Before studying this chapter you should know or, if necessary, review

1. Differences between manufacturing and service organizations, Chapter 1, pp. 4–6.
2. Differences between strategic and tactical decisions, Chapter 1, pp. 6–8.
3. Competitive priorities, Chapter 2, pp. 28–33.

LEARNING OBJECTIVES

After completing this chapter you should be able to

1. Define product design and explain its strategic impact on the organization.
2. Describe the steps used to develop a product design.
3. Use break-even analysis as a tool in deciding between alternative products.
4. Identify different types of production processes and explain their characteristics.
5. Describe the steps used in process design and selection.
6. Understand how to use a process flowchart.
7. Understand current technological advancements and how they impact process design.
8. Understand issues of designing service operations.

CHAPTER OUTLINE

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In this chapter we will learn about **product design**, which is the process of deciding on the unique characteristics and features of the company’s product. We will also learn about **process selection**, which is the development of the process necessary to produce the designed product. Product design and process selection decisions are typically made together. Pizza Hut’s stuffed-crust pizza dictated a certain design of the manufacturing process. The product design team had to ask questions like “Can we do it?” “How will we do it?” “How much longer will it take?” “Do we need special cheese, a different temperature setting, a special oven?” “How much will it cost?” Similarly, when Spagio was designing their wood-grilled pizza or Donato’s their crispy-thin pizza, they too were thinking about the special techniques and equipment they would need to make their product. This step—process selection—is necessary to realize the product design. A company can have a highly innovative design for its product, but if it has not figured out how to make the product cost effectively, the product will stay a design forever.

Product design and process selection affect product quality, product cost, and customer satisfaction. If the product is not well designed or if the manufacturing process is not true to the product design, the quality of the product may suffer. Further, the product has to be manufactured using materials, equipment, and labor skills that are efficient and affordable; otherwise, its cost will be too high for the market. We call this the product’s manufacturability—the ease with which the product can be made. Finally, if a product is to achieve customer satisfaction, it must have the combined characteristics of good design, competitive pricing, and the ability to fill a market need. This is true whether the product is pizzas or cars.

**PRODUCT DESIGN**

Most of us might think that the design of a product is not that interesting. After all, it probably involves materials, measurements, dimensions, and blueprints. When we think of design we usually think of car design or computer design and envision engineers working on diagrams. However product design is much more than that. Product
design brings together marketing analysts, art directors, sales forecasters, engineers, finance experts, and other members of a company to think and plan strategically. It is exciting and creative, and it can spell success or disaster for a company.

Product design is the process of defining all the features and characteristics of just about anything you can think of, from Starbucks’s cafe latte or Jimmy Dean’s sausage to GM’s Saturn or HP’s DeskJet printer. Product design also includes the design of services, such as those provided by Salazar’s Beauty Salon, La-Petite Academy Day Care Center, or Federal Express. Consumers respond to a product’s appearance, color, texture, performance. All of its features, summed up, are the product’s design. Someone came up with the idea of what this product will look like, taste like, or feel like so that it will appeal to you. This is the purpose of product design. Product design defines a product’s characteristics, such as its appearance, the materials it is made of, its dimensions and tolerances, and its performance standards.

**Tangible versus Intangible Products**

The design elements just discussed are typical of industries such as manufacturing and retail in which the product is tangible. For the service industries, in which the product is intangible, the design elements are equally important, but they have an added dimension.

Service design is different from product design in that we are designing both the service and the entire service concept. As with a tangible product, the service concept is based on meeting customer needs. The service design, however, adds to this the aesthetic and psychological benefits of the product. These are the service elements of the operation, such as promptness and friendliness. They also include the ambiance, image, and “feel-good” elements of the service. Consider the differences in service design of a company like Canyon Ranch, which provides a pampering retreat for health conscious but overworked professionals, versus Gold’s Gym, which caters to young athletes. As with a tangible product, the preference for a service is based on its product design. Service design defines the characteristics of a service, such as its physical elements, and the aesthetic and psychological benefits it provides.

**Strategic Importance of Product Design**

Product design is strategically important to a company. We learned in Chapter 2 that every business needs a long-range plan or vision, called a business strategy. A company’s business strategy maps out its business, customers, and competitors. The activities a company engages in and the decisions a company makes must support this business strategy. A company’s product designs must also support the company’s business strategy.

Suppose you are a software engineer at a startup software company. Your company’s product is database management software geared to large clients with substantial banks of data. Now there is talk about changing directions and making a “lite” version of the product for smaller clients with much less data. This could be a danger signal for your company. Why? The answer is that a company’s products define the company’s customers. Together, a company’s products and customers define the company’s image, competition, future growth, and position in the marketplace. For these reasons, product design is a major factor in a company’s ability to keep and build its customer base. Every company targets a particular customer group. Think about retailers like The Gap, which caters to a young, modern clientele versus Talbots, which caters to a slightly older and more conservative clientele. What would happen if Talbot’s...
The Gap started sharing the same concept in clothes design? They certainly would not meet the needs of their customer group and so might risk losing their market position.

To summarize: a company’s product design must match the needs and preferences of the customer group targeted by the company’s business strategy. Otherwise, the company will lose its customer base and erode its market position.

**Steps in Product Design**

Certain steps are common in the development of most product designs. They are the following:

**Step 1 Idea Development.**
All product designs begin with an idea. Someone thinks of a need and a product design that would satisfy it.

**Step 2 Product Screening.**
Once an idea is developed, it needs to be evaluated. Often a business comes up with numerous product ideas. At this stage we need to screen the ideas and decide which ones have the greatest chance of succeeding.

**Step 3 Preliminary Design and Testing.**
This is the stage where preliminary design of the product is made and market testing and prototype analysis are performed.

**Step 4 Final Design.**
This is the last stage, where the final design of the product is made.
Next we look at these steps in a little more detail.

**Idea Development**

All product designs begin with an idea. The idea might come from a product manager who spends time with customers and has a sense of what customers want, from an engineer with a flare for inventions, or from anyone else in the company. To remain competitive, companies must be innovative and bring out new products regularly. In some industries, the cycle of new product development is predictable. We see this in the auto industry, where new car models come out every year, or the retail industry, where new fashion is designed for every season.

In other industries, new product releases are less predictable but just as important. The Body Shop, retailer of plant-based skin care products, periodically comes up with new ideas for their product lines. The timing often has to do with the market for a product, and whether sales are declining or continuing to grow.

**Ideas from Customers and Competitors** The first source of ideas are customers, the driving force in the design of products and services. Marketing is a vital link between customers and product design. Market researchers collect customer information by studying customer buying patterns and using tools such as customer surveys and focus groups. Management may love an idea, but if market analysis shows that customers do not like it, the idea is not viable. Analyzing customer preferences is an ongoing process. Customer preferences next year may be quite different from what they are today. For this reason, the related process of forecasting future consumer preferences is important, though difficult.

Competitors are another source of ideas. A company learns by observing its competitors’ products and services and the success rate of these products and services.
This includes looking at product design, pricing strategy, and other aspects of the operation. Studying the practices of companies considered “best in class” and comparing the performance of our company against theirs is called **benchmarking**. We can benchmark against a company in a completely different line of business and still learn from some aspect of that company’s operation. For example, Lands’ End is well known for its successful catalog business, and companies considering catalog sales often benchmark against Lands’ End. Similarly, American Express is a company known for its success at resolving complaints and it too is used for benchmarking.

The importance of benchmarking can be seen by the efforts taken by IBM to improve its distribution system. In 1997 IBM found its distribution costs increasing, while customers were expecting decreasing cycle times from factory to delivery. It appeared that IBM’s supply chain practices were not keeping up with those of its competitors. To evaluate and solve this problem IBM hired Mercer Management Consultants, who performed a large benchmarking study. IBM’s practices were compared to those of market leaders in the PC industry, as well as to the best logistics practices outside the technology area. The objective was to evaluate IBM’s current performance, that of companies considered best-in-class, and identify the gaps. Through the study, IBM discovered which specific costs exceeded industry benchmarks and which parts of the cycle time were excessively long. It also uncovered ways to simplify and reorganize its processes to gain efficiency. Based on findings from the benchmarking effort, IBM made changes in its operations. The results were reduced costs, improved delivery, and improved relationships with suppliers. IBM found benchmarking so beneficial that it plans to perform similar types of studies on an ongoing basis in the future.

**Reverse Engineering** Another way of using competitors’ ideas is to buy a competitor’s new product and study its design features. Using a process called **reverse engineering**, a company’s engineers carefully disassemble the product and analyze its parts and features. This approach was used by the Ford Motor Company to design its Taurus model. Ford engineers disassembled and studied many other car models, such as BMW and Toyota, and adapted and combined their best features. Product design ideas are also generated by a company’s R & D department, whose role is to develop product and process innovation. Other sources of ideas are suppliers, the company’s employees, and new technological developments.

**Product Screening**

After a product idea has been developed it needs to be evaluated to determine its likelihood of success. This is called **product screening**. The company’s product screening team evaluates the product design idea according to the needs of the major business functions. In their evaluation, executives from each functional area may explore issues such as the following:

♦ **Operations** What are the production needs of the proposed new product and how do they match our existing resources? Will we need new facilities and equipment? Do we have the labor skills to make the product? Can the material for production be readily obtained?
Marketing  What is the potential size of the market for the proposed new product? How much effort will be needed to develop a market for the product and what is the long-term product potential?

Finance  The production of a new product is a financial investment like any other. What is the proposed new product’s financial potential, cost, and return on investment?

Unfortunately, there is no magic formula for deciding whether or not to pursue a particular product idea. Managerial skill and experience, however, are key. Companies generate new product ideas all the time, whether for a new brand of cereal or a new design for a car door. Approximately 80% of ideas do not make it past the screening stage. Management analyzes operations, marketing, and financial factors, and then makes the final decision. Fortunately, we have decision-making tools to help us evaluate new product ideas. A popular one is break-even analysis, which we will look at next.

Break-Even Analysis: A Tool for Product Screening  Break-even analysis is a technique that can be useful when evaluating a new product. This technique computes the quantity of goods a company needs to sell just to cover its costs, or break even, called the “break-even” point. When evaluating an idea for a new product it is helpful to compute its break-even quantity. An assessment can then be made as to how difficult or easy it will be to cover costs and make a profit. A product with a break-even quantity that is hard to attain might not be a good product choice to pursue. Next we look at how to compute the break-even quantity.

The total cost of producing a product or service is the sum of its fixed and variable costs. A company incurs fixed costs regardless of how much it produces. Fixed costs include overhead, taxes, and insurance. For example, a company must pay for overhead even if it produces nothing. Variable costs, on the other hand, are costs that vary directly with the amount of units produced, and include items such as materials and labor. Together, fixed and variable costs add up to total cost:

\[ \text{Total cost} = \text{fixed cost} + \text{variable cost} \]

Using symbols, we have the following equation:

\[ \text{Total cost} = F + (VC) Q \]

where  
\[ F = \text{fixed cost} \]
\[ VC = \text{variable cost per unit} \]
\[ Q = \text{number of units sold} \]

Figure 3-1 shows a graphical representation of these costs as well as the break-even quantity. The quantity produced is shown on the horizontal axis and dollars are shown on the vertical axis. Fixed cost is represented by a horizontal line and is the same regardless of how much is produced. The diagonal line above fixed cost is total cost, which is the sum of fixed and variable costs. When \( Q = 0 \), total cost is only equal to fixed cost. As \( Q \) increases, total cost increases through the variable cost component. The blue diagonal in the figure is revenue. Revenue is the amount of money brought in from sales:

\[ \text{Revenue} = (SP) Q \]

where \( SP = \text{selling price per unit} \).
When \( Q = 0 \), revenue is zero. As sales increase, so does revenue. Remember, however, that to cover all costs we have to sell the break-even amount. This is the quantity \( Q_{BE} \), where revenue equals total cost. If we sell below the break-even point we will incur a loss, since costs exceed revenue. To make a profit, we have to sell above the break-even point. Since revenue equals total cost at the break-even point, we can use the above equations to compute the value of the break-even quantity:

\[
\text{Total cost} = \text{total revenue} \\
F + (VC) Q = (SP) Q
\]

Algebraically solving for \( Q \), we get the following equation:

\[
Q_{BE} = \frac{F}{SP - VC}
\]

Note that we could also find the break-even point by drawing the graph and finding where the total cost and revenue lines cross.

**Example 3.1 Computing the Break-Even Quantity**

Fred Boulder, owner of Sports Feet Manufacturing, is considering whether to produce a new line of footwear. Fred has considered both the processing needs for the new product as well as the market potential. He has also estimated that the variable cost for each product manufactured and sold is $9 and the fixed cost per year is $52,000.

(a) If Fred offers the footwear at a selling price of $25, how many pairs must he sell to break even?

(b) If Fred sells 4000 pairs at the $25 price, what will be his contribution to profit?

**Solution**

(a) To compute the break-even quantity:

\[
Q = \frac{F}{SP - VC}
\]

\[
= \frac{$52,000}{25 - 9} = 3250 \text{ pairs}
\]
Break-even analysis is an excellent tool for more than simply deciding between different products. It can be used to make many other decisions, such as evaluating different processes or deciding whether it is better to make or buy a product.

Preliminary Design and Testing

Once a product idea has passed the screening stage, it is time to begin preliminary design and testing. At this stage, design engineers translate general performance specifications into technical specifications. Prototypes are built and tested. Changes are made based on test results and the process of revising, rebuilding a prototype, and testing continues. For service companies this may entail testing the offering on a small scale and working with customers to refine the service offering. Fast-food restaurants are known for this type of testing, where a new menu item may be tested in only one particular geographic area. Product refinement can be time consuming and there may be a desire on the part of the company to hurry through this phase to rush the product to market. However, rushing creates the risk that all the “bugs” have not been worked out, which can prove very costly.

Final Design

Following extensive design testing the product moves to the final design stage. This is where final product specifications are drawn up. The final specifications are then translated into specific processing instructions to manufacture the product, which include selecting equipment, outlining jobs that need to be performed, identifying specific materials needed and suppliers that will be used, and all the other aspects of organizing the process of product production.

FACTORS TO CONSIDER IN PRODUCT DESIGN

Here are some additional factors that need to be considered during the product design stage.

Design for Manufacture

When we think of product design we generally first think of how to please the customer. However, we also need to consider how easy or difficult it is to manufacture...
FACTORS TO CONSIDER IN PRODUCT DESIGN

Table 3-1 Guidelines for DFM

DFM guidelines include the following:

1. Minimize parts.
2. Design parts for different products.
3. Use modular design.
4. Avoid tools.
5. Simplify operations.

An example of the benefits of applying these rules is seen in Figure 3-2. We can see the progression in the design of a toolbox using the DFM approach. All of the pictures show a toolbox. However, the first design shown requires 20 parts. Through simplification and use of modular design the number of parts required has been reduced to 2. It would certainly be much easier to make the product with 2 parts versus 20 parts. This means fewer chances for error, better quality, and lower costs due to shorter assembly.

Product Life Cycle

Another factor in product design is the stage of the life cycle of the product. Most products go through a series of stages of changing product demand called the

Design for manufacture (DFM)
A series of guidelines to follow in order to produce a product easily and profitably.
Concurrent engineering is an approach that brings many people together in the early phase of product design in order to simultaneously design the product and the process. This type of approach has been found to achieve a smooth transition from the design stage to actual production in a shorter amount of development time with improved quality results.

The old approach to product and process design was to first have the designers of the idea come up with the exact product characteristics. Once their design was complete they would pass it on to operations who would then design the production
process needed to produce the product. This was called the “over-the-wall” approach, because the designers would throw their design “over-the-wall” to operations who then had to decide how to produce the product.

There are many problems with the old approach. First, it is very inefficient and costly. For example, there may be certain aspects of the product that are not critical for product success but are costly or difficult to manufacture, such as a dye color that is difficult to achieve. Since manufacturing does not understand which features are not critical, it may develop an unnecessarily costly production process with costs passed down to the customers. Because the designers do not know the cost of the added feature, they may not have the opportunity to change their design or may do so much later in the process, incurring additional costs. Concurrent engineering allows everyone to work together so these problems do not occur. Figure 3-4 shows the difference between the “over-the-wall” approach and concurrent engineering.

A second problem is that the “over-the-wall” approach takes a longer amount of time than when product and process design work together. As you can see in Figure 3.4, when product and process design work together much of the work is done in parallel rather than in sequence. In today’s markets, new product introductions are expected to occur faster than ever. Companies do not have the luxury of enough time to follow a sequential approach and then work the “bugs” out. They may eventually get a great product, but by then the market may not be there!

The third problem is that the old approach does not create a team atmosphere, which is important in today’s work environment. Rather, it creates an atmosphere where each function views its role separately in a type of “us versus them” mentality. With the old approach, when the designers were finished with the designs, they considered their job done. If there were problems, each group blamed the other. With concurrent engineering, the team is responsible for designing and getting the product to market. Team members continue working together to resolve problems with the product and improve the process.

---

**Figure 3-4**

The first illustration shows sequential design with walls between functional areas. The second illustration shows concurrent design with walls broken down.
Remanufacturing

Remanufacturing is a concept that has been gaining increasing importance, as our society becomes more environmentally conscious and focuses on efforts such as recycling and eliminating waste. Remanufacturing uses components of old products in the production of new ones. In addition to the environmental benefits, there are significant cost benefits because remanufactured products can be half the price of their new counterparts. Remanufacturing has been quite popular in the production of computers, televisions, and automobiles.

PROCESS SELECTION

So far we have discussed issues involved in product design. Though product design is very important for a company, it cannot be done separately from the selection of the process. In this section we will look at issues involved in process design. Then we will see how product design and process selection issues are related.

Types of Processes

When you look at different types of companies, ranging from a small coffee shop to IBM, it may seem like there are hundreds of different types of processes. Some are small, like your local Starbucks’, and some are very large, like a Ford Motor Company plant. Some produce standardized “off-the-shelf” products, like Pepperidge Farm’s frozen chocolate cake, and some work with customers to customize their product, like a gourmet bakery that makes cakes to order. Though there seem to be large differences between the processes of companies, many companies have certain processing characteristics in common. In this section we will divide these processes into groups with similar characteristics, allowing us to understand problems inherent with each type of process.

All processes can be grouped into two broad categories: intermittent operations and continuous operations. These two categories differ in almost every way. Once we understand these differences we can easily identify organizations based on the category of process they use.

Intermittent Operations

Intermittent operations are used to produce many different products with varying processing requirements in lower volumes. Examples are an auto body shop, a tool and dye shop, or a health-care facility. Because different products have different processing needs, there is no standard route that all products take through the facility. Instead, resources are grouped by function and the product is routed to each resource as needed. Think about a health-care facility. Each patient, “the product,” is routed to different departments as needed. One patient may need to get an x-ray, go to the lab for blood work, and then go to the examining room. Another patient may need to go to the examining room and then to physical therapy.

To be able to produce products with different processing requirements, intermittent operations tend to be labor intensive rather than capital intensive. Workers need to be able to perform different tasks depending on the processing needs of the products produced. Often we see skilled and semiskilled workers in this environment with a fair amount of worker discretion in performing their jobs. Workers need to be flexible and able to perform different tasks as needed for the different products that are being produced. Equipment in this type of environment is more general purpose...
to satisfy different processing requirements. Automation tends to be less common, because automation is typically product specific. Given that many products are being produced with different processing requirements, it is usually not cost efficient to invest in automation for only one product type. Finally, the volume of goods produced is directly tied to the number of customer orders.

**Continuous Operations** Continuous operations are used to produce one or a few standardized products in high volume. Examples are a typical assembly line, cafeteria, or automatic car wash. Resources are organized in a line flow to efficiently accommodate production of the product. Note that in this environment it is possible to arrange resources in a line because there is only one type of product. This is directly the opposite of what we find with intermittent operations.

To efficiently produce a large volume of one type of product these operations tend to be capital intensive rather than labor intensive. An example is “mass production” operations, which usually have much invested in their facilities and equipment to provide a high degree of product consistency. Often these facilities rely on automation and technology to improve efficiency and increase output rather than on labor skill. The volume produced is usually based on a forecast of future demands rather than on direct customer orders.

The most common differences between intermittent and continuous operations relate to two dimensions: (1) the amount of product volume produced, and (2) the degree of product standardization. Product volume can range from making a single unique product one at a time to producing a large number of products at the same time. Product standardization refers to a lack of variety in a particular product. Examples of standardized products are Fruit-of-the-Loom white undershirts, calculators, toasters, and television sets. The type of operation used, including equipment and labor, is quite different if a company produces one product at a time to customer specifications instead of mass production of one standardized product. Specific differences between intermittent and continuous operations are shown in Table 3-2.

**The Continuum of Process Types** Dividing processes into two fundamental categories of operations is helpful in our understanding of their general characteristics. To be more detailed, we can further divide each category according to product volume and degree of product standardization as follows. Intermittent operations can be di-
Continuous operations can be divided into project processes and batch processes. Continuous operations can be divided into line processes and continuous processes. Figure 3-5 shows a continuum of process types. Next we look at what makes these processes different from each other.

- **Project processes** are used to make one-at-a-time products exactly to customer specifications. These processes are used when there is high customization and low product volume, because each product is different. Examples can be seen in construction, shipbuilding, medical procedures, creation of artwork, custom tailoring, and interior design. With project processes the customer is usually involved in deciding on the design of the product. The artistic baker you hired to bake a wedding cake to your specifications uses a project process.

- **Batch processes** are used to produce small quantities of products in groups or batches based on customer orders or specifications. The volumes of each product produced are still small and there can still be a high degree of customization. Examples can be seen in bakeries, education, and printing shops. The classes you are taking at the university use a batch process.

- **Line processes** are designed to produce a large volume of a standardized product for mass production. With line processes the product that is produced is made in high volume with little or no customization. Think of a typical assembly line that produces everything from cars, computers, television sets, shoes, candy bars, even food items.

- **Continuous processes** operate continually to produce a very high volume of a fully standardized product. Examples include oil refineries, water treatment plants, and certain paint facilities. The products produced by continuous processes are usually in continual rather than discrete units, such as liquid or gas. Also, these facilities are usually highly capital intensive and automated.

Note that both project and batch processes have low product volumes and offer customization. The difference is in the volume and degree of customization. Project processes are more extreme cases of intermittent operations compared to batch processes. Also, note that both line and continuous processes primarily produce large quantities of products.
volumes of standardized products. Again, the difference is in the volume and degree of standardization. Continuous processes are more extreme cases of high volume and product standardization than are line processes.

Figure 3-5 positions these four process types along the diagonal to show the best process strategies relative to product volume and product customization. Companies whose process strategies do not fall along this diagonal may not have made the best process decisions. Bear in mind, however, that not all companies fit into only one of these categories: a company may use both batch and project processing to good advantage. For example, a bakery that produces breads, cakes, and pastries in batch may also bake and decorate cakes to order.

**Process Decisions**

**Vertical Integration** A major strategic decision involving process selection relates to the amount of vertical integration of the company. **Vertical integration** refers to the segments in the chain from acquisition of raw materials to final delivery of finished products that the company owns. Some companies are highly vertically integrated, and own their own raw material facilities, manufacturing plants, and fleets of trucks for delivery to customers. An example is Dole Pineapple, which owns and controls most of the canned pineapple production from pineapple farms to the processing plant. Other companies choose the opposite strategy, and use outside suppliers of materials and subassemblies and distributors of their products.

There are two types of vertical integration strategies. One is called **backward integration**, where a company owns or acquires sources of supply, raw materials, or subassemblies. **Forward integration**, on the other hand, is integration in the opposite
direction, where a company owns facilities closer to the customer, such as distribution channels, warehouses, and retail locations. Both of these strategies have their advantages and disadvantages. Both have the advantage of control over the quality, consistency, and delivery of raw materials and finished products. A disadvantage, however, can be cost. Often it can be much cheaper to use outside suppliers and third parties to perform certain tasks, like distribution and delivery, because these outside companies already have the resources, equipment, and “know-how” needed to perform these tasks.

Make-or-Buy Decisions An important decision that relates to vertical integration is the make-or-buy decision. Make or buy is a type of backward integration decision, where the company decides whether to purchase certain materials or tasks or perform the operations itself. Often this is called outsourcing. Many companies routinely outsource certain services, such as janitorial services, repair, security, payroll, or records management.

Outsourcing has been a big trend for companies over the past few years. The key for a company is to outsource activities that are not considered critical to its business strategy. Having someone else perform noncritical tasks allows a company to give more focus to its strategic decisions. For example, the trend in the auto industry has been to outsource many of the functions historically performed inside, such as quality control of incoming materials or package design. Outsourcing allows the automakers to focus more on product and process design, which are much more critical to their success. The importance of outsourcing is evidenced by the growth of companies that perform many noncritical tasks for other firms. For example, Grainger Industrial Supply is a company that performs purchasing and inventory control of noncritical items for companies such as American Airlines and Procter & Gamble, which frees up these companies to focus on what they do best.

Many factors must be considered in the make-or-buy decision. They include the following:

1. **Strategic impact.** Probably the most important factor in the make-or-buy decision is the strategic impact of outsourcing certain tasks. Once tasks are outsourced, a company usually has much less control over them. Customers may not be as satisfied with the product. Also, outsourcing certain tasks now makes it more difficult to bring them back at a later date due to cost and loss of expertise. Companies need to identify functions that are critical and non-critical to their success, as identified through the company’s business strategy. Critical functions that have strategic impact should not be outsourced. Noncritical functions, on the other hand, should be outsourced whenever possible in order to free up the company to focus on its main tasks.

2. **Available capacity.** A factor in favor of making products in-house is available capacity. Capacity refers to the output capability of a facility, such as the number of products it can produce over a period of time. If a company has available capacity, as well as skills and equipment required, it is often a good business decision to produce the items in-house.

3. **Expertise.** When considering outsourcing, a company should evaluate whether it has the expertise necessary to perform a job or the costs necessary to acquire the expertise. In many cases it is more efficient to hire somebody else who is proficient in performing certain tasks. For example, many companies will hire outside advertising firms for large promotions and advertising campaigns.
4. **Quality considerations.** As we saw in Chapter 2, quality is an important competitive priority and needs to be given consideration when making the make-or-buy decision. By making products in-house the firm has more control over quality. However, if special expertise is required the company may not be able to achieve the level of quality available from an outside expert. In that case it may be better to outsource.

5. **Speed.** Specialized suppliers can often provide parts more quickly than the manufacturer can produce. This is especially important for products that have fluctuating or unpredictable demands. Suppliers can also be more flexible in accommodating rapid design changes.

6. **Cost.** The last factor to consider is the cost of manufacturing the item in-house versus buying it from the outside. However, cost should not be the most important factor and needs to be balanced with the other factors discussed. A more expensive alternative that is strategically sound can prove to be a far better alternative in the long run.

### Designing Processes

**Process Flow Analysis**  
Process flow analysis is a tool for evaluating an operation in terms of the sequence of steps from inputs to outputs with the goal of improving its design. One of the most important tools in process flow analysis is a process flowchart. A process flowchart is used for viewing the flow of the processes involved in producing the product. It is a very useful tool for seeing the totality of the operation and for identifying potential problem areas. There is no exact format for designing the chart. The flowchart can be very simple or very detailed. Figure 3-6 shows a flowchart for Antonio’s Take-Out Pizza Shop that includes the steps involved in placing and processing a customer order. The points in the process for potential problems are indicated. Management can then take care to monitor these problem areas. The chart could be even more detailed, including information such as frequency of errors or approximate time to complete a task.

Another way of using a process flowchart is to overlay it on a facility layout to visually represent movement through the physical plant or store, as shown in Figure 3-7 for Antonio’s Take-Out Pizza Shop. Arrows indicate the direction of movement, with blue arrows indicating movement of the customer and red arrows indicating movement of the product, from order placement to delivery. The chart allows Antonio to analyze the flow. If one of the problem areas is experiencing difficulty, such as long wait for the order, Antonio can look at the layout to see whether there are ways to correct that, such as with an additional oven and workstation.

**Process Reengineering**  
Reengineering means redesigning the company’s processes. Reengineering is a drastic measure of analyzing the company’s processes and redeveloping them from scratch. The process requires teamwork from many areas of the company and good communication. Hard questions need to be asked and old ways of doing things questioned. Reengineering is usually applied to the core processes of a company, such as filling customer orders. Reengineering can produce dramatic improvements in quality, cost, and customer service. Many companies such as Bell Atlantic and Kodak have been able to achieve large benefits through reengineering. However, it does not always work. Reengineering is a radical measure that focuses on drastic changes rather than incremental changes. It usually means layoffs or shifts in job duties and a very different way of doing things for the company’s employees. Reengineering is usually applied as a last resort for companies that are either in trouble or foresee trouble in the future. When other measures for a company have failed, reengineering may be the last resort.
Make sure that you understand the key issues in product design. Be familiar with the different stages of the product life cycle. Recall that products in the early stages of the life cycle are still being refined based on the needs of the market. This includes product characteristics and features. At this stage the market for the product has not yet been fully developed and product volumes have not reached their peak. By contrast, products in the later stages of their life cycle have well-developed characteristics and demand volumes are fairly stable.

Review the different types of processes and their characteristics. Recall that intermittent processes are designed to produce products with different processing requirements in smaller volumes. Continuous operations, on the other hand, are designed for one or a few types of products produced in high volumes.

Next we discuss how product design and process selection decisions are interrelated.
Decisions of product design and process selection are directly linked and cannot be made independently of one another. The type of product a company produces defines the type of operation needed. The type of operation needed, in turn, defines many other aspects of the organization. This includes how a company competes in the marketplace (competitive priorities), the type or equipment and its arrangement in the facility, the type of organizational structure, and future types of products that can be produced by the facility. Table 3-3 summarizes some key decisions and how they differ for intermittent and continuous types of operations. Next we look at each of these decision areas.

**Product Design Decisions**

Intermittent and continuous operations typically focus on producing products in different stages of the product life cycle. Intermittent operations focus on products in the early stage of the life cycle because facilities are general purpose and can be adapted to the needs of the product. As products in the early stage of the life cycle are still being refined, intermittent operations are ideally suited for these types of products. Also, demand volumes for these products are still uncertain and intermittent operations are designed to focus on producing lower volumes of products with differing characteristics.

**Table 3-3 Differences in Key Organizational Decisions for Different Types of Operations**

<table>
<thead>
<tr>
<th>Decision</th>
<th>Intermittent Operations</th>
<th>Continuous Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product design</td>
<td>Early stage of product life cycle</td>
<td>Later stage of product life cycle</td>
</tr>
<tr>
<td>Competitive priorities</td>
<td>Delivery, flexibility, and quality</td>
<td>Cost and quality</td>
</tr>
<tr>
<td>Facility layout</td>
<td>Resources grouped by function</td>
<td>Resources arranged in a line</td>
</tr>
<tr>
<td>Vertical integration</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>
Once a product reaches the later stages of the life cycle both its product features and its demand volume are predictable. As volumes are typically larger at this stage, a facility that is dedicated to producing a large volume of one type of product is best from both efficiency and cost perspectives. This is what a continuous operations provides. Recall that continuous operations are capital intensive with much automation dedicated to the efficient production of one type of product. It would not be a good decision to invest such a large amount of resources for a product that is uncertain relative to its features or market. However, once a product is well defined with a sizable market, continuous types of operations are a better business alternative. This is why continuous operations tend to focus on products in the later stages of their life cycle.

The product focus of both types of operations has significant implications for a company’s future product choices. Once a company has an intermittent operation in place, designed to produce a variety of products in low volumes, it is a poor strategic decision to pursue production of a highly standardized product in the same facility. The same holds true for attempting to produce a newly introduced product in a continuous operation.

The differences between the two types operations are great, including the way they are managed. Not understanding the differences between the two types of operations and the products they are designed to produce is a mistake often made by companies. A company may be very successful at managing a continuous operation that produce a standardized product. Management may then see an opportunity involving products in the early stage of the life cycle. Not understanding the differences in the operational requirements, management may decide to produce this new product by applying their “know-how.” The results can prove disastrous.

The problems that can arise when a company does not understand the differences between intermittent and continuous operations are illustrated by the experience of the Babcock & Wilcox Company in the late 1960s. B & W was very successful at producing fossil fuel boilers, a standardized product made via a continuous operation. Then the company decided to pursue production of nuclear pressure vessels, a new product in the early stages of its life cycle requiring an intermittent operation. B & W saw the nuclear pressure vessels as a wave of the future. Because they were successful at producing boilers, they believed they could apply those same skills to production of the new product. Unfortunately, B & W failed miserably and almost went out of business at that time.

**Competitive Priorities**

The decision of how a company will compete in the marketplace—its competitive priorities—is largely affected by the type of operation it has in place. Intermittent operations are typically less competitive on cost than continuous operations. The reason is that continuous operations mass produce a large volume of one product. The cost of the product is spread over a large volume, allowing the company to offer that product at a comparatively lower price.
Think about the cost difference you would incur if you decided to buy a business suit “off the rack” from your local department store (produced by a continuous operation) versus having it custom made by a tailor (an intermittent operation). Certainly a custom-made suit would cost considerably more. The same product produced by a continuous operation typically costs less than one made by an intermittent operation. However, intermittent operations have their own advantages. Having a custom-made suit allows you to choose precisely what you want in style, color, texture, and fit. Also, if you were not satisfied you could easily return it for adjustments and alterations. Intermittent operations compete more on flexibility and delivery compared to continuous operations.

Today all organizations understand the importance of quality. However, the elements of quality that a company focuses on may be different depending on the type of operation used. Continuous operations provide greater consistency between products. The first and last products made in the day are almost identical. Intermittent operations, on the other hand, offer greater variety of features and workmanship not available with mass production.

It is important that companies understand the competitive priorities best suited for the type of process that they use. It would not be a good strategic decision for an intermittent operation to try to compete primarily on cost, as it would not be very successful. Similarly, the primary competitive priority for a continuous operation should not be variety of features, because this would take away from the efficiency of the process design.

Facility Layout

Facility layout, covered in Chapter 10, is concerned with the arrangement of resources of a facility to enhance the production process. If resources are not arranged properly, a company will have inefficiency and waste. The type of process a company uses directly affects the facility layout of the organization and the inherent problems encountered.

Intermittent operations group their resources based on similar processes or functions. There is no one typical product that is produced; rather, a large variety of items are produced in low volumes, each with their own unique processing needs. Since no one product justifies the dedication of an entire facility, resources are grouped based on their function. Products are then moved from resource to resource, based on their processing needs. The challenge with intermittent operations is to arrange the location of resources to maximize efficiency and minimize waste of movement. If the intermittent operation has not been designed properly, many products will be moved long distances. This type of movement adds nothing to the value of the product and contributes to waste. Any two work centers that have much movement between them should be placed close to one another. However, this often means that another work center will have to be moved out of the way. This can make the problem fairly challenging.

Intermittent operations are less efficient and have longer production times due to the nature of the layout. Material handling costs tend to be high and scheduling resources is a challenge. Intermittent operations are common in practice. Examples include a doctor’s office or a hospital. Departments are grouped based on their function, with examining rooms in one area, lab in another, and x-rays in a third. Patients are moved from one department to another based on their needs. Another example is a bakery that makes custom cakes and pastries. The work centers are set up to perform different functions, such as making different types of dough, different types of
filings, and different types of icing and decorations. The product is routed to different workstations depending on the product requirements. Some cakes have the filing in the center (i.e., Boston cream pie), others only on top (i.e., sheet cake), and some have no filling at all (i.e., pound cake).

Continuous operations have resources arranged in sequence to allow for efficient production of a standardized product. Since only one product or a few highly similar products are being produced, all resources are arranged to efficiently meet production needs. Examples are seen on an assembly line, in a cafeteria, or even a car wash. Numerous products, from breakfast cereals to computers, are made using continuous operations.

Though continuous operations have faster processing rates, lower material handling costs, and greater efficiency than intermittent operations, they also have their shortcomings. Resources are highly specialized and the operation is inflexible relative to the market. This type of operation cannot respond rapidly to changes in market needs for the products wanted or the changes in demand volume. The challenge is to arrange workstations in sequence and designate the jobs that will be performed by each to produce the product in the most efficient way possible.

Vertical Integration

The larger the number of processes performed by a company in the chain from raw materials to product delivery, the higher is the vertical integration. Vertical integration is a strategic decision that should support the future growth direction of the company. Vertical integration is a good strategic option when there are high volumes of a small variety of input materials, as is the case with continuous operations. The reason is that the high volume and narrow variety of input material allows task specialization and cost justification. Recall the example of Dole Pineapple. The company’s product is canned pineapple. The input material is fresh pineapple. Since one input material is needed in large volume the company has chosen to be vertically integrated so as to have greater control of costs and product quality.

It is typically not a good strategic decision to vertically integrate into specialized processes that provide inputs in small volumes. This would be the case for intermittent operations. For example, let’s consider a bakery that makes a variety of different types of cakes and pies. Maybe the bakery purchases different fillings from different sources, such as apple pie filling from one company, chocolate filling from another, and cream filling from a third. If the company were to purchase production of the apple filling, it would not gain much strategically because it still relies on other suppliers. However, if the bakery shifted its production to only making apple pies, then the vertical integration may be a good choice.

In summary, vertical integration is typically a better strategic decision for continuous operations. For intermittent operations it is generally a poor strategic choice.

MANUFACTURING TECHNOLOGY DECISIONS

Advancements in technology have had the greatest impact on process design decisions. Technological advances have enabled companies to produce products faster, with better quality, at a cheaper rate. Many processes that were not imaginable only a few years ago have been made possible through the use of technology. In this section we look at some of the greatest impacts technology has had on process design.
**Automation**

An important decision in designing processes is deciding whether the firm should automate, to what degree, and the type of automation that should be used. Automation is machinery that is able to perform work without human operators. Automation can be a single machine or an entire factory. Although there are tremendous advantages to automation, there are also disadvantages. Companies need to consider these carefully before making the final decision.

Automation has the advantage of product consistency and ability to efficiently produce large volumes of product. With automated equipment the last part made in the day will be exactly like the first one made. Because automation brings consistency, quality tends to be higher and easier to monitor. With automation, production can flow uninterrupted throughout the day, without breaks for lunch, and there is no fatigue factor.

However, automation does have its disadvantages. First, automation is typically very costly. These costs can be justified only through a high volume of production. Second, automation is typically not flexible in accommodating product and process changes. Therefore, automation would probably not be good for products in the early stages of their life cycle or for products with short life cycles. Automation needs to be viewed as another capital investment decision and financial payback is critical. For all these reasons automation is typically less present in intermittent than in continuous operations.

Next we look at different types of automation.

**Automated Material Handling**

Material handling devices are used to move and store products. Historically the primary method of moving products used conveyors in the form of belts or chains. Today’s material handling devices can read bar codes that tell them which location to go to and are capable of moving in many directions. One such device is an automated guided vehicle (AGV). This is a small battery-driven truck that moves materials from one location to the other. The AGV is not operated by a human and takes its directions from either an on-board or central computer. Even AGVs have become more sophisticated over time. The older models followed a cable that was installed under the floor. The newer models follow optical paths and can go anywhere there is aisle space.

One of the biggest advantages of AGVs is that they can pretty much go anywhere, as compared to traditional conveyor belts. Managers can use them to move materials wherever they are needed, avoiding huge piles of inventory in one area.

Another type of automated material handling are automated storage and retrieval system (AS/RSs), which are basically automated warehouses. AS/RSs use AGVs to move material and computer-controlled racks and storage bins. The storage bins can typically rotate like a carousel, so that the desired storage bin is available for either storage or retrieval. All this is controlled by a computer that keeps track of the exact location and quantity of each item. The computer controls how much will be stored or retrieved in a particular area. AS/RSs can have great advantages over traditional warehouses. Though they are much more costly to operate, they are also much more efficient and accurate.

**Computer-Aided Design (CAD)**

Computer-aided design (CAD) is a system that uses computer graphics to design new products. Gone are the days of drafting designs by hand. Today’s powerful desk-
Top computers combined with graphics software allow the designer to create drawings on the computer screen and then manipulate them geometrically to be viewed from any angle. With CAD the designer can rotate the object, split it to view the inside, and magnify certain sections for closer view.

CAD can also perform other functions. Engineering design calculations can be performed to test the reactions of the design to stress and evaluate strength of materials. This is called computer-aided engineering (CAE). For example, the designer can test how different dimensions, tolerances, and materials respond to different conditions such as rough handling or high temperatures. The designer can use the computer to compare alternative designs and determine the best design for a given set of conditions. The designer can also perform cost analysis on the design, evaluating the advantages of different types of materials.

Another advantage of CAD is that it can be linked to manufacturing. We already discussed the importance of linking product design to process selection. Through CAD this integration is made easy. Computer-aided manufacturing (CAM) is the process of controlling manufacturing through computers. Since the product designs are stored in the computer database, the equipment and tools needed can easily be simulated to match up with the processing needs. Efficiencies of various machine choices and different process alternatives can be computed.

As you can imagine, there are numerous advantages to CAD. It has dramatically increased the speed and flexibility of the design process. Designs can be made on the computer screen and printed out when desired. Electronic versions can be shared by many members of the organization for their input. Also, electronic version can be archived and compared to future versions. The designer can catalogue features based on their characteristics—a very valuable feature. As future product design are being considered, the designer can quickly retrieve certain features from past designs and test them for inclusion in the design being currently developed. Overall, it is estimated that CAD can speed up the design process by up to 50%.

Flexible Manufacturing Systems (FMS)

A flexible manufacturing system (FMS) is a type of automation system that provides the flexibility of intermittent operations with the efficiency of continuous operations. As you can see by the definition, this is a system of automated parts not only one machine. An FMS consists of groups of computer-controlled machines and/or robots, automated handling devices for moving, loading, and unloading, and a computer control center.

Based on the instructions from the computer control center, parts and materials are automatically moved to appropriate machines or robots. The machines perform their tasks and the parts are then moved to the next set of machines with the parts automatically loaded and unloaded. The routes taken by each product are determined with the goal of maximizing efficiency of the operation. Also, the FMS “knows” when one machine is down due to maintenance or if there is a backlog of work on a machine, and it will automatically route the materials to an available machine.

Flexible manufacturing systems are still fairly limited in the variety of products that they handle. Usually they can only produce similar products from the same family. Flexible manufacturing systems are not very widespread. One of the primary reasons is their high cost. A decision to use an FMS needs to be long term and strategic, requiring a sizable financial outlay.
Robotics

When most of us think of robots we think of something like the robot from the old television show “Lost In Space,” which resembles humans. However, in manufacturing a robot is usually nothing more than a mechanical arm with a power supply and a computer control mechanism that controls the movements of the arm. The arm can be used for many tasks, such as painting, welding, assembly, loading, and unloading of machines. Robots are excellent for physically dangerous jobs such as working with radioactive or toxic materials. Also, robots can work 24 hours a day to produce a highly consistent product.

Robots range in their degree of sophistication. Some robots are fairly simple and follow a repetitive set of instructions. Other robots follow complex instructions, and some can be programmed to recognize objects and even make simple decisions. One type of automation that is similar to simple robotics is the numerically controlled (NC) machine. NC machines are controlled by a computer and can do a variety of tasks such as drilling, boring, or turning parts of different sizes and shapes. Factories of the future will most likely be composed of a number of robots and NC machines working together.

The use of robots has not been very widespread in U.S. firms. However, this is an area that can provide a competitive advantage for a company. Cost justification should not only consider reduction in labor costs but also the increased flexibility of operation and improvement in quality. The cost of robots can vary greatly and depends on the robots’ size and capabilities. Generally, it is best for a company to consider purchasing multiple robots or forms of automation to spread the costs of maintenance and software support. Also, the decision to purchase automation such as robotics needs to be a long-term strategic decision that considers the totality of the production process. Otherwise, the company may have one robot working 24 hours a day and piling up inventory while it waits for the other processes to catch up.

Robots can be used to improve operations of almost any business—even literal “operations.” Recently robots have begun to be used in performing certain medical surgeries. The first minimally invasive robotic surgery on a human heart valve was performed by three robot arms at the New York University Medical center in April 2000. To perform the surgery, doctors at NYU used the robot arms to cut a 6-centimeter incision between the ribs and send an endoscope that would allow the surgeons to see what they were doing. The robot arms controlled through a complex robotic surgical system. The doctors, seated at a workstation, can manipulate conventional surgical instruments while the robotic surgical system mirrors these movements on an ultra-fine scale. The advantage of using robots is that they can perform delicately fine, small, motor movements, have consistent finger dexterity, and require only tiny incisions. The prediction is that robots will become involved in performing many surgeries, such as eye surgery, neurosurgery, and cosmetic surgery.
Computer-Integrated Manufacturing

Computer-integrated manufacturing (CIM) is a term used to describe the integration of product design, process planning, and manufacturing using an integrated computer system. Computer-integrated manufacturing systems vary greatly in their complexity. Simple systems might integrate computer-aided design (CAD) with some numerically controlled machines (NC machines). A complex system, on the other hand, might integrate purchasing, scheduling, inventory control, and distribution, in addition to the other areas of product design.

The key element of CIM is the integration of different parts of the operation process to achieve greater responsiveness and flexibility. The purpose of CIM is to improve how quickly the company can respond to customer needs of product design and availability, as well as quality, productivity, and improve overall efficiency.

DESIGNING SERVICES

Most of the issues discussed in this chapter are as applicable to manufacturing as they are to service organizations. However, there are issues unique to services that pose special challenges for service design.

Most of us think we know what is needed to run a good service organization. After all, we encounter services almost every day, at banks, fast-food restaurants, doctor’s offices, barber shops, grocery stores, and even the university. We have all experienced poor service quality and would gladly offer advice as to how we think it could be run better. However, there are some very important features of services you may have not thought about. Let’s see what they are.

How Are Services Different from Manufacturing?

In Chapter 1 we learned about two basic features that make service organizations different from manufacturing. These are the intangibility of the product produced and the high degree of customer contact. Next we briefly review these and see how they impact service design.

Intangible Product Service organizations produce an intangible product, which cannot be touched or seen. It cannot be stored in inventory for later use or traded in for another model. The service produced is experienced by the customer. The design of the service needs to specify exactly what the customer is supposed to experience. For example, it may be relaxation, comfort, and pampering such as offered by Canyon Ranch Spa. It may be efficiency and speed, such as offered by Federal Express. Defining the customer experience is part of the service design. It requires identifying precisely what the customer is going to feel and think, and consequently how he or she is going to behave. This is not always as easy as it might seem.

The experience of the customer is directly related to customer expectations. For services to be successful the customer experience needs to meet or even exceed these expectations. However, customer expectations can greatly vary depending on the type of customer and customer demographic. This includes customer age, gender, background, and knowledge. The expectation is made through product marketing to a particular market segment. It is highly important in designing the service to identify the target market the service is geared to and create the correct expectation.
**High Degree of Customer Contact** Service organizations have a high degree of customer contact. The customer is often present while the service is being delivered, such as at a theater, restaurant, or bank. Also, the contact between the customer and service provider is often the service itself, such as what you experience at a doctor’s office. For a service to be successful this contact needs to be a positive experience for the customer, and this depends greatly on the service provider.

Unfortunately, since services often have multiple service providers, there can be great variation in the type of service delivered. We have all had experiences where the service of one organization varied greatly depending on the skills of the service provider. This could be a hairdresser at a hair salon, a food server at a restaurant, or a teller at a bank. We have all heard people say something similar to “I often have dinner at Aussie Steak Grill and I insist that Jenny be my server.” Similarly, someone might say “I go to Olentangy Family Physicians, but I won’t see Dr. Jekyl because he is rude and unfriendly.” For a service to be successful, the service experience must be consistent at all times. This requires close quality management to ensure high consistency and reliability. Many of the procedures we use in manufacturing to ensure high quality, such as standardization and simplification, are used in services as well. Fast-food restaurants such as McDonald’s and Wendy’s are known for their consistency. The same is true of hotel chains such as Holiday Inn and Embassy Suites.

To ensure that the service contact is a positive experience for the customer, employees of the service need to have training that encompasses a great array of skills that include courtesy, friendliness, and overall disposition. The service company also needs to structure the proper incentive system to motivate employees. For example, studies have shown that employee performance is motivated more by monetary incentives rather than by their belief in the idea of the service.

**The Service Package**

The really successful service organizations do not happen spontaneously. They are carefully thought out and planned, down to every employee action. To design a successful service we must first start with a service concept or idea, which needs to be very comprehensive. We have learned that when purchasing a service, customers actually buy a service package or bundle of goods. The service package is a grouping of features that are purchased together as part of the service. There are three elements of the service package: (1) the physical goods, (2) the sensual benefits, and (3) the psychological benefits. The physical goods of the service are the tangible aspects of the service that we receive, or are in contact with, during service delivery. In a fine-dining restaurant the physical goods are the food consumed, as well as facilities such as comfortable tables and chairs, table cloths, and fine china. The sensual benefits are the sights, smell, and sounds of the experience—all the items we experience through our senses. Finally, the psychological benefits include the status, comfort, and well-being of the experience.

It is highly important that the design of the service specifically identify every aspect of the service package. When designing the service we should not focus only on the tangible aspects; it is often the sensual and psychological benefits that are the deciding factors in the success of the service. The service package needs to be designed to precisely meet the expectations of the target customer group.

Once the service package is identified it can then be translated into a design using a process that is not too different from the one used in manufacturing. Details of the service, such as quality standards and employee training, can later be defined in keeping with the service concept. The service providers—the individuals who come in
direct contact with the customers—must be trained and motivated to precisely understand and satisfy customer expectations.

Imagine going to a fast-food restaurant and having the server take his time asking you how you want your hamburger cooked and precisely what condiments you would like to accompany it, then waiting a long time to receive your food. Similarly, imagine going to an expensive hair salon and having the staff rush you through the process. In both cases, you as the customer would not be satisfied because the service delivery did not meet your expectations. Next time you might choose to go somewhere else. These examples illustrate what happens when there is a mismatch between the service concept and the service delivery.

Differing Service Designs

There is no one model of successful service design. The design selected should support the company’s service concept and provide the features of the service package that the target customers want. Different service designs have proved successful in different environments. In this section we look at three very different service designs that have worked well for the companies that adopted them.

Substitute Technology for People

Substituting technology for people is an approach to service design that was advocated some years ago by Theodore Levitt.1 Levitt argued that one way to reduce the uncertainty of service delivery is to use technology to develop a production line approach to services. One of the most successful companies to use this approach is McDonald’s. Technology has been substituted wherever possible to provide product consistency and take the guesswork away from employees. Some examples of the use of technology include the following:

- Buzzers and lights are used to signal cooking time for frying perfect french fries.
- The size of the french fryer is designed to produce the correct amount of fries.
- The french fry scoop is the perfect size to fill an order.
- “Raw materials” are received in usable form (e.g., hamburger patties are pre-made; pickles and tomatoes are presliced; french fries are precut).
- There are 49 steps for producing the perfect french fries.
- Steps for producing the perfect hamburger are detailed and specific.
- Products have different colored wrappings for easy identification.

In addition to the use of technology in the production of the product, there is consistency in facilities and a painstaking focus on cleanliness. For example, the production process at McDonald’s is not left to the discretion of the workers. Rather, their job is to follow the technology and preset processes.

Today, we are all accustomed to the product consistency, speed of delivery, and predictability that are a feature of most fast-food restaurants. However, this concept was very new in the early 1970s. It is this approach to services that has enabled McDonald’s to establish its global reputation.

Substituting technology for people is an approach we have seen over the years in many service industries. For example, almost all gas stations have reduced the number of cashiers and attendants with the advent of credit card usage at self-serve pumps. Also, many hospitals are using technology to monitor patient heart rate and blood pressure without relying exclusively on nurses. As technologies develop in different

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service industries we will continue to see an ever increasing reliance on its use and the elimination of workers.

**Get the Customer Involved** A different approach to service design was proposed by C. H. Lovelock and R. F. Young. Their idea was to take advantage of the customer’s presence during the delivery of the service and have him or her become an active participant. This is different from traditional service designs where the customer passively waits for service employees to deliver the service. Lovelock and Young proposed that since the customers are already there, “get them involved.”

We have all seen a large increase in the self-serve areas of many service firms. Traditional salad bars have led to self-serve food buffets of every type. Many fast-food restaurants no longer fill customer drink orders, but have the customers serve themselves. Grocery stores allow customers to select and package baked goods on their own. Many hotels provide in-room coffee makers and prepackaged coffee, allowing customers to make coffee at their convenience.

This type of approach has a number of advantages. First, it takes a large burden away from the service provider. The delivery of the service is made faster and costs are reduced due to lowered staffing requirements. Second, this approach empowers customers and gives them a greater sense of control in terms of getting what they want. This approach provides a great deal of customer convenience and increases satisfaction. However, as different types of customers have different preferences, many facilities are finding that it is best to offer full-service and self-service options. For example, many breakfast bars still allow a request for eggs cooked and served to order, and most gas stations still offer some full-service pumps.

**High Customer Attention Approach** A third approach to service design is providing a high level of customer attention. This is in direct contrast to the first two approaches we discussed. The first approach discussed automates the service and makes it more like manufacturing. The second approach requires greater participation and responsibility from the customer. The third approach is different from the first two in that it does not standardize the service and does not get the customer involved. Rather, it is based on customizing the service needs unique to each customer and having the customer be the passive and pampered recipient of the service. This approach relies on developing a personal relationship with each customer and giving the customer precisely what he or she wants.

There are a number of examples of this type of approach. Nordstrom Department Stores is recognized in the retail industry for its attention to customer service. Salespeople typically know their customers by name and keep a record of their preferences. Returns are handled without question and the customer is always right without questions asked. Another example of this is a midwestern grocer called Dorothy Lane Market. Dorothy Lane prides itself on its ability to provide unique cuts of specialty meats precisely to customer order. Like at Nordstrom, a list is kept of primary customers and their preferences. Customers are notified of special purchases, such as unique wines, specialty chocolates, and special cuts of meat.

Whereas the first two approaches to service design result in lowered service costs, this third approach is geared toward customers that are prepared to pay a higher amount for the services they receive. As you can see, different approaches are meant to serve different types of customers. The design chosen needs to support the specific service concept of the company.

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The strategic and financial impact of product design and process selection mandates that operations work closely with other organizational functions to make these decisions. Operations is an integral part of this decision because it understands issues of production, ease of fabrication, productivity, and quality. Now let’s see how the other organizational functions are involved with product design and process selection.

**Marketing** is impacted by product design issues because they determine the types of products that will be produced and affect marketing’s ability to sell them. Marketing’s input is critical at this stage because marketing is the function that interfaces with customers and understands the types of product characteristics customers want. It is marketing that can provide operations with information on customer preferences, competition, and future trends.

Process selection decisions impact marketing as well. Process selection decisions typically require large capital outlays. Once in place, process decisions are typically difficult to change and are in place for a long time. Process decisions affect the types of future products that the company can produce. Because of this, marketing needs to be closely involved in ensuring that the process can meet market demands for many years to come.

**Finance** plays an integral role in product design and process selection issues because these decisions require large financial outlays. Finance needs to be a part of these decisions to evaluate the financial impact on the company. Process selection decisions should be viewed as any other financial investment, with risks and rewards. Finance must ensure that the tradeoff between the risks and rewards is acceptable. Also, it is up to finance to provide the capital needed for this investment and balance that against future capital requirements.

**Information systems** needs to be part of the process selection decision. Operations decisions, such as forecasting, purchasing, scheduling, and inventory control differ based on the type of operation the company has. Information systems will be quite different for intermittent versus continuous operations. Therefore, the information system has to be developed to match the needs of the production process being planned.

**Human resources** provides important input to process selection decisions because it is the function directly responsible for hiring employees. If special labor skills are needed in the process of production, human resources needs to be able to provide information on the available labor pool. The two types of operations discussed, intermittent and continuous, typically require very different labor skills. Intermittent operations usually require higher-skilled labor than continuous operations. Human resources needs to understand the specific skills that are needed.

**Purchasing** works closely with suppliers to get the needed parts and raw materials at a favorable price. It is aware of product and material availability, scarcity, and price. Often certain materials or components can use less expensive substitutes if they are designed properly. For this reason it is important to have purchasing involved in product design issues from the very beginning.

**Engineering** needs to be an integral part of the product design and process selection decision because this is the function that understands product measurement, tolerances, strength of materials, and specific equipment needs. There can be many product design ideas, but it is up to engineering to evaluate their manufacturability.

As you can see, product design and process selection issues involve many functions and affect the entire organization. For this reason, product design and process selection decisions need to be made using a team effort with all these functions working closely together to come up with a product plan that is best for the company.
Product and process design affect your everyday life in more ways than you might realize. Every time you are dissatisfied with the features of a product or the delivery or a service, you can blame product and process design. Your loyalty toward a particular product, like the pizza preferences we discussed in the beginning of the chapter, are all because of product and process design.

Product and process design are a big part of your life in other ways too. Often you “design” products and processes even when you are not aware of it. Suppose you decide to be creative in the kitchen and create a recipe for your own chocolate cream pie. You base your “design” on the best ideas from old recipes, including an Oreo-cookie crust and marshmallow cream topping. You purchase all the ingredients and proceed to “produce” your product. However, halfway through “production” you realize that the recipe calls for a double-boiler to make the cream filling and you do not have one. This means that you will have to stop what you are doing and go to a store to buy a double-boiler. In the meantime, some of the ingredients might get stale and your pie will not be as good as you hoped. Also, the cost of the pie might be more than you bargained for. Had you designed your “process” while you were designing the product you would not have this problem. Next time you are “designing” a product you might want to use the concept of concurrent engineering and design the process along with the product.

CHAPTER HIGHLIGHTS

1. Product design is the process of deciding on the unique characteristics and features of a company’s product. Process selection, on the other hand, is the development of the process necessary to produce the product we design. Product design is a big strategic decision for a company, because the design of the product defines who the company’s customers will be, as well as the company’s image, its competition, and its overall future growth.

2. Steps in product design include idea generation, product screening, preliminary design and testing, and final design. A useful tool at the product-screening stage is break-even analysis.

3. Break-even analysis is a technique used to compute the amount of goods we would have to sell just to cover our costs.

4. Production processes can be divided into two broad categories: intermittent and continuous operations. Intermittent operations are used when products with different characteristics are being produced in smaller volumes. These types of operations tend to organize their resources by grouping similar processes together and having the product routed through the facility based on their needs. Continuous operations are used when one or a few similar products are produced in high volume. These operations arrange resources in sequence to allow for an efficient build-up of the product. Both intermittent and continuous operations have their advantages and disadvantages. Intermittent operations provide great flexibility but have high material handling costs and challenges scheduling resources. Continuous operations are highly efficient but inflexible.

5. Product design and process selection decisions are linked. The type of operation a company has in place is defined by the product the company produces. The type of operation then affects other organizational decisions, such as competitive priorities, facility layout, and degree of vertical integration.

6. A process flowchart is used for viewing the flow of the processes involved in producing the product. It is a very useful tool for seeing to totality of the operation and for identifying potential problem areas. There is no exact format for designing the chart. The flowchart can be very sample or very detailed.

7. Different types of technologies can significantly enhance product and process design. These include automation, automated material handling devices, computer-aided design (CAD), numerically controlled (NC) equipment, flexible manufacturing systems (FMS), and computer-integrated manufacturing (CIM).

8. Designing services has a few more complexities than manufacturing, because services produce an intangible product and typically have a high degree of customer contact. Different service designs include substituting technology for people, getting the customer involved, and the high customer attention approach.
KEY TERMS

product design 43
service design 43
benchmarking 45
reverse engineering 45
break-even analysis 46
design for manufacture (DFM) 49
product life cycle 49
concurrent engineering 50
remanufacturing 52
intermittent operations 52
continuous operations 52
project process 53
batch process 54
line process 54
continuous process 54
vertical integration 55
make-or-buy decision 56
process flowchart 57
reengineering 57
automation 63
computer-aided design (CAD) 63
flexible manufacturing system (FMS) 64
numerically controlled (NC) machine 65
computer-integrated manufacturing (CIM) 66
service package 67

FORMULA REVIEW

1. Total cost = fixed cost + variable cost
2. Revenue = \((SP) Q\)
3. \(F + (VC) Q = (SP) Q\)
4. \(Q_{BE} = \frac{F}{SP - VC}\)

SOLVED PROBLEMS

Problem 1

Joe Jenkins, owner of Jenkins Manufacturing, is considering whether to produce a new product. He has considered the operations requirements for the product as well as the market potential. Joe estimates the fixed costs per year to be $40,000 and variable costs for each unit produced to be $50.

(a) If Joe sells the product at a price of $70, how many units of product does he have to sell in order to break even? Use both the algebraic and graphical approach.

(b) If Fred sells 3000 units at the product price of $70, what will be his contribution to profit?

Solution

(a) To compute the break-even quantity we follow our basic equation and substitute the appropriate numbers:

\[ Q = \frac{F}{SP - VC} = \frac{40,000}{70 - 50} = 2000 \text{ units} \]

The break-even quantity is 2000 units. This is how much Fred would have to sell in order to cover his costs.

Graphically we can obtain the same result. This is shown in Figure 3-8.

(b) To compute the contribution to profit with sales of 3000 units:

\[ \text{Profit} = \text{total revenue} - \text{total cost} \]
\[ = (SP) Q - [F + (VC) Q] \]

Now we can substitute numerical values:

\[ \text{Profit} = 70(3000) - [40,000 + 50(3000)] = 20,000 \]

The contribution to profit is $20,000 if Joe can sell 3000 units of product.
DISCUSSION QUESTIONS

1. Define product design and explain its relationship to business strategy.
2. What are the differences between product and service design?
3. Explain the meanings of benchmarking and reverse engineering.
4. Explain the meaning of design for manufacture (DFM) and give some examples.
5. Describe the stages of the product life cycle. What are demand characteristics at each stage?
6. Explain the term concurrent engineering. Why is it important?
7. Identify the two general types of operations. What are their characteristics?

PROBLEMS

1. See-Clear Optics is considering producing a new line of eyewear. After considering the costs of raw materials and the cost of some new equipment, the company estimates fixed costs to be $40,000 with a variable cost of $45 per unit produced.

   (a) If the selling price of each new product is set at $100, how many units need to be produced and sold to break even? Use both the graphical and algebraic approaches.

   (b) If the company produces 500 tables a year, which method provides a lower total cost?

2. Med-First is a medical facility that offers outpatient medical services. The facility is considering offering an additional service, mammography screening tests on site. The facility estimates the annual fixed cost of the equipment and skills necessary for the service to be $120,000. Variable costs for each patient processed are estimated at $35 per patient. If the clinic plans to charge $55 for each screening test, how many patients must it process a year in order to break even?

3. Tasty Ice Cream is a year-round take-out ice cream restaurant that is considering offering an additional product, hot chocolate. Considering the additional machine it would need plus cups and ingredients, it estimates fixed cost per year to be $200 per year and the variable cost at $.20. If it charges $1.00 for each hot chocolate, how many hot chocolates does it need to sell in order to break even?

4. Slick Pads is a company that manufactures laptop notebook computers. The company is considering adding its own line of computer printers as well. It has considered the implications from marketing and financial perspectives and estimates fixed costs to be $500,000. Variable costs are estimated at $200 per unit produced and sold.

   (a) If the company plans to offer the new printers at a price of $350, how many printers does it have to sell to break even?

   (b) Describe the types of operations considerations that the company needs to consider before making the final decision.

5. Perfect Furniture is a manufacturer of kitchen tables and chairs. The company is currently deciding between two new methods for making kitchen tables. The first process is estimated to have a fixed cost of $80,000 and a variable cost of $75 per unit. The second process is estimated to have a fixed cost of $100,000 and a variable cost of $60 per unit.

   (a) Graphically plot the total costs for both methods. Identify which ranges of product volume are best for each method.

   (b) If the company produces 500 tables a year, which method provides a lower total cost?

6. Harrison Hotels is considering adding a spa to its current facility in order to improve their list of amenities. Operating the spa would require a fixed cost of $25,000 a year. Variable cost is estimated at $35.00 per customer. The Hotel wants to break even if 12,000 customers use the spa facility. What should be the price of the spa services?

7. Kaizer Plastics produces a variety of plastic items for packaging and distribution. One item, container #145, has had a low contribution to profits. Last year, 20,000 units of container #145 were produced and sold. The selling price of the container was $20.00 per unit, with a variable cost of $18 per unit and a fixed cost of $70,000 per year.

   (a) If the selling price is set at $80 per unit yield a higher contribution to profit?

   (b) If the company produces 1500 units. Will the pricing strategy of $100 per unit or $80 per unit be better for the company?
(a) What is the break-even quantity for this product? Use both graphic and algebraic methods to get your answer.
(b) The company is currently considering ways to improve profitability by either stimulating sales volumes or reducing variable costs. Management believes that sales can be increased by 35 percent of their current levels or that variable cost can be reduced to 90 percent of their current level. Assuming all other costs equal, identify which alternative would lead to a higher profit contribution.

8. George Fine, owner of Fine Manufacturing, is considering the introduction of a new product line. George has considered factors such as costs of raw materials, new equipment, and requirements of a new production process. He estimates that the variable costs of each unit produced would be $8 and fixed cost would be $70,000.

(a) If the selling price is set at $20 each, how many units have to be produced and sold for Fine Manufacturing to break even? Use both graphical and algebraic approaches.
(b) If the selling price of the product is set at $18.00 per unit, Fine Manufacturing expects to sell 15,000 units. What would be the total contribution to profit from this product at this price?
(c) Fine Manufacturing estimates that if it offers the price at the original target of $20 per unit, the company will sell about 12,000 units. Which pricing strategy—$18.00 per unit or $20.00 per unit—will yield a higher contribution to profit?
(d) Identify additional factors the George Fine should consider in deciding whether to produce and sell the new product.

9. Handy-Maid Cleaning Service is considering offering an additional line of services to include professional office cleaning. Annual fixed costs for this additional service are estimated to be $9,000. Variable costs are estimated at $50.00 per unit of service. If the price of the new service is set at $80.00 per unit of service, how many units of service are needed for Handy-Maid to break even?

10. Easy-Tech software corporation is evaluating the production of a new software product to compete with the popular word processing software currently available. Annual fixed costs of producing the item are estimated at $150,000 while the variable costs is $10.00 per unit. The current selling price of the item is $35.00 per unit, and the annual sales volume is estimated at 50,000 units.

(a) Easy-Tech is considering adding new equipment that would improve software quality. The negative aspect of this new equipment would be an increase in both fixed and variable costs. Annual fixed cost would increase by $50,000 and variable cost by $3.00. However, marketing expects the better quality product to increase demand to 70,000 units. Should Easy-Tech purchase this new equipment and keep the price of their product the same? Explain your reasoning.
(b) Another option being considered by Easy-Tech is the increase in the selling price to $40.00 per unit to offset the additional equipment costs. However, this increase would result in a decrease in demand to 40,000 units. Should Easy-Tech increase their selling price if they purchase the new equipment? Explain your reasoning.

CASE: Biddy’s Bakery (BB)

Biddy’s Bakery was founded by Elizabeth McDoole in 1984. Nicknamed “Biddy,” Elizabeth started the home-style bakery in Cincinnati, Ohio as an alternative to commercially available baked goods. The mission of Biddy’s Bakery was to produce a variety of baked goods with old-fashioned style and taste. The goods produced included a variety of pies and cakes, and were sold to the general public and local restaurants.

The operation was initially started as a hobby by Elizabeth and a group of her friends. Many of the recipes they used had been passed down for generations in their families. The small production and sales facility was housed in a mixed commercial and residential area on the first floor of “Biddy’s” home. Elizabeth (“Biddy”) and three of her friends worked in the facility from 6 AM to 2 PM making and selling the pies. The operation was arranged as a job-shop with work stations set up to perform a variety of tasks as needed. Most of the customers placed advanced orders and Biddy’s Bakery took pride in accepting special requests. The Bakery’s specialty was the McDoole Pie, a rich chocolate confection in a cookie crust.

Meeting Capacity Needs

Initially sales were slow and there were periods when the business operated at a loss. However, after a few years Biddy’s Bakery began to attract a loyal customer following. Sales continued to grow slowly but steadily. In 1994, a first floor storage area was expanded to accommodate the growing business. However, Biddy’s Baker quickly outgrew its current capacity. In May of 2000 Elizabeth decided to purchase the adjacent building and move the entire operation into the much large facility. The new facility had considerably more capacity than needed, but the expectation was that business would continue to grow. Unfortunately, by the end of 2000 Elizabeth found that her sales expectations had not been met and she was paying for a facility with unused space.
Getting Management Advice

Elizabeth knew that her operations methods, though traditional, were sound. A few years ago she had called upon a team of business students from a local university for advice, as part of their course project. They had offered some suggestions, but were most impressed with the efficient manner with which she ran her operation. Recalling this experience she decided to contact the same university for another team of business students to help her with her predicament.

After considerable analysis the team of business students came up with their plan: Biddy’s Bakery should primarily focus on production of the McDoogle Pie in large volumes, with major sales to go to a local grocery store. The team of business students discussed this option with a local grocery store chain that was pleased with the prospect. Under the agreement Biddy’s Bakery would focus its production on the McDoogle Pie, which would be delivered in set quantities to one store location twice a week. The volume of pies required would use up all of the current excess capacity and take away most of capacity from production of other pies.

Elizabeth was confused. The alternative being offered would solve her capacity problems, but it seemed that the business would be completely different though she did not understand how or why. For the first time in managing her business she did not know what to do.

Case Questions:
1. Explain the challenge faced by Elizabeth in meeting her capacity needs. What should she have considered before moving into the larger facility?
2. What is wrong with the proposal made by the team of business students? Why?
3. What type of operation does Biddy’s Bakery currently have in place? What type of operation is needed to meet the proposal made by the team of business students? Explain the differences between these two operations.
4. Elizabeth senses that the business would be different if she accepts the proposal, but does not know how and why. Explain how it would be different.
5. What would you advise Elizabeth?

INTERACTIVE LEARNING

Enhance and test your knowledge of Chapter 3 using the interactive CD.

1. Simulation Understanding Intermittent and Continuous Operations
2. Video Xerox Corporation
3. Company Tour Ercol Furniture
5. INTERNET CHALLENGE Country Comfort Furniture

You have just taken a position with Country Comfort Furniture, a furniture manufacturer known for its custom-designed country furniture. The primary focus of the company has been on kitchen and dining room furniture in the upper portion of the high-price range. Due to competitive pressures and changes in the market, Country Comfort is now considering production of prefabricated kitchen and dining room furniture in the medium-price range.

You have been asked to help Country Comfort evaluate the new product design it is considering. Perform an Internet search to identify at least two major competitors that Country Comfort would have if it chooses to pursue the new product line. Next, identify key product design features of each competitor’s products, their target market, and price range. Based on your search, what are your recommendations to Country Comfort on product design and current competition?
BIBLIOGRAPHY


