-managed work teams are one form of empowerment.

Process-centered: A fundamental part of TQM is a focus on process thinking. A process is a series of steps that take inputs from suppliers (internal or external) and transforms them into outputs that are delivered to customers (internal or external). The steps required to carry out the process are defined, and performance measures are continuously monitored in order to detect unexpected variation.

Integrated system: Although an organization may consist of many different functional specialties often organized into vertically structured departments, it is the horizontal processes interconnecting these functions that are the focus of TQM.

Micro-processes add up to larger processes, and all processes aggregate into the business processes required for defining and implementing strategy. Everyone must understand the vision, mission, and guiding principles as well as the quality policies, objectives, and critical processes of the organization. Business performance must be monitored and communicated continuously.

Strategic and systematic approach: A critical part of the management of quality is the strategic and systematic approach to achieving an organization's vision, mission, and goals. This process, called strategic planning or strategic management, includes the formulation of a strategic plan that integrates quality as a core component.

Continual improvement: A large aspect of TQM is continual process improvement. Continual improvement drives an organization to be both analytical and creative in finding ways to become more competitive and more effective at meeting stakeholder expectations.

Fact-based decision making: In order to know how well an organization is performing, data on performance measures are necessary. TQM requires that an organization continually collect and analyze data in order to improve decision making accuracy, achieve consensus, and allow prediction based on past history.

Communications: During times of organizational change, as well as part of day-to-day operation, effective communications plays a large part in maintaining morale and in motivating employees at all levels. Communications involve strategies, method, and timeliness.

To be successful implementing TQM, an organization must concentrate on the eight key elements:

– Ethics

– Integrity

– Trust

– Training

– Teamwork

– Leadership

– Recognition

– Communication

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CHAPTER 10.

10.1 The reason to apply quality control

Quality control is a process that measures output relative to a standard and suggests corrective action when output does not meet standards. If the results are acceptable, no further action is required; unacceptable results call for corrective action. Every process generates output that exhibits random variability. Quality control tools are used to decide when corrective action is needed.

Quality assurance that relies primarily on inspection of lots (batches) of previously produced items is referred to as acceptance sampling. It is described in the chapter supplement. Quality control efforts that occur during production are referred to as statistical process control, and these we examine in the following sections. The best companies emphasize designing quality into the process, thereby greatly reducing the need for inspection or control efforts. As you might expect, different business organizations are in different stages of this evolutionary process: Some rely heavily on inspection. However, inspection alone is generally not sufficient to achieve a reasonable level of quality.

Quality assurance vs. quality control

- Revolves around manufacturing.
- It is proactive: it deals with all activity associated with building a product.
- Its role is to ensure that the production protocol is going according to plan.
- It is a safeguard against production error
- Occurs before any quality control takes place.

- Focuses on the product.
- It is reactive, identifying errors and figuring out how to best remedy them before the product goes to market.
- Can involve inspection, testing, reviewing, and analysis.
- Quality control specifics are determined by the product’s unique features and functions.
- Usually performed by a quality control inspector or a designated team.

In order to implement an effective Quality Control (QC) program, an enterprise must first decide which specific standards the product or service must meet. Then the extent of QC actions must be determined -- for example, the percentage of units to be tested from each lot.

Next, real-world data must be collected -- such as the percentage of units that fail -- and the results reported to management personnel. After this, corrective action must be decided upon and taken. For example, defective units must be repaired or rejected, and poor service repeated at no charge until the customer is satisfied. If too many unit failures or instances of poor service occur, a plan must be devised to improve the production or service process; then that plan must be put into action.

Finally, the QC process must be ongoing to ensure that remedial efforts, if required, have produced satisfactory results and to immediately detect recurrences or new instances of trouble.

10.2. Inspection

Inspection is an appraisal activity that compares goods or services to a standard. Inspection is a vital but often unappreciated aspect of quality control. Although for well-designed processes little inspection is necessary, inspection cannot be completely eliminated. And with increased outsourcing of products and services, inspection has taken on a new level of significance. In lean organizations, inspection is less of an issue than it is for other organizations because lean organizations place extra emphasis on quality in the design of both products and processes. Moreover, in lean operations, workers have responsibility for quality (quality at the source). However, many organizations do not operate in a lean mode, so inspection is important for them. This is particularly true of service operations, where quality continues to be a challenge for management. Inspection can occur at three points: before production, during production, and after production. The logic of checking conformance before production is to make sure that inputs are acceptable. The logic of checking conformance during production is to make sure that the conversion of inputs into outputs is proceeding in an acceptable manner. The logic of checking conformance of output is to make a final verification of conformance before passing goods on to customers. Inspection before and after production often involves acceptance sampling procedures; monitoring during the production process is referred to as process control. Figure 10.2 gives an overview of where these two procedures are applied in the production process. To determine whether a process is functioning as intended or to verify that a batch or lot of raw materials or final products does not contain more than a specified percentage of defective goods, it is necessary to physically examine at least some of the items in question. The purpose of inspection is to provide information on the degree to which items conform to a standard.

The basic issues are:

1. How much to inspect and how often

2. At what points in the process inspection should occur

3. Whether to inspect in a centralized or on-site location

4. Whether to inspect attributes (i.e., count the number of times something occurs) or variables

(i.e., measure the value of a characteristic)

The amount of inspection can range from no inspection whatsoever to inspection of each item numerous times. Low-cost, high-volume items such as paper clips, roofing nails, and wooden pencils often require little inspection because (1) the cost associated with passing defective items is quite low and (2) the processes that produce these items are usually highly reliable, so defects are rare. Conversely, high-cost, low-volume items that have large costs associated with passing defective products often require more intensive inspections.

Thus, critical components of a manned-flight space vehicle are closely scrutinized because of the risk to human safety and the high cost of mission failure. In high-volume systems, automated inspection is one option that may be employed. The majority of quality control applications lie somewhere between the two extremes. Most require some inspection, but it is neither possible nor economically feasible to critically examine every part of a product or every aspect of a service for control purposes. The cost of inspection, resulting interruptions of a process or delays caused by inspection, and the manner of testing typically outweigh the benefits of 100 percent inspection. The frequency of inspection depends largely on the rate at which a process may go out of control or on the number of lots being inspected. A stable process will require only infrequent checks, whereas an unstable one or one that has recently given trouble will require more frequent checks. Likewise, many small lots will require more samples than a few large lots because it is important to obtain sample data from each lot. For high-volume, repetitive operations, computerized automatic inspections at critical points in a process are cost effective.

Many operations have numerous possible inspection points. Because each inspection adds to the cost of the product or service, it is important to restrict inspection efforts to the points where they can do the most good.

In manufacturing, some of the typical inspection points are:

1. Raw materials and purchased parts. There is little sense in paying for goods that do not meet quality standards and in expending time and effort on material that is bad to begin with. Supplier certification programs can reduce or eliminate the need for inspection.

2. Finished products. Customer satisfaction and the firm's image are at stake here, and repairing or replacing products in the field is usually much more costly than doing it at the factory. Likewise, the seller is usually responsible for shipping costs on returns, and payments for goods or service may be held up pending delivery of satisfactory goods or remedial service. Well-designed processes, products and services, quality at the source, and process monitoring can reduce or eliminate the need for inspection.

3. Before a costly operation. The point is to not waste costly labor or machine time on items that are already defective.

4. Before an irreversible process. In many cases, items can be reworked up to a certain point; beyond that point they cannot. For example, pottery can be reworked prior to firing. After that, defective pottery must be discarded or sold as seconds at a lower price.

5. Before a covering process. Painting, plating, and assemblies often mask defects.

10.3 Statistical process control

Quality control is concerned with the quality of conformance of a process: Does the output of a process conform to the intent of design?

Variations in characteristics of process output provide the rationale for process control. Statistical process control (SPC) is used to evaluate process output to decide if a process is “in control” or if corrective action is needed. The natural or inherent process variations in process output are referred to as chance or random variations. Such variations are due to the combined influences of countless minor factors, each one so unimportant that even if it could be eliminated, the impact on process variations would be negligible. In Deming’s terms, this is referred to as common variability.

The amount of inherent variability differs from process to process. For instance, older machines generally exhibit a higher degree of natural variability than newer machines, partly because of worn parts and partly because new machines may incorporate design improvements that lessen the variability in their output. A second kind of variability in process output is called assignable variation, or nonrandom variation. In Deming’s terms, this is referred to as special variation.

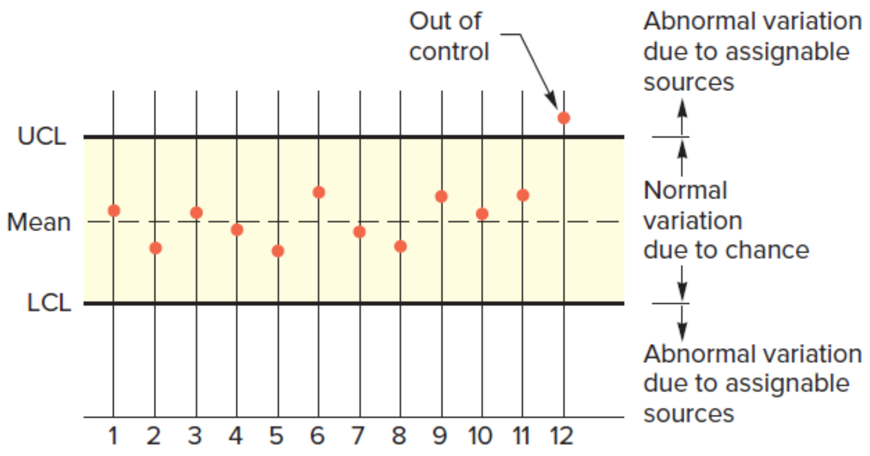
Random variations	Nonrandom variations
Occur for phenomena constantly active within the system	New, unanticipated, emergent or previously neglected phenomena within the system
Predictable probabilistically	Variation inherently unpredictable, even probabilistically
Irregular variation within a historical experience base	Variation outside the historical experience base
Occur due to the combined influences of countless minor factors	Evidence of some inherent change in the system or our knowledge of it
the main sources of random variation is hard to be identified and eliminated	The main sources of unrandom variation can usually be identified (assigned to a specific cause) and eliminated
In Deming’s terms, this is referred to as common variability.	In Deming’s terms, this is referred to as special variability.

Unlike natural variation, the main sources of assignable variation can usually be identified (assigned to a specific cause) and eliminated. Tool wear, equipment that needs adjustment, defective materials, human factors (carelessness, fatigue, noise and other distractions, failure to follow correct procedures, and so on) and problems with measuring devices are typical sources of assignable variation.

In statistical process control, periodic samples of process output are taken and sample statistics, such as sample means or the number of occurrences of a certain type of outcome, are determined. The sample statistics can be used to judge randomness of process variations. The sample statistics exhibit variation, just as processes do. The variability of sample statistics can be described by its sampling distribution, a theoretical distribution that describes the random variability of sample statistics. For a variety of reasons, the most frequently used distribution is the normal distribution.

An important tool in statistical process control is the control chart, which was developed by Walter Shewhart. A control chart is a time-ordered plot of sample statistics. It is used to distinguish between random variability and nonrandom variability. It has upper and lower limits, called control limits, that define the range of acceptable (i.e., random) variation for the sample statistic. The basis for the control chart is the sampling distribution, which essentially describes random variability.

There is, however, one minor difficulty relating to the use of a normal sampling distribution. The theoretical distribution extends in either direction to infinity. Therefore, any value is theoretically possible, even one that is a considerable distance from the mean of the distribution.



Source: Stevenson (2018) Operations management, McGraw Hill Education, p. 426

Sampling and corrective action are only a part of the control process. Effective control requires the following steps:

1. Define. The first step is to define in sufficient detail what is to be controlled. It is not enough, for example, to simply refer to a painted surface. The paint can have a number of important characteristics such as its thickness, hardness, and resistance to fading or chipping. Different characteristics may require different approaches for control purposes.

2. Measure. Only those characteristics that can be counted or measured are candidates for control. Thus, it is important to consider how measurement will be accomplished.

3. Compare. There must be a standard of comparison that can be used to evaluate the measurements. This will relate to the level of quality being sought.

4. Evaluate. Management must establish a definition of out of control. Even a process that is functioning as it should will not yield output that conforms exactly to a standard, simply because of the natural (i.e., random) variations inherent in all processes, manual or mechanical—a certain amount of variation is inevitable. The main task of quality control is to distinguish random from nonrandom variability, because nonrandom variability means that a process is out of control.

5. Correct. When a process is judged to be out of control, corrective action must be taken. This involves uncovering the cause of nonrandom variability (e.g., worn equipment, incorrect methods, failure to follow specified procedures) and correcting it.

6. Monitor results. To ensure that corrective action is effective, the output of a process must be monitored for a sufficient period of time to verify that the problem has been eliminated.

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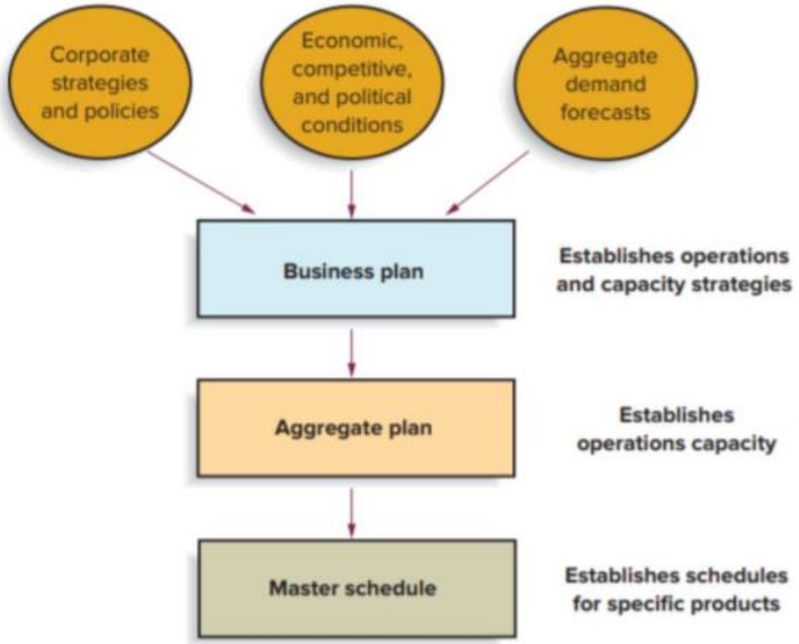
CHAPTER 11.

11.1 Understanding aggregate planning

Aggregate planning is intermediate-range capacity planning that typically covers a time horizon of 2 to 12 months, although in some companies it may extend to as much as 18 months. It is particularly useful for organizations that experience seasonal or other fluctuations in demand or capacity. The goal of aggregate planning is to achieve a production plan that will effectively utilize the organization's resources to match expected demand. Planners must make decisions on output rates, employment levels and changes, inventory levels and changes, back orders, and subcontracting in or out. They do this for products that are grouped (i.e., aggregated) into categories rather than for individual products.



The place of aggregate planning in the planning sequence. Source: Stevenson (2018): *Operations Management.* McGraw Hill Education. P. 465.

Aggregate planning is essentially a "big-picture" approach to planning. Planners usually try to avoid focusing on individual products or services—unless the organization has only one major product or service. Instead, they focus on a group of similar products or services, or sometimes an entire product or service line. For example, planners in a company producing high-definition television sets would not concern themselves with 40-inch sets versus 46-inch or 55-inch sets. Instead, planners would lump all models together and deal with them as though they were a single product, hence the term aggregate planning.

Effective aggregate planning requires good information. First, the available resources over the planning period must be known. Then, a forecast of expected demand must be available. Finally, planners must take into account any policies regarding changes in employment levels (e.g., some organizations view layoffs as extremely undesirable, so they would use that only as a last resort).

The most common inputs to aggregate planning are:

- Resources
    - Workforce
    - Facilities
- Demand forecast
- Policies
    - Subcontracting
    - Overtime
    - Inventory levels
    - Back orders

– Costs

  – Inventory carrying

  – Back orders

  – Hiring/firing

  – Overtime

  – Inventory changes

  – subcontracting

While the most common outputs include:

– Total cost of a plan

– Projected levels of inventory

  – Inventory

  – Output

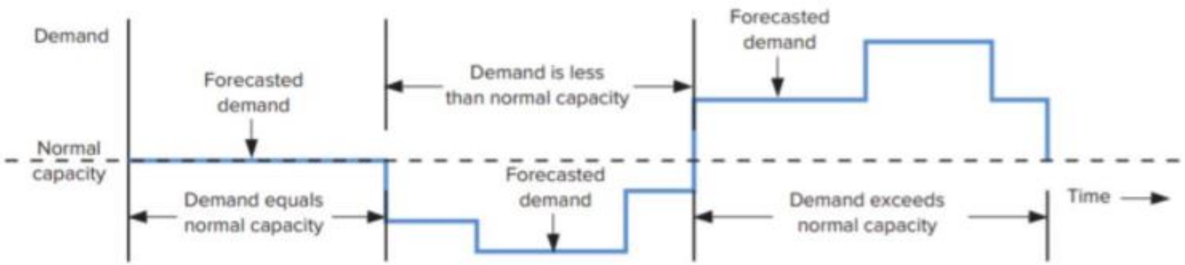
  – Employment

  – Subcontracting

  – Backordering

Seasonal variations in demand are quite common in many industries - such as air-conditioning, fuel, public utilities, police and fire protection, and travel.

Generally, organizations cannot predict exactly the quantity and timing of demands for specific products or services months in advance under these conditions. Even so, they typically must assess their capacity needs (e.g., labor, inventories) and costs months in advance in order to be able to handle demand.



Uneven demand. Source: Stevenson (2018): *Operations Management.* McGraw Hill Education. P. 472.

11.2 Basic strategies for meeting uneven demand

Managers have a wide range of decision options they can consider for achieving a balance of demand and capacity in aggregate planning. Since the options that are most suited to influencing demand fall more in the realm of marketing than in operations (with the exception of backlogging), we shall concentrate on the capacity options, which are in the realm of operations but include the use of back orders. Aggregate planners might adopt a number of strategies.

Some of the more prominent ones are the following:

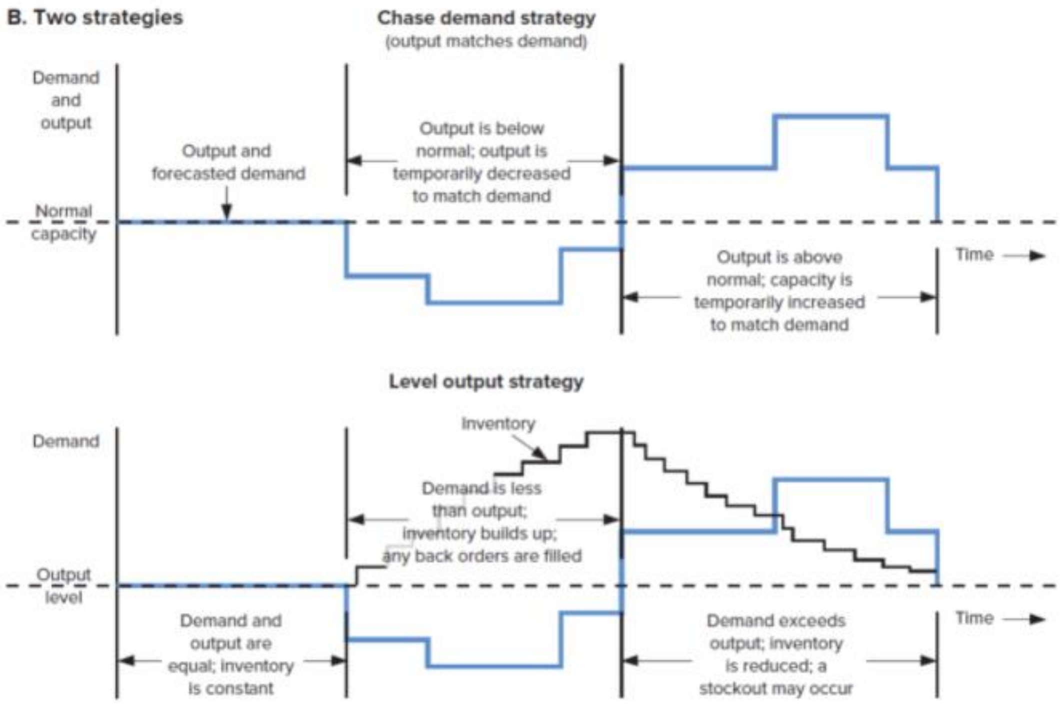
1. Maintain a level workforce (level capacity)

2. Maintain a steady output rate (level capacity)

3. Match demand period by period (chase demand)

4. Use a combination of decision variables

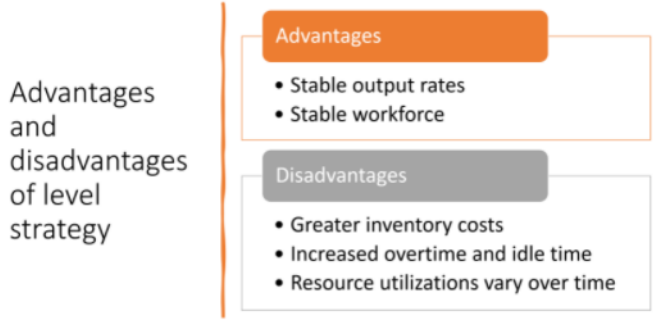
While other strategies might be considered, these will suffice to give you a sense of how aggregate planning operates in a vast number of organizations. The first three strategies are “pure” strategies because each has a single focal point; the last strategy is “mixed” because it lacks the single focus. Under a level capacity strategy, variations in demand are met by using some combination of inventories, overtime, part-time workers, subcontracting, and back orders while maintaining a steady rate of output. Matching capacity to demand implies a chase demand strategy; the planned output for any period would be equal to expected demand for that period.



Demand strategies. Source: Stevenson (2018): *Operations Management.* McGraw Hill Education. P. 472.

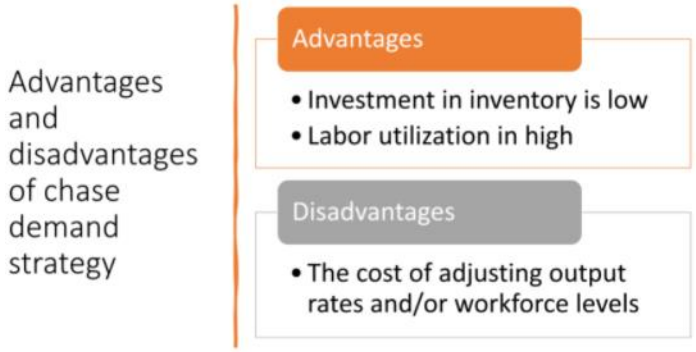
The purpose of the level capacity or level output strategy is maintaining a steady rate of regular-time output while meeting variations in demand by a combination of options. These include inventories, overtime, part-time workers, subcontracting, and back orders while maintaining a steady rate of output. The focus is on the process where product output remains at a somewhat fixed level and increases/decreases in demand are satisfied through strategic decisions of utilizing inventory (maintain buffer stock), outsourcing and backorders.

When demand is less than capacity, output continues at normal capacity, and the excess output is put into inventory in anticipation of the time when demand exceeds capacity. When demand exceeds capacity, inventory is used to offset the shortfall in output.



On the other hand, the purpose of a chase demand strategy is maintaining a steady rate of regulartime output while meeting variations in demand by a combination of options. Workforce levels are adjusted through the process of hiring, firing or lay off of production employees to produce output levels to match demand requirements. In situations of high demand variability, necessitating fluctuating schedules, output levels vary as the workforce changes in response to demand

When normal capacity would exceed demand, capacity is cut back to match demand. Then, when demand exceeds normal capacity, the chase approach is to temporarily increase capacity to match demand.



CHAPTER 12.

12.1 An overview of MRP

Material requirements planning (MRP) is a methodology used for planning the production of assembled products such as smartphones, automobiles, kitchen tables, and a whole host of other products that are assembled. Some items are produced repetitively while others are produced in batches. The process begins with a master schedule. The master schedule designates the quantity and completion time of an assembled product, often referred to as the end item. Materials requirements planning then generates a production plan for the end item that indicates the quantities and timing of the subassemblies, component parts, and raw materials required for assembly of that end item. MRP is designed to answer three questions: What is needed? How much is needed? and When is it needed? The primary inputs of MRP are a bill of materials, which tells the composition of a finished product; a master schedule, which tells how much finished product is desired and when; and an inventory records file, which tells how much inventory is on hand or on order. The planner processes this information to determine the net requirements for each period of the planning horizon. Outputs from the process include planned-order schedules, order releases, changes, performance- control reports, planning reports, and exception reports.

The main features of an MRP system are:

– A master production schedule: A statement of the planning including orders, forecasts and capacity.

– Bill of materials (BOM): All the materials and components required to make the final product.

– Inventory status file: Stock records that allow gross requirements to be adjusted to net requirements.

While there are many advantages of applying an MRP system within the organization, some of the most important benefits include:

– plays a crucial part in decreasing factory inventory

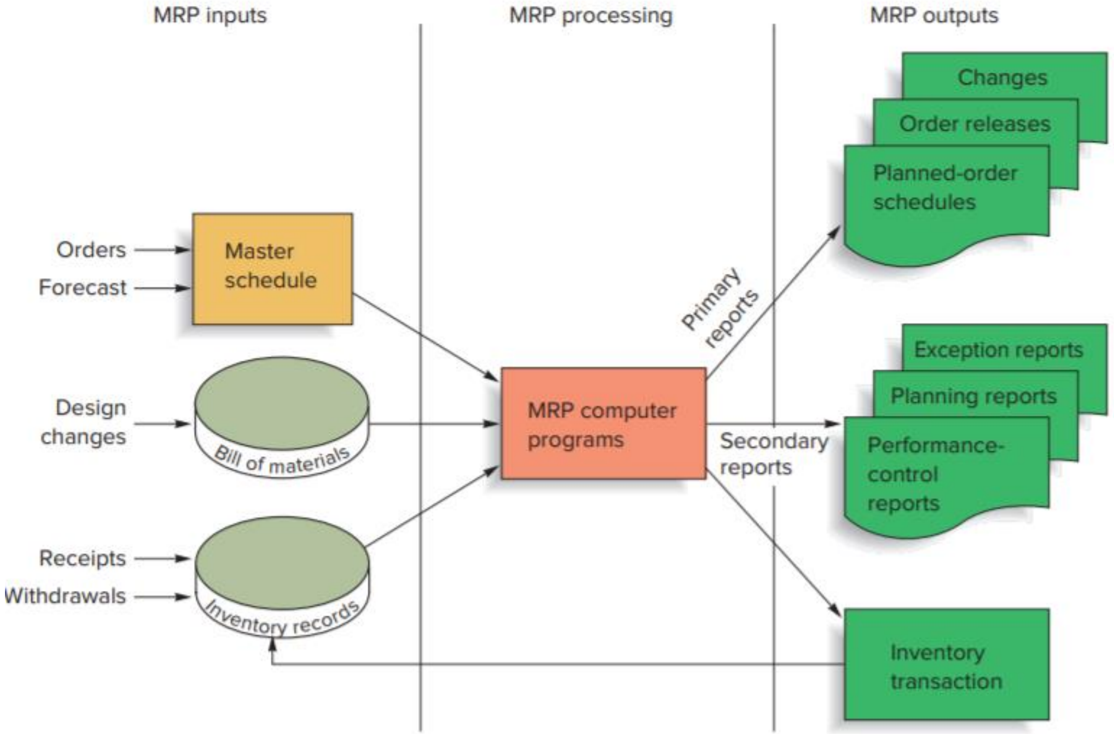
– Assists in manufacturing industrial products that are more complex

– Focuses on what materials are required and when they need to be sourced. Therefore, it is helpful in product customisation

– Tracks every order whether for production or purchase

12.2 MRP inputs and processes

A material requirements plan indicates quantity and timing details needed to achieve the master schedule



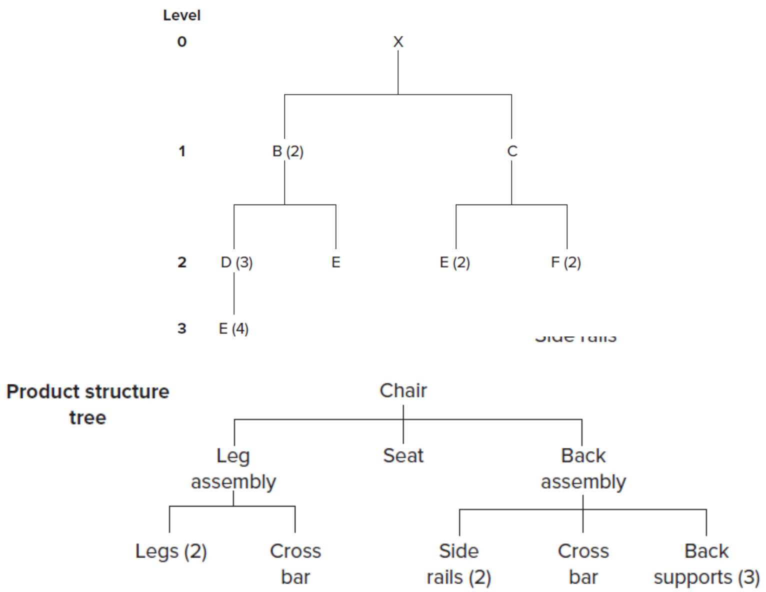
Source: Stevenson (2018): *Operations management.* McGraw Hill Education. P. 502.

A bill of materials (BOM) contains a listing of all of the assemblies, subassemblies, parts, part costs, and raw materials that are needed to produce one unit of a finished product. Thus, each finished product has its own bill of materials. The listing in the bill of materials is hierarchical; it shows the quantity of each item needed to complete one unit of its parent item. The nature of this aspect of a bill of materials is clear when you consider a product structure tree, which provides a visual depiction of the subassemblies and components needed to assemble a product. A product structure tree is useful in illustrating how the bill of materials is used to determine the quantities of each of the ingredients (requirements) needed to obtain a desired number of end items. Items at the lowest levels of a tree often are raw materials or purchased parts, while items at higher levels are typically assemblies or subassemblies. Product-structure trees for items at the lowest levels are the concerns of suppliers.

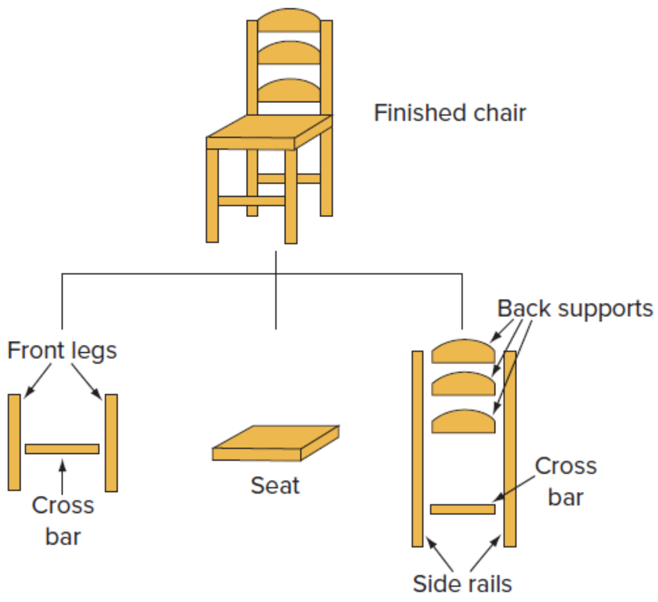
Bill of Materials

Level		Quantity
0	Chair	1
1	Leg assembly	1
2	Legs	2
2	Cross bar	1
1	Seat	1
1	Back assemby	1
2	Side rails	2
2	Cross bar	1
2	Back supports	3

BOM of a chair. Source: Stevenson (2018): *Operations management.* McGraw Hill Education. P. 504.



Product structure diagram of a chair. Source: Stevenson (2018): *Operations management.* McGraw Hill Education. P. 504.



Assembly diagram of a chair. Source: Stevenson (2018): *Operations management.* McGraw Hill Education. P. 504.

Inventory records refer to stored information on the status of each item by time period, called time buckets. This includes quantities on hand quantities ordered. It also includes other details for each item, such as supplier, lead time, and lot size policy. Changes due to stock receipts and withdrawals, canceled orders, and similar events also are recorded in this file. Like the bill of materials, inventory records must be accurate. Erroneous information on requirements or lead times can have a detrimental impact on MRP and create turmoil when incorrect quantities are on hand or expected delivery times are not met.

MRP systems have the ability to provide management with a fairly broad range of outputs.

These are often classified as primary reports, which are the main reports, and secondary reports, which are optional outputs.

Primary Reports.

Production and inventory planning and control are part of primary reports.

These reports normally include the following:

1. Planned orders, a schedule indicating the amount and timing of future orders.

2. Order releases, authorizing the execution of planned orders.

3. Changes to planned orders, including revisions of due dates or order quantities and cancellations of orders.

Secondary Reports.

Performance control, planning, and exceptions belong to secondary reports.

1. Performance-control reports evaluate system operation. They aid managers by measuring deviations from plans, including missed deliveries and stockouts, and by providing information that can be used to assess cost performance.

2. Planning reports are useful in forecasting future inventory requirements. They include purchase commitments and other data that can be used to assess future material requirements.

3. Exception reports call attention to major discrepancies such as late and overdue orders, excessive scrap rates, reporting errors, and requirements for nonexistent parts.

The wide range of outputs generally permits users to tailor MRP to their particular needs.

12.3 ERP

In a successful company, production, distribution, sales, human resources, finance, and accounting must work together to achieve the goals of the organization. However, in the functional structure used by many business organizations, information flows freely within each function, but not so between functions. That makes information sharing among functional areas burdensome. Enterprise resource planning (ERP) is a computerized system designed to connect all parts of a business organization as well as key portions of its supply chain to a single database for the purpose of information sharing.

SAP and PeopleSoft are major vendors, although there are many others. ERP software provides a system to capture and make data available in real time to decision makers and other users throughout an organization. It also provides a set of tools for planning and monitoring various business processes to achieve the goals of the organization. ERP systems are composed of a collection of integrated modules. There are many modules to choose from, and different software vendors offer different but similar lists of modules. Some are industry specific, and others are general purpose. The modules relate to the functional areas of business organizations. For example, there are modules for accounting and finance, HR, product planning, purchasing, inventory management, distribution, order tracking, finance, accounting, and marketing. Organizations can select the modules that best serve their needs and budgets.

The overview of some ERP system modules.

Module	Brief Description
Accounting/Finance	A central component of most ERP systems. It provides a range of financial reports, including general ledger, accounts payable, accounts receivable, payroll, income statements, and balance sheets.
Marketing	Supports lead generation, target marketing, direct mail, and sales.
Human Resources	Maintains a complete database of employee information such as date of hire, salary, contact information, performance evaluations, and other pertinent information.
Purchasing	Facilitates vendor selection, price negotiation, making purchasing decisions, and bill payment.
Production Planning	Integrates information on forecasts, orders, production capacity, on-hand inventory quantities, bills of material, work in process, schedules, and production lead times.
Inventory Management	Identifies inventory requirements, inventory availability, replenishment rules, and inventory tracking.
Distribution	Contains information on third-party shippers, shipping and delivery schedules, delivery tracking.
Sales	Information on orders, invoices, order tracking, and shipping.
Supply Chain Management	Facilitates supplier and customer management, supply chain visibility, and event management.
Customer Relationship Management	Contact information, buying behavior, shipping preferences, contracts, payment terms, and credit history.

Source: Stevenson (2018): *Operations management*. McGraw Hill Education. P. 522.

ERP automates the tasks involved in performing a business process—such as order fulfillment, which involves taking an order from a customer, shipping it, and billing for it. With ERP, when a customer service representative takes an order from a customer he or she has all the information necessary to complete the order (the customer's credit rating and order history, the company's inventory levels and the shipping dock's trucking schedule). Everyone else in the company sees the same computer screen and has access to the single database that holds the customer's new order. When one department finishes with the order it is automatically routed via the ERP system to the next department. To find out where the order is at any point, one need only log into the ERP system and track it down. With luck, the order process moves like a bolt of lightning through the organization, and customers get their orders faster and with fewer mistakes than before. ERP can apply that same magic to the other major business processes, such as employee benefits or financial reporting.

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CHAPTER 13.

13.1 The nature and importance of inventories

An inventory is a stock or store of goods. Firms typically stock hundreds or even thousands of items in inventory, ranging from small things such as pencils, paper clips, screws, nuts, and bolts to large items such as machines, trucks, construction equipment, and airplanes. Naturally, many of the items a firm carries in inventory relate to the kind of business it engages in. Thus, manufacturing firms carry supplies of raw materials, purchased parts, partially finished items, and finished goods, as well as spare parts for machines, tools, and other supplies. Department stores carry clothing, furniture, carpeting, stationery, cosmetics, gifts, cards, and toys. Some also stock sporting goods, paints, and tools. Hospitals stock drugs, surgical supplies, life-monitoring equipment, sheets and pillow cases, and more. Supermarkets stock fresh and canned foods, packaged and frozen foods, household supplies, magazines, baked goods, dairy products, produce, and other items. Inventories are a vital part of business. Not only are they necessary for operations, but they also contribute to customer satisfaction.

Inventory decisions in service organizations can be especially critical. Hospitals, for example, carry an array of drugs and blood supplies that might be needed on short notice. Being out of stock on some of these could imperil the well-being of a patient. However, many of these items have a limited shelf life, so carrying large quantities would mean having to dispose of unused, costly supplies.

The different kinds of inventories include the following:

– Raw materials and purchased parts.

– Partially completed goods, called work-in-process (WIP).

– Finished-goods inventories (manufacturing firms) or merchandise (retail stores).

– Tools and supplies.

– Maintenance and repairs (MRO) inventory.

– Goods-in-transit to warehouses, distributors, or customers (pipeline inventory).

Both manufacturing and service organizations have to take into consideration the space requirements of inventory. In some cases, space limitations may pose restrictions on inventory storage capability, thereby adding another dimension to inventory decisions. Inventories serve a number of functions. Among the most important are the following.

1. To meet anticipated customer demand. A customer can be a person who walks in off the street to buy a new stereo system, a mechanic who requests a tool at a tool crib, or a manufacturing operation. These inventories are referred to as anticipation stocks because they are held to satisfy expected (i.e., average) demand.

2. To smooth production requirements. Firms that experience seasonal patterns in demand often build up inventories during preseason periods to meet overly high requirements during seasonal periods. These inventories are aptly named seasonal inventories. Companies that process fresh fruits and vegetables deal with seasonal inventories. So do stores that sell greeting cards, skis, snowmobiles, or Christmas trees.

3. To decouple operations. Historically, manufacturing firms have used inventories as buffers between successive operations to maintain continuity of production that would otherwise be disrupted by events such as breakdowns of equipment and accidents that cause a portion of the operation to shut down temporarily. The buffers permit other operations to continue temporarily while the problem is resolved. Similarly, firms have used buffers of raw materials to insulate production from disruptions in deliveries from suppliers, and finished goods inventory to buffer sales operations from manufacturing disruptions.

4. To reduce the risk of stockouts. Delayed deliveries and unexpected increases in demand increase the risk of shortages. Delays can occur because of weather conditions, supplier stockouts, deliveries of wrong materials, quality problems, and so on. The risk of shortages can be reduced by holding safety stocks, which are stocks in excess of expected demand to compensate for variabilities in demand and lead time.

5. To take advantage of order cycles. To minimize purchasing and inventory costs, a firm often buys in quantities that exceed immediate requirements. This necessitates storing some or all of the purchased amount for later use. Similarly, it is usually economical to produce in large rather than small quantities. Again, the excess output must be stored for later use. Thus, inventory storage enables a firm to buy and produce in economic lot sizes without having to try to match purchases or production with demand requirements in the short run. This results in periodic orders or order cycles.

6. To hedge against price increases. Occasionally a firm will suspect that a substantial price increase is about to occur and purchase larger-than-normal amounts to beat the increase.

7. To permit operations. The fact that production operations take a certain amount of time (i.e., they are not instantaneous) means that there will generally be some work-in-process inventory. In addition, intermediate stocking of goods—including raw materials, semifinished items, and finished goods at production sites, as well as goods stored in warehouses—leads to pipeline inventories throughout a production-distribution system.

8. To take advantage of quantity discounts. Suppliers may give discounts on large orders.

13.2 Requirements for effective inventory management

Management has two basic functions concerning inventory. One is to establish a system to keep track of items in inventory, and the other is to make decisions about how much and when to order.

To be effective, management must have the following:

1. A system to keep track of the inventory on hand and on order.

2. A reliable forecast of demand that includes an indication of possible forecast error.

3. Knowledge of lead times and lead time variability.

4. Reasonable estimates of inventory holding costs, ordering costs, and shortage costs.

5. A classification system for inventory items.

Inventory counting systems can be periodic or perpetual. Under a periodic system, a physical count of items in inventory is made at periodic, fixed intervals (e.g., weekly, monthly) in order to decide how much to order of each item. A perpetual inventory system (also known as a continuous review system) keeps track of removals from inventory on a continuous basis, so the system can provide information on the current level of inventory for each item. When the amount on hand reaches a predetermined minimum, a fixed quantity, Q, is ordered. An obvious advantage of this system is the control provided by the continuous monitoring of inventory withdrawals. Another advantage is the fixed-order quantity; management can determine an optimal order quantity. One disadvantage of this approach is the added cost of record keeping.

Inventories are used to satisfy demand requirements, so it is essential to have reliable estimates of the amount and timing of demand. Similarly, it is essential to know how long it will take for orders to be delivered. In addition, managers need to know the extent to which demand and lead time (the time between submitting an order and receiving it) might vary; the greater the potential variability, the greater the need for additional stock to reduce the risk of a shortage between deliveries. Thus, there is a crucial link between forecasting and inventory management. Four basic costs are associated with inventories: purchase, holding, ordering, and shortage costs.

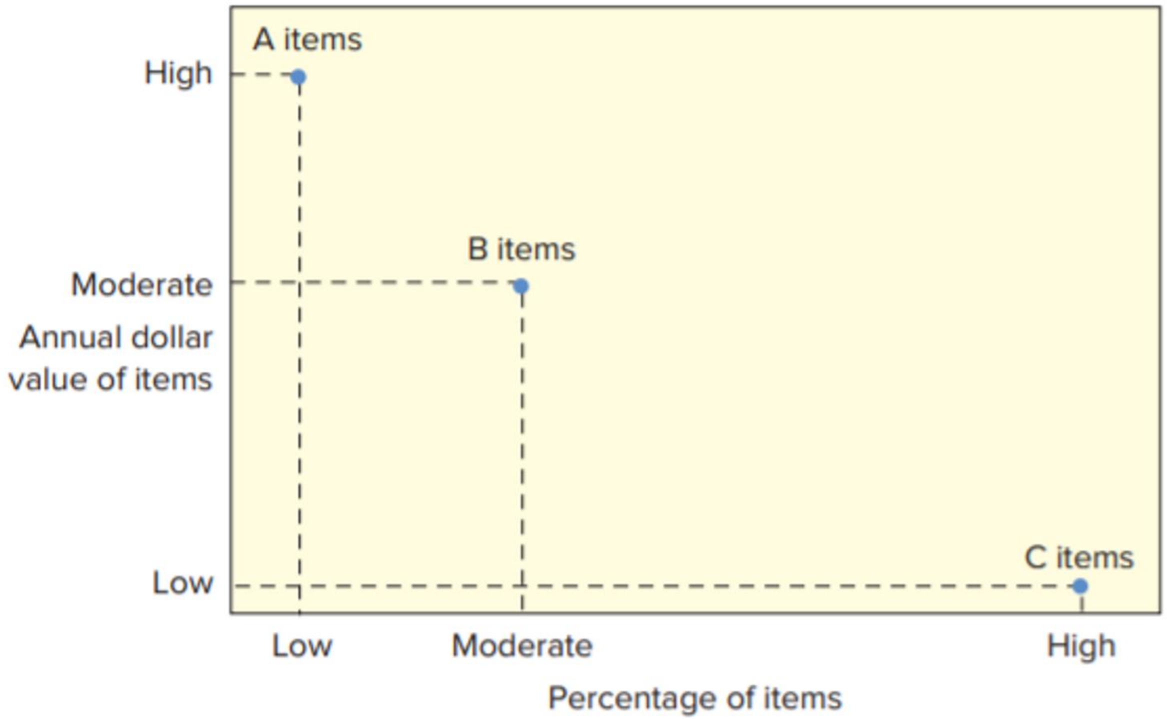
1. Purchase cost is the amount paid to a vendor or supplier to buy the inventory. It is typically the largest of all inventory costs.

2. Holding, or carrying, costs relate to physically having items in storage. Costs include interest, insurance, taxes (in some states), depreciation, obsolescence, deterioration, spoilage, pilferage, breakage, tracking, picking, and warehousing costs (heat, light, rent, workers, equipment, security).

3. Ordering costs are the costs of ordering and receiving inventory. They are the costs that occur with the actual placement of an order. They include determining how much is needed, preparing invoices, inspecting goods upon arrival for quality and quantity, and moving the goods to temporary storage. Ordering costs are generally expressed as a fixed dollar amount per order, regardless of order size.

4. Shortage costs result when demand exceeds the supply of inventory on hand. These costs can include the opportunity cost of not making a sale, loss of customer goodwill, late charges, backorder costs, and similar costs. An important aspect of inventory management is that items held in inventory are not of equal importance in terms of dollars invested, profit potential, sales or usage volume, or stockout penalties. Therefore, it would be unrealistic to devote equal attention to each of these items. Instead, a more reasonable approach would be to allocate control efforts according to the relative importance of various items in inventory.

The A-B-C approach classifies inventory items according to some measure of importance, usually annual dollar value (i.e., dollar value per unit multiplied by annual usage rate), and then allocates control efforts accordingly. Typically, three classes of items are used: A (very important), B (moderately important), and C (least important). However, the actual number of categories may vary from organization to organization, depending on the extent to which a firm wants to differentiate control efforts. With three classes of items, A items generally only account for about 10 to 20 percent of the number of items in inventory but about 60 to 70 percent of the annual dollar value. At the other end of the scale, C items might account for about 50 to 60 percent of the number of items but only about 10 to 15 percent of the dollar value of an inventory. These percentages vary from firm to firm, but in most instances a relatively small number of items will account for a large share of the value or cost associated with an inventory, and these items should receive a relatively greater share of control efforts. For instance, A items should receive close attention through frequent reviews of amounts on hand and control over withdrawals, where possible, to make sure that customer service levels are attained. The C items should receive only loose control (two-bin system, bulk orders), and the B items should have controls that lie between the two extremes.



Source: Stevenson (2018): *Operations management.* McGraw Hill Education. p. 559.

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