Operations Management

Product Design and Process Selection

5.1 Introduction

In this lesson 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. A company can have a highly innovative design for its product, but if it has not determined how to make the product in a cost-effective way, 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. Furthermore, 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.

5.2 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' cafe latte or Jimmy Dean's sausage to GM's Saturn or HP's Desk Jet 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 FedEx. Consumers respond to a product's appearance, color, texture, and 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.

5.3 Design of Services versus Goods

The design elements discussed are typical of industries such as manufacturing and retail in which the product is tangible. For service industries, where the product is intangible, the design elements are equally important, but they have an added dimension. Service design is unique in that both the service and the entire ***service concept*** are being designed. As with a tangible product, the service concept is based on meeting customer needs. The service design, however, adds 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.

Certain steps are common to the development of most product designs: idea generation, product screening, preliminary design and testing, and final design. Product designs are never finished, but are always updated with new ideas.

5.4 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 its product lines. The timing often has to do with the market for a product and whether sales are declining or continuing to grow.

5.4.1 Ideas from Customers, Competitors, and Suppliers

The first source of ideas is customers, the driving force in the design of goods 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 their success rate. 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 one's own 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 IBM's efforts to improve its distribution system. In 1997, IBM found its distribution costs increasing while customers were expecting decreasing 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 personal computer (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.

5.4.2 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. Ford Motor Company used this approach 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 (research and development) department, whose role is to develop product and process innovation. Suppliers are another source of product design ideas. To remain competitive, more companies are developing partnering relationships with their suppliers to jointly sat isfy the end customer. Suppliers participate in a program called **early supplier involvement** (**ESI**), which involves them in the early stages of product design.

5.4.3 Product Screening

After a product idea has been developed, it is 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 function 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 percent 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 look at next.

5.4.4 Break-Even Analysis: A Tool for Product Screening

Break-even analysis is a technique that can be useful when evaluating a new product. It 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 direct materials and labor. Together, fixed and variable costs add up to total cost.

5.4.5 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 the company may want 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.

5.4.6 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.

5.5 Factors Impacting Product Design

Here are some additional factors that need to be considered during the product design stage. 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 the product. Otherwise, we might have a great idea that is difficult or too costly to manufacture.

Design for manufacture (**DFM**) is a series of guidelines that we should follow to produce a product easily and profitably. DFM guidelines focus on two issues:

1. ***Design simplification*** means reducing the number of parts and features of the product whenever possible. A simpler product is easier to make, costs less, and gives higher quality.

2. ***Design standardization*** refers to the use of common and interchangeable parts. By using interchangeable parts, we can make a greater variety of products with less inventory and significantly lower cost and provide greater flexibility.

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 time.

5.5.1 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 **product life cycle**. There are typically four stages of the product life cycle: introduction, growth, maturity, and decline. Products in the introductory stage are not well defined, and neither is their market. Often all the ***"bugs"*** have not been worked out, and customers are uncertain about the product. In the growth stage, the product takes hold and both product and market continue to be refined. The third stage is that of maturity, where demand levels off and there are usually no design changes: the product is predictable at this stage and so is its market. Many products, such as toothpaste, can stay in this stage for many years.

Finally, there is a decline in demand because of new technology, better product design, or market saturation. The first two stages of the life cycle can collectively be called the early stages because the product is still being improved and refined and the market is still in the process of being developed. The last two stages of the life cycle can be referred to as the later stages because here both the product and market are well defined.

Understanding the stages of the product life cycle is important for product design purposes, such as knowing at which stage to focus on design changes. Also, when considering a new product, the expected length of the life cycle is critical in order to estimate future profitability relative to the initial investment. The product life cycle can be quite short for certain products, as seen in the computer industry. For other products it can be extremely long, as in the aircraft industry. A few products, such as paper, pencils, nails, milk, sugar, and flour, do not go through a life cycle. However, almost all products do, and some may spend a long time in one stage.

5.5.2 Concurrent Engineering

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.

A second problem is that the "over-the-wall" approach takes a longer amount of time than when product and process design are performed concurrently. 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.

5.5.3 Remanufacturing

Remanufacturing is a concept that has been gaining increasing importance as our society becomes more environmentally conscious and focuses on 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.

5.5.4 Process Selection

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

5.5.5 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 locations 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 cakes made to order by a gourmet bakery. Though there seem to be large differences between the processes of companies, many 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 repetitive 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** are used to produce a variety of products with different processing requirements in lower volumes. Examples are an auto body shop, a tool and die shop, or a healthcare 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 healthcare 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. 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.

5.5.6 Repetitive Operations

Repetitive 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 repetitive 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 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 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.

5.6 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 divided into ***project processes*** and ***batch processes***. Repetitive operations can be divided into ***line processes*** and ***continuous processes*****.** Next we look at what makes these processes different from each other.

1) **Project processes** are used to make one-of-a-kind 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.

2) **Batch processes** are used to produce small quantities of products in groups or batches based on customer orders or product specifications. They are also known as job shops. 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.

3) **Line processes** are designed to produce a large volume of a standardized product for mass production. They are also known as flow shops, flow lines, or assembly lines. 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.

4) **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.

They usually have a single input and a limited number of outputs. 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 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.

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 batches may also bake and decorate cakes to order.

5.7 Designing Processes

Now that we know about different types of processes, let's look at a technique that can help with process design. **Process flow analysis** is a technique used for evaluating a process 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 sequence of steps involved in producing the product and the flow of the product through the process. It is useful for seeing the totality of the operation and for identifying potential problem areas.

There is no exact format for designing a flowchart. It can be very simple or highly detailed. The typical symbols used are arrows to represent flows, triangles to represent decision points, inverted triangles to represent storage of goods, and rectangles as tasks. For example, let's say that the first stage of a multistage process produces one product in 40 seconds and the second stage in 60 seconds.

That means that for every unit produced the first stage would have to stop and wait 20 seconds for the second stage to finish its work. Because the capacity of the second stage is holding up the speed of the process, it is called a **bottleneck**. Now let's see what happens if the first stage takes 60 seconds to produce a product and the second stage 40 seconds. In this case the first stage becomes the bottleneck, and the second stage has to wait 20 seconds to receive a product. Obviously, the best is for both stages to produce at the same rate, though this is often not possible. Inventory is then placed between the stages to even out differences in production capacity.

This is called a **make-to-stock strategy**. Second are pizzas that use a standard crust prepared ahead of time but are assembled based on specific customer requests. This is called an **assemble-to-order strategy**. Lastly are pizzas made to order based on specific customer requirements, allowing choices of different types of crusts and toppings. This is called a **make-toorder strategy**. We will look at these product strategies more closely later in this lesson.

Process flowcharts can also be used to map the flow of the customer through the process and to identify potential problem areas. Figure 3-9 shows a flowchart for Antonio's Pizzeria 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 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. As you can see, process flowcharts are very useful tools when designing and evaluating processes.

5.7.1 Process Performance Metrics

An important way of ensuring that a process is functioning properly is to regularly measure its performance. **Process performance metrics** are measurements of different process characteristics that tell us how a process is performing. Just as accountants and finance managers use financial metrics, operations managers use process performance metrics to determine how a process is performing and how it is changing over time. There are many process performance metrics that focus on different aspects of the process.

A basic process performance metric is **throughput time**, which is the average amount of time it takes a product to move through the system. This includes the time someone is working on the product as well as the waiting time. A lower through put time means that more products can move through the system. One goal of process improvement is to reduce throughput time. For example, think about the time spent at your last doctor's appointment. The total amount of time you spent at the facility, regardless of whether you were waiting, talking with the physician, or having lab work performed, is throughput time.

Quite possibly much of the time at your last doctor's appointment was spent waiting. An important metric that measures how much wasted time exists in a process is **process velocity**. Process velocity is computed as a ratio of throughput time to value added time: where value-added time is the time spent actually working on the product. Notice that the closer this ratio is to 1.00, the lower the amount of time the product spends on non-value-adding activities (e.g., waiting). Again recall your last doctor's appointment. What was the value-added time? What was the throughput time? Can you estimate the process velocity?

Another important metric is **productivity**, which is the ratio of outputs over inputs. Productivity measures how well a company converts its inputs to outputs. Productivity was discussed in detail in Chapter 2, so we will not repeat its computation here. Also important is **utilization**, which is the ratio of the time a resource is actually used versus the time it is available for use. Unlike productivity, which tends to focus on financial measures (e.g., dollars of output), utilization measures the actual time that a resource (e.g., equipment or labor) is being used. Last, **efficiency** is a metric that measures actual output relative to some standard of output. It tells us whether we are performing at, above, or below standard.

5.7.2 Linking Product Design and Process Selection

Decisions concerning 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.

5.7.3 Product Design Decisions

Intermittent and repetitive 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. Because products in the early stage of the life cycle are still being refined, intermittent operations are ideally suited to them. 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.

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 repetitive operation provides. Recall that repetitive 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, repetitive types of operations are a better business alternative.

This is why repetitive 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 repetitive operation. The differences between the two types of operations are great, including the way they are managed. Not understanding their differences is a mistake often made by companies. A company may be very successful at managing a repetitive operation that produces 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 repetitive 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 repetitive operation. Then the company decided to pursue production of nuclear pressure vessels, a new product in the early stages of its life cycle that required 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.

They began managing the production of nuclear pressure vessels—an intermittent operation—as if it were a repetitive operation. They focused primarily on cost rather than delivery, did not give enough time for product refinement, and did not invest in labor skills necessary for a new product. Consequently, the venture failed, and the company almost went out of business. It was saved by its success in the production of boilers, to which it was able to return.