Key Terms

Average fixed cost, 338
Average product of labor, 333
Average total cost, 330
Average variable cost, 338
Constant returns to scale, 340
Diseconomies of scale, 341
Economies of scale, 339
Explicit cost, 328
Fixed costs, 327
Implicit cost, 328
Law of diminishing returns, 331
Long run, 327
Long-run average cost curve, 339
Marginal cost, 335
Marginal product of labor, 331
Minimum efficient scale, 340
Opportunity cost, 328
Production function, 329
Short run, 327
Technological change, 326
Technology, 326
Total cost, 327
Variable costs, 327

10.1 Technology: An Economic Definition, pages 326-327
LEARNING OBJECTIVE: Define technology and give examples of technological change.

Summary

The basic activity of a firm is to use inputs, such as workers, machines, and natural resources, to produce goods and services. The firm’s technology is the processes it uses to turn inputs into goods and services. Technological change refers to a change in the ability of a firm to produce a given level of output with a given quantity of inputs.

Review Questions

1.1 What is the difference between technology and technological change?
1.2 Is it possible for technological change to be negative? If so, give an example.

Problems and Applications

1.3 Briefly explain whether you agree with the following observation: “Technological change refers only to the introduction of new products, so it is not relevant to the operations of most firms.”

1.4 Which of the following are examples of a firm experiencing positive technological change?
   a. A firm is able to cut each worker’s wage rate by 10 percent and still produce the same level of output.
   b. A training program makes a firm’s workers more productive.
   c. An exercise program makes a firm’s workers more healthy and productive.
   d. A firm cuts its workforce and is able to maintain its initial level of output.
   e. A firm rearranges the layout of its factory and finds that by using its initial set of inputs, it can produce exactly as much as before.

1.5 (Related to the Making the Connection on page 326) The 7-Eleven chain of convenience stores in Japan reorganized its system for supplying its stores with food. This led to a sharp reduction in the number of trucks the company had to use, while increasing the amount of fresh food on store shelves. Someone discussing 7-Eleven’s new system argues, “This is not an example of technological change because it did not require the use of new machinery or equipment.” Briefly explain whether you agree with this argument.

10.2 The Short Run and the Long Run in Economics, pages 327-331
LEARNING OBJECTIVE: Distinguish between the economic short run and the economic long run.

Summary

In the short run, a firm’s technology and the size of its factory, store, or office are fixed. In the long run, a firm is able to adopt new technology and to increase or decrease the size of its physical plant. Total cost is the cost of all the inputs a firm uses in production. Variable costs are costs that change as output changes. Fixed costs are costs that remain constant as output changes. Opportunity cost is the highest-valued alternative that must be given up to engage in an activity. An explicit cost is a cost that involves spending money. An implicit cost is a nonmonetary opportunity cost.
The relationship between the inputs employed by a firm and the maximum output it can produce with those inputs is called the firm's production function.

**Review Questions**

1. What is the difference between the short run and the long run? Is the amount of time that separates the short run from the long run the same for every firm?
2. What are implicit costs? How are they different from explicit costs?

**Problems and Applications**

2.1 An article in *BusinessWeek* discussed Apple's cost to produce the iPod shuffle: "All told, the cost of the shuffle's components, the headphones, and the packaging it ships in comes to $21.77... That's about 28% of the device's retail price ($79)." Can we conclude from this information that Apple is making a profit of about $57 per shuffle? Briefly explain.


2.2 (Related to the Making the Connection on page 328) Many firms consider their wage costs to be variable costs. Why do publishers usually consider their wage and salary costs to be fixed costs? Are the costs of utilities always fixed, are they always variable, or can they be both? Briefly explain.

2.3 (Related to the Making the Connection on page 328) For Jill Johnson's pizza restaurant, explain whether each of the following is a fixed cost or a variable cost.

a. The payment she makes on her fire insurance policy
b. The payment she makes to buy pizza dough
c. The wages she pays her workers
d. The lease payment she makes to the landlord who owns the building where her store is located
e. The $300-per-month payment she makes to her local newspaper for running her weekly advertisements

2.4 (Related to the Making the Connection on page 328) The Statistical Abstract of the United States is published each year by the U.S. Census Bureau. It provides a summary of business, economic, social, and political statistics. It is available for free online, and a printed copy can also be purchased from the U.S. Government Printing Office for $37. Because government documents are not copyrighted, anyone can print copies of the Statistical Abstract and sell them. Each year, one or two companies typically will print and sell copies for a significantly lower price than the Government Printing Office does. The copies of the Statistical Abstract that these companies sell are usually identical to those sold by the government, except for having different covers. How can these companies sell the same book for a lower price than the government and still cover their costs?

2.5 In 2008, Clay Bennett, the owner of the Seattle Supersonics basketball team, estimated that if the team remained in Seattle, he would suffer a loss of about $63 million over the following two seasons. If the team were allowed to move to Oklahoma City, he estimated that he would earn a profit of $19 million. What was the opportunity cost to Bennett of his team playing in Seattle rather than Oklahoma City? Briefly explain.


2.6 Suppose Jill Johnson operates her pizza restaurant in a building she owns in the center of the city. Similar buildings in the neighborhood rent for $4,000 per month. Jill is considering selling her building and renting space in the suburbs for $3,000 per month. Jill decides not to make the move. She reasons, "I would like to have a restaurant in the suburbs, but I pay no rent for my restaurant now, and I don't want to see my costs rise by $3,000 per month." What do you think of Jill's reasoning?

2.7 When the DuPont chemical company first attempted to enter the paint business, it was not successful. According to a company report, in one year it "lost nearly $500,000 in actual cash in addition to an expected return on investment of nearly $500,000, which made a total loss to the company of nearly a million." Why did this report include as part of the company's loss the amount it had expected to earn—but didn't—on its investment in manufacturing paint?


---

**10.3 The Marginal Product of Labor and the Average Product of Labor, pages 331–335**

**LEARNING OBJECTIVE:** Understand the relationship between the marginal product of labor and the average product of labor.

**Summary**

The marginal product of labor is the additional output produced by a firm as a result of hiring one more worker. Specialization and division of labor cause the marginal product of labor to rise for the first few workers hired. Eventually, the law of diminishing returns causes the marginal product of labor to decline. The average product of labor is the total amount of output produced by a firm divided by the quantity of workers hired. When the marginal product of labor is
greater than the average product of labor, the average product of labor increases. When the marginal product of labor is less than the average product of labor, the average product of labor decreases.

3.4 Use the numbers from problem 3.3 to draw one graph showing how total output increases with the quantity of workers hired and a second graph showing the marginal product of labor and the average product of labor.

3.5 A student looks at the data in Table 10-3 on page 331 and draws this conclusion: "The marginal product of labor is increasing for the first two workers hired, and then it declines for the next four workers. I guess each of the first two workers must have been hard workers. Then Jill must have had to settle for increasingly poor workers." Do you agree with the student's analysis? Briefly explain.

3.6 (Related to the Making the Connection on page 333) Briefly explain whether you agree with the following argument:

Adam Smith's idea of the gains to firms from the division of labor makes a lot of sense when the good being manufactured is something complex like automobiles or computers, but it doesn't apply in the manufacturing of less complex goods or in other sectors of the economy, such as retail sales.

3.7 Sally looks at her college transcript and says to Sam, "How is this possible? My grade point average for this semester's courses is higher than my grade point average for last semester's courses, but my cumulative grade point average still went down from last semester to this semester." Explain to Sally how this is possible.

3.8 Is it possible for a firm to experience a technological change that would increase the marginal product of labor while leaving the average product of labor unchanged? Explain.

The Relationship between Short-Run Production and Short-Run Cost, pages 335-337

LEARNING OBJECTIVE: Explain and illustrate the relationship between marginal cost and average total cost.

Summary

The marginal cost of production is the increase in total cost resulting from producing another unit of output. The marginal cost curve has a U shape because when the marginal product of labor is rising, the marginal cost of output is falling. When the marginal product of labor is falling, the marginal cost of output is rising. When marginal cost is less than average total cost, average total cost falls. When marginal cost is greater than average total cost, average total cost rises.

4.1 If the marginal product of labor is rising, is the marginal cost of production rising or falling? Briefly explain.

4.2 Explain why the marginal cost curve intersects the average total cost curve at the level of output where average total cost is at a minimum.
Problems and Applications

4.3 Is it possible for average total cost to be decreasing over a range of output where marginal cost is increasing? Briefly explain.

4.4 Suppose a firm has no fixed costs, so all its costs are variable, even in the short run.
   a. If the firm’s marginal costs are continually increasing (that is, marginal cost is increasing from the first unit of output produced), will the firm’s average total cost curve have a U shape?
   b. If the firm’s marginal costs are $5 at every level of output, what shape will the firm’s average total cost have?

4.5 (Related to Solved Problem 10-4 on page 337) Is Jill Johnson right or wrong when she says the following: “Currently, I am producing 20,000 pizzas per month at a total cost of $75,000. If I produce 20,001 pizzas, my total cost will rise to $75,002. Therefore, my marginal cost of producing pizzas must be increasing.” Illustrate your answer with a graph.

4.6 (Related to Solved Problem 10-4 on page 337) (This problem is somewhat advanced.) Using symbols, we can write that the marginal product of labor is equal to \( \Delta Q/\Delta L \). Marginal cost is equal to \( \Delta TC/\Delta Q \). Because fixed costs by definition don’t change, marginal cost is also equal to \( \Delta VC/\Delta Q \). If Jill Johnson’s only variable cost is labor cost, then her variable cost is just the wage multiplied by the quantity of workers hired, \( wL \).
   a. If the wage Jill pays is constant, then what is \( \Delta VC \) in terms of \( w \) and \( L \)?
   b. Use your answer to question (a) and the expressions given above for the marginal product of labor and the marginal cost of output to find an expression for marginal cost, \( \Delta TC/\Delta Q \), in terms of the wage, \( w \), and the marginal product of labor, \( \Delta Q/\Delta L \).
   c. Use your answer to question (b) to determine Jill’s marginal cost of producing pizzas if the wage is $750 per week and the marginal product of labor is 150 pizzas. If the wage falls to $600 per week and the marginal product of labor is unchanged, what happens to Jill’s marginal cost? If the wage is unchanged at $750 per week and the marginal product of labor rises to 250 pizzas, what happens to Jill’s marginal cost?

10.5 Graphing Cost Curves, page 338

LEARNING OBJECTIVE: Graph average total cost, average variable cost, average fixed cost, and marginal cost.

Summary

Average fixed cost is equal to fixed cost divided by the level of output. Average variable cost is equal to variable cost divided by the level of output. Figure 10-5 on page 339 shows the relationship among marginal cost, average total cost, average variable cost, and average fixed cost. It is one of the most important graphs in microeconomics.

Review Questions

5.1 As the level of output increases, what happens to the value of average fixed cost?

5.2 As the level of output increases, what happens to the difference between the value of average total cost and average variable cost?

Problems and Applications

5.3 Suppose the total cost of producing 10,000 tennis balls is $30,000, and the fixed cost is $10,000.
   a. What is the variable cost?
   b. When output is 10,000, what are the average variable cost and the average fixed cost?
   c. Assuming that the cost curves have the usual shape, is the dollar difference between the average total cost and the average variable cost greater when the output is 10,000 tennis balls or when the output is 30,000 tennis balls? Explain.

5.4 One description of the costs of operating a railroad makes the following observation: “The fixed . . . expenses which attach to the operation of railroads . . . are in the nature of a tax upon the business of the road; the smaller the [amount of] business, the larger the tax.” Briefly explain why fixed costs are like a tax. In
what sense is this tax smaller when the amount of business is larger?


5.5 In the ancient world, a book could be produced either on a scroll or as a codex, which was made of folded sheets glued together, something like a modern book. One scholar has estimated the following variable costs (in Greek drachmas) of the two methods:

<table>
<thead>
<tr>
<th>Cost of writing (wage of a scribe)</th>
<th>SCROLL</th>
<th>CODEX</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.33 drachmas</td>
<td>11.33 drachmas</td>
<td></td>
</tr>
<tr>
<td>Cost of paper</td>
<td>16.50 drachmas</td>
<td>9.25 drachmas</td>
</tr>
</tbody>
</table>

Another scholar points out that a significant fixed cost was involved in producing a codex:

In order to copy a codex . . . the amount of text and the layout of each page had to be carefully calculated in advance to determine the exact number of sheets . . . needed. No doubt, this is more time-consuming and calls for more experimentation than the production of a scroll would. But for the next copy, these calculations would be used again.

a. Suppose that the fixed cost of preparing a codex was 58 drachmas and that there was no similar fixed cost for a scroll. Would an ancient book publisher who intended to sell 5 copies of a book be likely to publish it as a scroll or as a codex? What if he intended to sell 10 copies? Briefly explain.

b. Although most books were published as scrolls in the first century A.D., by the third century, most were published as codices. Considering only the factors mentioned in this problem, explain why this change may have taken place.


5.6 Use the information in the following graph to find the values for the following at an output level of 1,000.

a. Marginal cost
b. Total cost
c. Variable cost
d. Fixed cost

5.7 List the errors in the following graph. Carefully explain why the curves drawn this way are wrong. In other words, why can’t these curves be as they are shown in the graph?

5.8 Explain how the listed events (a–d) would affect the following at Southwest Airlines:

i. Marginal cost
ii. Average variable cost
iii. Average fixed cost
iv. Average total cost

a. Southwest signs a new contract with the Transport Workers Union that requires the airline to increase wages for its flight attendants.
b. The federal government starts to levy a $20 per passenger carbon emissions tax on all commercial air travel.
c. Southwest decides on an across-the-board 10 percent cut in executive salaries.
d. Southwest decides to double its television advertising budget.
Costs in the Long Run, pages 338-343

LEARNING OBJECTIVE: Understand how firms use the long-run average cost curve in their planning.

Summary

The long-run average cost curve shows the lowest cost at which a firm is able to produce a given level of output in the long run. For many firms, the long-run average cost curve falls as output expands because of economies of scale. Minimum efficient scale is the level of output at which all economies of scale have been exhausted. After economies of scale have been exhausted, firms experience constant returns to scale, where their long-run average cost curve is flat. At high levels of output, the long-run average cost curve turns up as the firm experiences diseconomies of scale.

Review Questions

6.1 What is the difference between total cost and variable cost in the long run?
6.2 What is minimum efficient scale? What is likely to happen in the long run to firms that do not reach minimum efficient scale?
6.3 What are economies of scale? What are diseconomies of scale? What is the main reason that a firm eventually encounters diseconomies of scale as it keeps increasing the size of its store or factory?

Problems and Applications

6.4 Factories for producing computer chips are called "fabs." As the semiconductors used in computer chips have become smaller and smaller, the cost of the machines necessary to make them have become more and more expensive. According to an article in the Economist magazine:

To reach the economies of scale needed to make such investments pay, chipmakers must build bigger fabs. . . . In 1966 a new fab cost $14 million. By 1995 the price had risen to $1.5 billion. Today, says Intel, the cost of a leading-edge fab exceeds $6 billion.

Why would the rising costs of chipmaking machines lead chipmaking companies, such as Intel, to build larger factories?


6.5 [Related to Solved Problem 10-6 on page 341] Suppose that Jill Johnson has to choose between building a smaller restaurant and a larger restaurant. In the following graph, the relationship between costs and output for the smaller restaurant is represented by the curve $ATC_1$, and the relationship between costs and output for the larger restaurant is represented by the curve $ATC_2$.

- a. If Jill expects to produce 5,100 pizzas per week, should she build a smaller restaurant or a larger restaurant? Briefly explain.
- b. If Jill expects to produce 6,000 pizzas per week, should she build a smaller restaurant or a larger restaurant? Briefly explain.
- c. A student asks, "If the average cost of producing pizzas is lower in the larger restaurant when Jill produces 7,500 pizzas per week, why isn't it also lower when Jill produces 5,200 pizzas per week?" Give a brief answer to the student's question.

6.6 [Related to Solved Problem 10-6 on page 341] Consider the following description of U.S. manufacturing in the late nineteenth century:

When . . . Standard Oil . . . reorganized its refinery capacity in 1883 and concentrated almost two-fifths of the nation's refinery production in three huge refineries, the unit cost dropped from 1.5 cents a gallon to 0.5 cents. A comparable concentration of two-fifths of the nation's output of textiles or shoes in three plants would have been impossible, and in any case would have brought huge diseconomies of scale and consequently higher prices.

- a. Use this information to draw a long-run average cost curve for an oil-refining firm and a long-run average cost curve for a firm manufacturing shoes.
- b. Is it likely that there were more oil refineries or more shoe factories in the United States in the late nineteenth century? Briefly explain.
- c. Why would concentrating two-fifths of total shoe output in three factories have led to higher shoe prices?

6.7 (Related to Solved Problem 10-6 on page 341) An account of the difficulties of Japanese mobile-phone manufacturers argues that these firms made a mistake by concentrating on selling in high-income countries, while making little effort to sell in low-income countries:

The main growth in the wireless industry overall is in emerging markets, which need cheap phones. The world’s top three makers—Nokia, Samsung and Motorola—focus on this segment. . . . Japanese firms are caught in a vicious circle: because they are not selling to poor countries, their volume stays low, which keeps prices high, which makes selling to poor countries infeasible.

Why would the price of Japanese mobile phones be high because Japanese firms are producing these phones in low volumes? Use a graph like Figure 10-6 on page 340 to illustrate your answer.


6.8 (Related to Solved Problem 10-6 on page 341) In 2003, Time Warner and the Walt Disney Company discussed merging their news operations. Time Warner owns the Cable News Network (CNN), and Disney owns ABC News. After analyzing the situation, the companies decided that a combined news operation would have higher average costs than either CNN or ABC News had separately. Use a long-run average cost curve graph to illustrate why the companies did not merge their news operations.


6.9 (Related to the Making the Connection on page 342) Suppose that Henry Ford had continued to experience increasing returns to scale, no matter how large an automobile factory he built. Discuss what the implications of this would have been for the automobile industry.

6.10 (Related to the Making the Connection on page 342) According to one account of the problems DuPont had in entering the paint business, “the du Ponts had assumed that large volume would bring profits through lowering unit costs.” In fact, according to one company report, “The more paint and varnish we sold, the more money we lost.” Draw an average cost curve graph showing the relationship between paint output and the average cost DuPont expected. Draw another graph that explains the result that the more paint the company sold, the more money it lost.


6.11 Online booksellers have captured a very large portion of the retail book market over the past several years. Companies such as Amazon, Barnes & Noble, and Borders, which all have a large online presence, now dominate this market. According to the American Booksellers Association, over the past 15 years, the number of independent booksellers has fallen from 4,700 to 1,600. Briefly explain what role costs may have played in explaining the large decline in independent booksellers.

Source: Alex Beam, "Where Have All the Bookstores Gone?" New York Times, February 20, 2009.

6.12 (Related to the Don’t Let This Happen to You! on page 343) Explain whether you agree with the following statement: "Henry Ford expected to be able to produce cars at a lower average cost at his River Rouge plant. Unfortunately, because of diminishing returns, his costs were actually higher."

6.13 (Related to the Chapter Opener on page 325) Review the discussion at the beginning of the chapter of Akio Morita selling transistor radios in the United States. Suppose that Morita became convinced that Sony would be able to sell more than 75,000 transistor radios each year in the United States. What steps would he have taken?

6.14 TIAA-CREF is a retirement system for people who work at colleges and universities. For some years, TIAA-CREF also offered long-term care insurance to its customers. Before deciding to sell that business to MetLife, a large insurance company, TIAA-CREF’s chairman and chief executive officer explained the decision this way:

In recent years, the long-term care insurance market has experienced significant consolidation. A few large insurance companies now own most of the business. MetLife has 428,000 policies, for example—nearly 10 times the number we have—and can achieve economies of scale that we can’t. Over time, we would have had difficulty holding down premium rates.

Briefly explain what economies of scale have to do with the premiums (that is, the prices buyers have to pay for insurance policies) that insurance companies can charge for their policies.


6.15 In January, 2009, the U.S. Department of Agriculture released a report on the changing dynamics of the U.S. livestock industry. It concluded that: “U.S. livestock production is shifting to much larger enterprises, in part because of scale economies.” What are “scale economies”? What would scale economies have to do with livestock production shifting to much larger operations?