

7

Production and Cost

Production and Cost Are Behind Decisions About Supply

Having looked in the last chapter at what lies behind demand curves by examining how consumers make choices, in this chapter we turn to what lies behind supply curves by examining how producers decide what to produce. It is important to understand why firms exist and how they determine their costs, in both the short run and the long run.

This Is What You Need to Know

STEP 1

After studying this chapter you should be able to:

- Describe the nature of firms and markets.
- Explain the difference between accounting and economic costs and how they affect the determination of profits.
- Differentiate between the short run and long run.
- Describe the nature of short-run production, total product, marginal product, and average product.
- Differentiate among increasing, constant, and decreasing returns.
- Explain the importance of marginal costs in a firm's production decision.
- Describe and compare fixed costs, variable costs, average costs, and marginal costs.

- Use graphs to show the relationship between short-run average fixed cost, average variable cost, average total cost, and marginal cost curves.
- Describe long-run costs.
- Describe the reasons for economies and diseconomies of scale.

STEP 2

Review the Key Concepts

Firm: An economic institution that transforms resources (factors of production) into outputs for consumers.

Sole proprietor: A single owner of a business who supervises and manages the business and is subject to unlimited liability.

Partnership: Similar to a sole proprietorship, but involves more than one owner who shares the management of the business. Partnerships are also subject to unlimited liability.

Corporation: A business that has most of the legal rights of individuals, and in addition, can issue stock to raise capital. Stockholders' liability is limited to the value of their stock.

Profit: The difference between total revenue and total cost.

Total revenue: Price per unit times quantity sold.

Economic costs: The sum of explicit and implicit costs.

Explicit costs: Expenses paid directly to another economic entity, including wages, lease payments, taxes, and utilities.

Implicit costs: The opportunity costs of using resources that belong to the firm, including depreciation, depletion of business assets, and the opportunity cost of the firm's capital employed in the business.

Sunk costs: Costs that have been incurred and cannot be recovered, including, for example, funds spent on existing technology that has become obsolete and past advertising that has run in the media.

Accounting profit: The difference between total revenue and explicit costs.

Economic profits: Profits in excess of normal—that is, in excess of both explicit and implicit costs.

Normal profits: The return on capital necessary to keep investors satisfied and keep capital in the business over the long run.

Short run: A period during which at least one factor of production (resource) is fixed, or cannot be changed.

Long run: A period sufficient for firms to adjust all factors of production, including plant capacity.

Production: The process of turning inputs into outputs.

Marginal product: The change in output that results from a change in labor ($\Delta Q/\Delta L$).

Average product: Output per worker, found by dividing total output by the number of workers employed to produce that output (Q/L).

Increasing marginal returns: Result when a new worker hired adds more to total output than the previous worker hired, so that both average and marginal products are rising.

Diminishing marginal returns: Result when an additional worker adds to total output, but at a diminishing rate.

Fixed costs: Costs that do not change as a firm's output expands or contracts, often called overhead. These include items such as lease payments, administrative expenses, property taxes, and insurance.

Variable costs: Costs that vary directly with output fluctuations, including expenses such as labor and material costs.

Marginal cost: The change in total costs arising from the production of additional units of output ($\Delta TC/\Delta Q$). Since fixed costs do not change with output, marginal costs are the change in variable costs associated with additional production ($\Delta TVC/\Delta Q$).

Average fixed cost: Total fixed cost divided by output (FC/Q).

Average variable cost: Total variable cost divided by output (VC/Q).

Average total cost: Total cost divided by output (TC/Q). Average total cost is also equal to $AFC + AVC$.

Long-run average total cost (LRATC): The lowest unit cost at which any particular output can be produced in the long run, often facilitated by adjustment of plant size.

Economies of scale: Tendency of LRATC to decline as a firm's output increases. This results from specialization of labor and management, and potentially a better use of capital and complementary production techniques.

Constant returns to scale: A range of output at which average total costs are relatively constant. Fast-food restaurants and movie theaters are examples.

Diseconomies of scale: A range of output at which average total costs tend to increase. Firms often become so big that management becomes bureaucratic and unable to efficiently control its operations.

Economies of scope: Ability to produce and market goods at lower costs by producing a number of products that are interdependent.

Work Through the Chapter Tutorials

STEP 3

Firms, Profits, and Economic Costs

Frequently Asked Questions

Q: What are firms and what do they do?

A: Firms are economic institutions that transform inputs (factors of production) into outputs (products and services). Firms produce the goods and services we consume.

Q: How are entrepreneurs grouped?

A: Entrepreneurs are organized into three basic business structures: sole proprietorships, partnerships, and corporations.

Q: What is a sole proprietorship?

A: A sole proprietorship is composed of one owner who usually supervises the business's operation. Sole proprietorships are easily established and managed, but proprietors are limited in their ability to raise capital, and their personal assets are subject to unlimited liability.

Q: What is a partnership, and how does it differ from a sole proprietorship?

A: A partnership is similar to a sole proprietorship, except that it has more than one owner. Partnerships can raise capital more easily and spread around the management responsibilities, but as with sole proprietors, partners are subject to unlimited liability for the entire partnership.

Q: What is a corporation, and how does it differ from sole proprietorships and partnerships?

A: A corporation is a business structure that has most of the legal rights of individuals, and in addition, can issue stock to raise capital. Stockholders' liability is limited to the value of their stock. While the number of businesses organized as sole proprietorship is substantially greater than the number of corporations, much more of the nation's output is produced by corporations than by sole proprietorships.

Q: How are profits defined, and how do they relate to the goals of firms?

A: Profits are the difference between total revenue and total cost. Firms are assumed to seek to maximize their profits. Although firms may have other goals, profit maximization is the typical assumption economists use.

Q: How are economic costs defined?

A: Economic costs are separated into explicit (out-of-pocket) and implicit (opportunity) costs. Explicit costs are paid to some other entity. They include wages, lease expenses, taxes, and so on. Implicit costs are not directly paid to others. These costs include the depreciation and depletion of company assets, as well as the cost of the capital the firm employs.

Q: What are normal profits?

A: Economists define a normal return as the return on capital that keeps investors willing to invest their capital in an industry over the long run. Firms earning just this level of profit are said to be earning normal profits. Firms earning more than this are earning economic profits, and firms earning less are taking economic losses.

Q: How are the short and long run defined?

A: The short run is a period during which at least one factor of production is fixed, usually plant capacity. Firms can vary output in the short run by hiring more labor or changing other variable factors. In the long run, firms are able to vary all factors, including plant size. Moreover, existing firms can leave the industry, and new firms can enter.

Firms, Profits, and Economic Costs Quick Check

Circle the Correct Answer

- (T / F) Firms transform inputs and outputs into goods and services for consumers.
- (T / F) Corporations, relative to sole proprietorships, find it easier to gain access to funding because their liability is limited.
- (T / F) Total revenue is the difference between the amount of money a firm receives from the sale of its products and its total costs.
- (T / F) Total revenue equals number of units sold times price per unit.
- (T / F) Depreciation is an explicit cost.
- Which of the following is *not* an explicit cost in your new business?
 - rent
 - insurance
 - the amount of wages you pay yourself
 - the amount of wages you give up if you quit your old job to start your new business
- A normal rate of return on capital is:
 - a return that generates economic profits in excess of zero.
 - the same for every business and industry.
 - a profit just sufficient to keep investors satisfied and thus to keep capital in a business over the long run.
 - okay in the short run but not okay in the long run.
- Which of the following factors of production is usually assumed to be fixed in the short run?
 - quantity of raw materials purchased
 - number of workers employed
 - number of shifts a factory operates
 - plant size

9. Economic profits are equal to total revenue minus:
- explicit costs.
 - explicit and implicit costs.
 - implicit costs.
 - capital costs.
10. Opportunity costs:
- do not have to be considered in figuring profit.
 - are explicit costs.
 - are implicit costs.
 - are zero when economic profits are normal.
11. The long run is usually the longest, in terms of actual months and years, for:
- small, family-run businesses.
 - firms that use labor-intensive production methods.
 - large corporations that operate massive factories.
 - industries capable of making quick adjustments to changes in market demand.
- Score: _____

Answers: 1. F; 2. T; 3. F; 4. T; 5. F; 6. d; 7. c; 8. d; 9. b; 10. c; 11. c

If You Got 10 or 11 Correct

You have a good understanding of the nature of firms, entrepreneurs, profits, implicit and explicit costs, and the short run versus the long run. These are the basic concepts underlying production and cost. These are also the easiest ideas presented in the chapter. Go on to the next section, Production in the Short Run, and get ready for a little more of a challenge.

If You Didn't Get at Least 10 Correct

You need to do a few things. These are relatively intuitive concepts, so first take a moment and reread the list of terms you need to know. That may be enough to cement these concepts in your mind. If not, reread the first section of the chapter, and go back and make sure you know why you missed the questions you did. As you work through the next section, Production in the Short Run, this material should become clearer.

But before you move on, take a piece of paper, define explicit and implicit costs, and list three examples of each. Now define normal profits, think of an example of some small business earning economic profits, then have costs increase sufficiently to cause the firm to earn only normal profits. Keeping these four concepts straight will make the remaining material in the chapter a lot easier. ■

Production in the Short Run

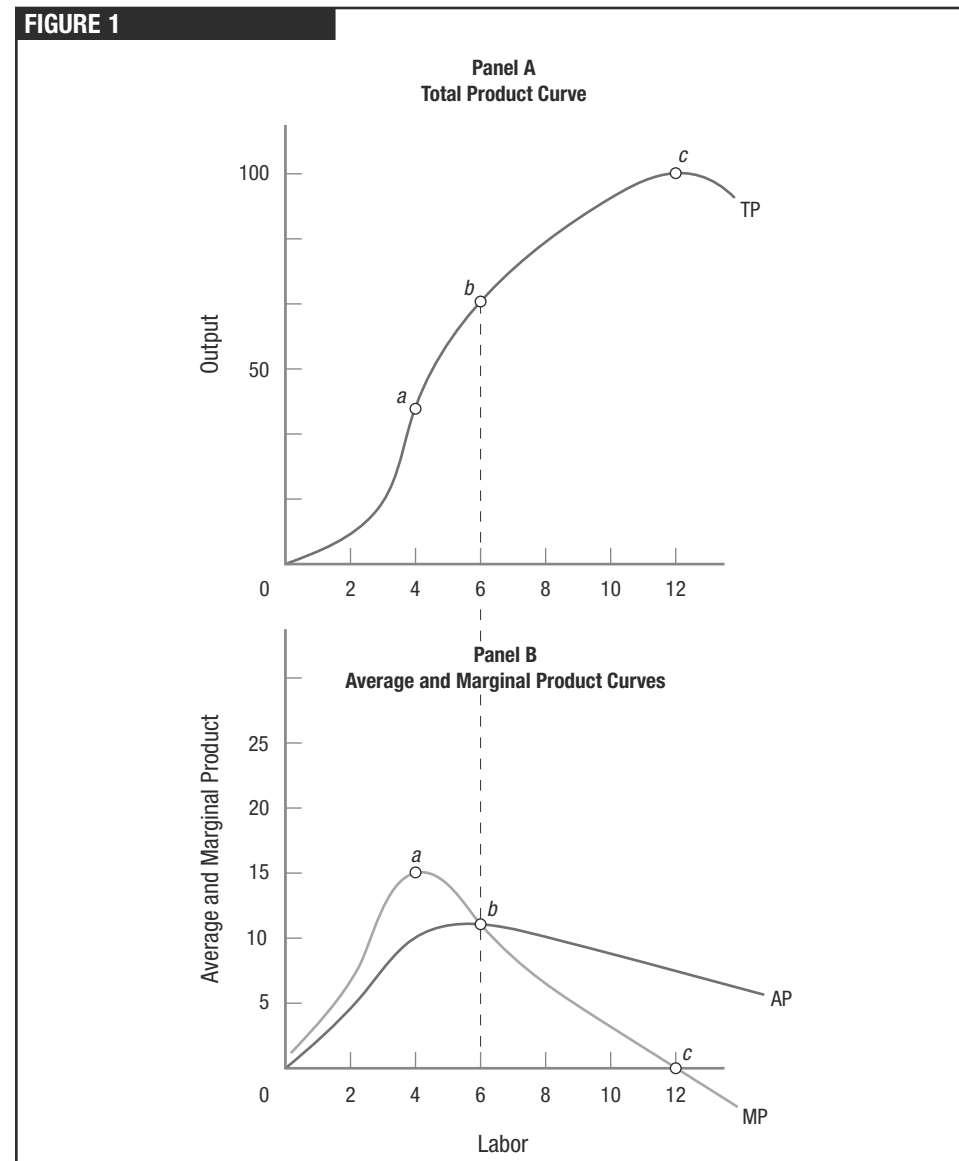
Frequently Asked Questions

Q: How are average and marginal products defined?

A: In the short run, firms can vary the output they produce by varying their labor inputs. The total product curve relates labor inputs to outputs. Marginal product is the change in output resulting from a change in labor input ($\Delta Q/\Delta L$). Marginal product is thus the change in output associated with hiring one additional worker. Average product or output per worker is equal to total output divided by labor input (Q/L).

Q: What do typical marginal and average product curves look like?

A: Figure 1 graphs total, average, and marginal product for a hypothetical firm. The marginal product curve cuts the average product curve at its maximum point (point *b*); once marginal product (the output from one additional worker) is less than average product, it pulls the average down (the movement from point *b* to *c*). Marginal returns diminish between points *a* and *c*, and negative returns occur after 12 workers are hired (point *c*).

**Q: What are increasing and decreasing returns?**

A: Typical production functions exhibit both increasing and decreasing returns. When increasing returns are present, each additional worker adds more to total output than previous workers. This can occur because of specialization. In the short run all production is eventually subject to the law of diminishing returns, whereby additional workers add less and less to total output.

Production in the Short Run Quick Check

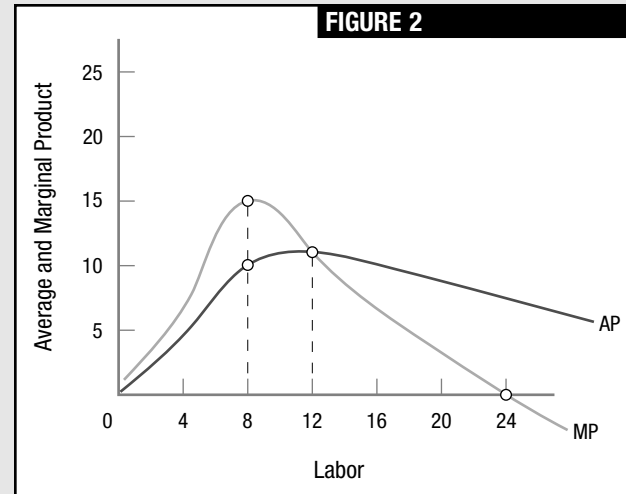
Circle the Correct Answer

- (T / F) Hiring additional workers invariably leads to increases in total output.
- (T / F) When marginal product is at a maximum, average product will always be at a maximum.
- If hiring an additional worker yields a negative marginal return:
 - hiring the additional worker will still raise total output, but at a diminishing rate.
 - hiring the additional worker will actually reduce total output.
 - hiring the additional worker will increase average product.
 - the additional worker will be paid a lower wage than other employees.

Use Figure 2 to answer questions 4 and 5.

- Going from eight workers to nine workers illustrates:
 - decreasing average returns.
 - diminishing marginal returns.
 - negative returns.
 - increasing returns.
- Rational firms would never hire more than how many workers?

a. 8	c. 22
b. 12	d. indeterminate



Score: ____

Answers: 1. F; 2. F; 3. b; 4. b; 5. c

If You Got All 5 Correct

Short-run production is not a problem for you. This is relatively difficult material, with its average and marginal product curves and the law of diminishing returns. Move on to the next section, Costs of Production, which builds on this section.

If You Didn't Get All of Them Correct

You should review this section. First, reread the text. Then keep the following in mind and work through the solved problem on the next page.

Key Point to Remember

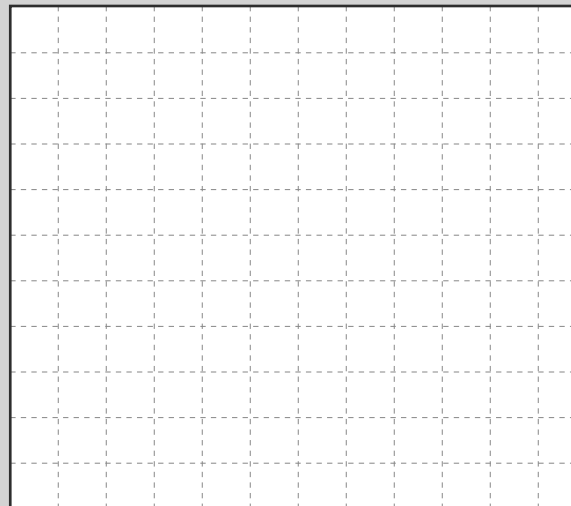
Remember that in the short run, at least one factor of production is fixed (usually capital or plant size). Therefore, output varies directly with labor input. *Average product* is average output per worker, or Q/L . If 10 workers can produce 200 units of output, then average product is 20. *Marginal product* is the extra output the firm produces when one more worker is hired. So, if 10 workers can produce 200 units, the firm hires a new worker (the 11th), and total output rises to 225, then marginal product is 25 ($\Delta Q = 25$, $\Delta L = 1$, so $\Delta Q/\Delta L = 25/1 = 25$).

Don't make this material harder than it is. It is really quite straightforward. Take some time and review the solved problem that follows. It will help you a lot when you get to the next section, Costs of Production.

Solved Problem: Production in the Short Run

Complete the following table, and graph average product and marginal product in the grid provided. Try to complete this before looking at the solution. After you have completed this review, move on to Final Check.

L	Q	MP	AP
0	0		
1	14		
2	30		
3	50		
4	80		
5	108		
6	130		
7	150		
8	168		
9	180		

**Solution Discussion**

Values for marginal and average product are shown in the table. Both marginal and average product initially increase; then marginal product declines until they are roughly equal when 6 units of output are produced. After that, both continue to decline.

L	Q	MP	AP
0	0	—	—
1	14	14	14.00
2	30	16	15.00
3	50	20	16.66
4	80	30	20.00
5	108	28	21.60
6	130	22	21.66
7	150	20	21.42
8	168	18	21.00
9	180	12	20.00

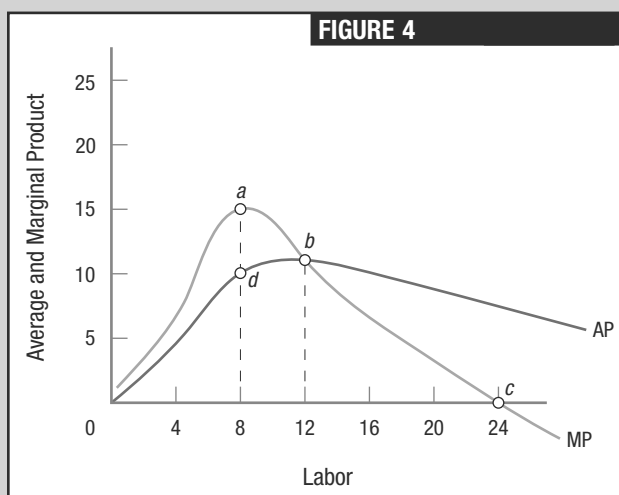
Both marginal and average product are shown in Figure 3.



Production in the Short Run Final Check

- (T / F) Marginal product is the change in output that results from hiring one additional worker.
- (T / F) Total product equals average product plus marginal product.
- (T / F) The production process for this good exhibits increasing returns up to the eighth worker and diminishing returns after the eighth worker.

Use Figure 4 to answer questions 4–6.



- Should the firm hire more than eight workers?
 - No, because that is where production is maximized.
 - No, because after that the firm will face diminishing returns.
 - No, because after that the firm faces negative returns.
 - Yes, because average and marginal product are still positive.
- After which point will there be negative returns?
 - a*
 - b*
 - c*
 - d*
- Average product will be at its maximum when marginal product:
 - is at its maximum.
 - is zero.
 - equals average product.
 - Average product never reaches a maximum.

Score: _____

Answers: 1. T; 2. F; 3. T; 4. d; 5. c; 6. c

You should not have missed any in this quiz. Average and marginal product are the underlying concepts for the cost curves in the next section. Continue on, but you may have to review this section if you begin to have problems with cost curves. The next section, on costs, however, gives you further practice with marginal and average calculations. As you work through these problems, the concepts from production may take hold. This is fundamental material that may take a little time to absorb. ■

Costs of Production

Frequently Asked Questions

Q: What are fixed and variable costs?

A: In the short run, firms have fixed and variable costs. Fixed costs, or overhead, are those the firm incurs whether it produces anything or not and will not vary with the level of output. These costs include administrative overhead, lease payments, and insurance. Variable costs are those that vary directly with output, such as wages, utilities, and raw materials costs. Total costs are equal to total fixed costs plus total variable costs ($TC = TFC + TVC$).

Q: How are average total costs, average fixed costs, and average variable costs computed?

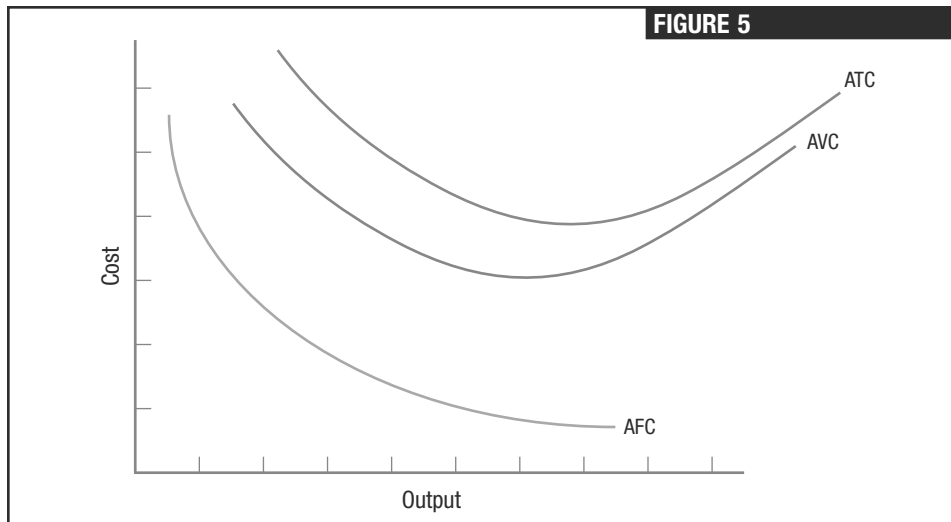
A: *Average total cost* (ATC) is total cost per unit of production, or TC/Q . *Average fixed cost* (AFC) is equal to TFC/Q , and *average variable cost* (AVC) is equal to TVC/Q . Consequently, $ATC = AFC + AVC$.

Core Equations: Cost Equations

Key Points	
$TC = TFC + TVC$	Total costs are split into fixed and variable costs. Fixed costs do not vary with output; variable costs do.
$ATC = TC/Q = AFC + AVC$	Average total costs are equal to total costs divided by output, which is also equal to the sum of average fixed costs and average variable costs.
$MC = \Delta TC/\Delta Q = \Delta TVC/\Delta Q$	Marginal cost is equal to the change in total costs associated with a change in output. Since fixed costs do not change when output changes, marginal cost is also equal to a change in total variable costs divided by the change in output.

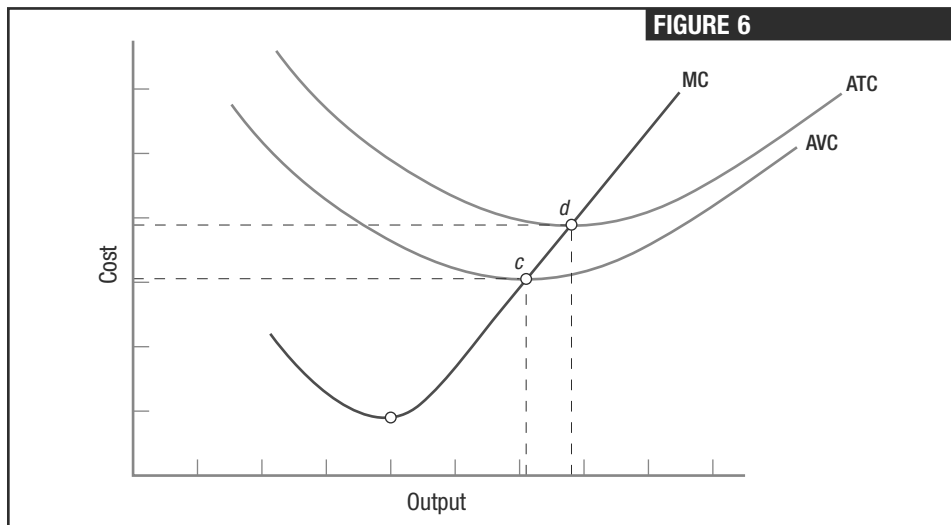
Q: What do typical ATC, AFC, and AVC curves look like when graphed?

A: Figure 5 graphs average total cost, average fixed cost, and average variable cost. Average fixed cost declines continuously as output increases, because this fixed amount of cost is being spread over larger quantities of output. In contrast, average variable cost and average total cost first decrease, then increase because of diminishing returns.



Q: How are marginal costs defined and graphed?

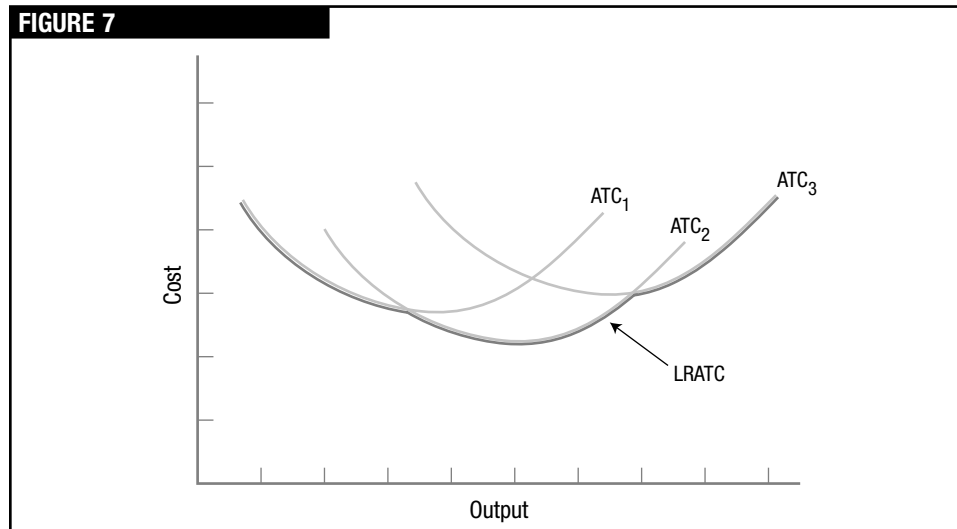
A: Marginal cost (MC) is the change in total costs associated with producing one additional unit. Since fixed costs do not change in the short run ($\Delta TFC = 0$), marginal cost is equal to the change in variable costs when one additional unit is produced; hence, $MC = \Delta TVC / \Delta Q$. Figure 6 graphs marginal cost along with average variable cost and average total cost. Marginal costs cut the average variable cost curve and the average total cost curve at their minimum points.



Q: How is the long-run average total cost curve (LRATC) determined?

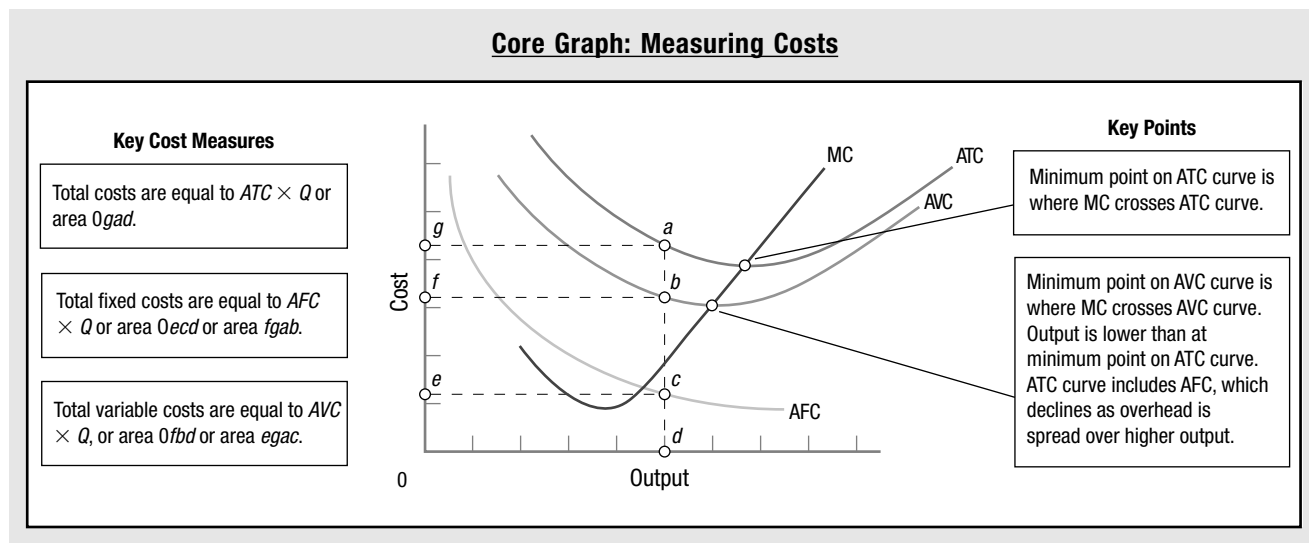
A: In the long run, all factors of production are variable, and firms can enter or leave the industry. The LRATC is the efficient set and is the lowest unit cost (ATC) for any specific output level in the long run. Figure 7 graphs the LRATC curve

as the minimum parts of several short-run average cost curves, using the assumption that in the long run, firms will build plants of the size best fitting the levels of output desired.



Q: Why do firms face economies and diseconomies of scale?

A: With falling LRATC, economies of scale associated with larger firm size result from such factors as specialization in labor and management. As a firm grows, the average cost of production falls. Eventually, however, a firm will encounter diseconomies of scale when it becomes so large that efficient management becomes impossible. At this point, average costs begin to rise. Today, advanced computer and communications technologies have radically increased the limit on the size of firms that can be efficiently managed.



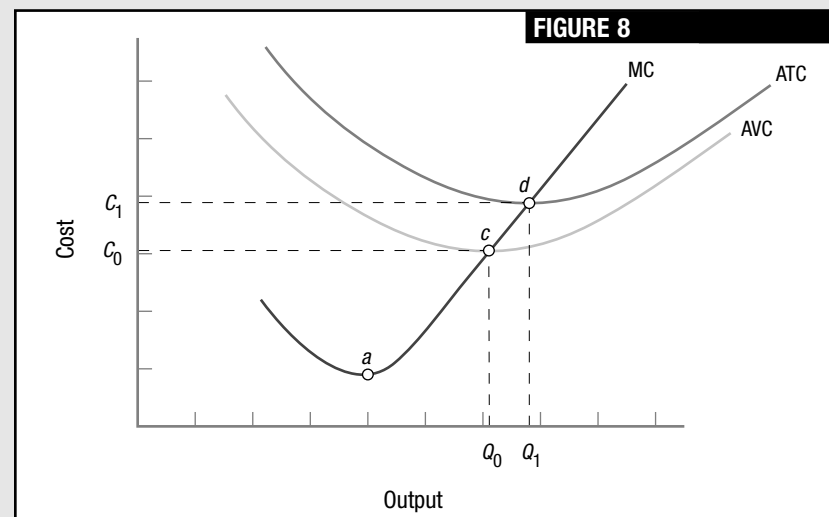
Costs of Production Quick Check

Circle the Correct Answer

- (T / F) Fixed costs include insurance and rent.
- (T / F) Average variable costs equal average total costs minus average fixed costs.
- (T / F) Fixed costs do not vary with the level of output.
- (T / F) Total variable costs vary inversely with the level of output.
- (T / F) With economies of scale the LRATC curve will be downward sloping.
- In Figure 8, at what point will average variable cost exactly equal the cost of hiring one additional worker?
 - c
 - d
 - cannot tell because average fixed costs are not included
 - at the minimum point of the marginal cost curve
- A firm's LRATC curve is formed by combining a number of curves that represent:
 - the firm's average total costs at various times, plant size being held constant.
 - the firm's average variable cost, average fixed cost, and marginal cost.
 - the firm's total product, average product, and marginal product.
 - the firm's short-run average total costs for a variety of plant sizes.
- Diseconomies of scale result when:
 - fixed costs are large.
 - a firm shrinks so much that individual workers must perform multiple tasks.
 - a firm grows so large that it becomes difficult to manage in an efficient manner.
 - a firm grows large enough that it can purchase advanced machinery.

Score: ____

Answers: 1.T; 2.T; 3.T; 4.F; 5.T; 6.a; 7.d; 8.c



If You Got 7 or 8 Correct

Short-run and long-run costs are not a problem for you. You might find the Hints, Tips, and Reminders in the next section useful.

If You Didn't Get at Least 7 Correct

You will need to review this section again. Even though this is difficult material, it is essential that you understand costs of production and cost curves to be able to master the concepts of profit maximization and market structure analysis that follow in the next few chapters. Review this section in the text and be sure to work the Chapter-wide Practice Questions. When you have completed this work, study carefully the solved problem that follows. First, work the problem on your own, then read through the answer and the description of how each cost was determined. When you are done, take the short Final Quiz after this solved problem.

Solved Problem: Costs of Production

Complete the table, assuming that fixed costs are \$1,500 and wages are \$100 per worker.

L	Q	MP	AP	TVC	TC	ATC	AVC	MC
0	—	—	—	—	—	—	—	—
1	5	—	—	—	—	—	—	—
2	12	—	—	—	—	—	—	—
3	18	—	—	—	—	—	—	—
4	22	—	—	—	—	—	—	—
5	25	—	—	—	—	—	—	—

Solution Discussion

The table that follows shows the answers. Keep in mind that:

- Average product is equal to Q/L . Therefore, when three workers are hired, output is 18 and average product is 6 ($18/3 = 6$).
- Marginal product is equal to the change in output associated with an increase in labor, or $\Delta Q/\Delta L$. Thus, when the fourth worker is hired, output grows from 18 to 22 units, and marginal product is 4.
- Total variable cost in this case is just equal to labor cost, and each worker costs 100, so when five workers are hired, $TVC = 500$.
- Total cost is equal to total fixed cost plus total variable cost ($TC = TFC + TVC$). Fixed cost is 1,500, so adding 1,500 to TVC will give us total cost.
- Average total cost is total costs divided by output (TC/Q). Therefore, when output is equal to 12, total cost is 1,700 and $AVC = 1,700/12 = 141.7$.
- Average variable cost is equal to total variable cost divided by output. Thus, when output is equal to 22, total variable cost is 400, so $AVC = 400/22 = 18.2$.
- Marginal cost is just the change in total cost (but since fixed cost is fixed, we can use total variable cost) divided by the change in output. When labor goes from 3 to 4 units, output increases from 18 to 22 units, so marginal cost is $\Delta TVC/\Delta Q = 100/4 = 25$.

L	Q	MP	AP	TVC	TC	ATC	AVC	MC
0	—	—	—	—	1,500	—	—	—
1	5	5	5.0	100	1,600	320.0	20.0	20.0
2	12	7	6.0	200	1,700	141.7	16.7	14.3
3	18	6	6.0	300	1,800	100.0	16.7	16.7
4	22	4	5.4	400	1,900	86.4	18.2	25.0
5	25	3	5.0	500	2,000	80.0	20.0	33.3

If the firm has three workers, total cost is \$1,800. If the firm can sell the 18 units of output it produces for \$100 each, revenue to the firm is also \$1,800, so the firm breaks even (earns a normal profit—remember that the cost curves include opportunity costs).

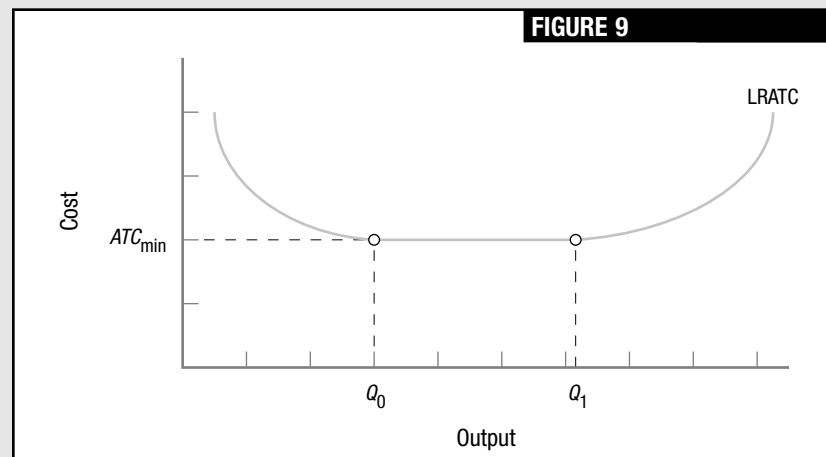
Now complete the Final Check section on the following page.

Costs of Production Final Check

- (T / F) Fixed cost is considered fixed in the short run but not in the long run.
- Average cost, or cost per unit of output (TC/Q), is equal to:
 - $TFC + TVC$.
 - $TFC/Q + TVC/Q$.
 - $TC - TFC/Q$.
 - $PVC + PDQ$.
- Which curve is *not* typically bowl-shaped?
 - the average total cost curve
 - the average fixed cost curve
 - the short-run average cost curve
 - the average variable cost curve
- In Figure 9, output in the range from Q_0 to Q_1 is considered:
 - economies of scale.
 - constant returns to scale.
 - diseconomies of scale.
 - an example of the law of diminishing returns.
- Marginal cost:
 - crosses through the minimum point of the total cost curve.
 - crosses through the minimum point of the ATC curve before crossing through the minimum point of the AVC curve.
 - crosses through the minimum point of the AVC before crossing through the minimum point of the ATC curve.
 - is equal to the change in average fixed costs divided by the change in output.

Score: _____

Answers: 1. T; 2. b; 3. b; 4. b; 5. c



You shouldn't miss any in this exercise. If you did, you are still having trouble with the material in this chapter. If you have consistently had problems with this chapter, start at the beginning, reread the text, and work through the material again to this point. Since cost and production are fundamental to much of the rest of the book, you will want to make sure you have these concepts down pat. ■

Consider These Hints, Tips, and Reminders

STEP 4

- Don't let the distinction between economic and accounting costs fool you. Accounting costs are essentially out of pocket; costs for which you pay cash or for which you write checks. Economic costs include accounting costs plus opportunity costs.

When you start a business, two opportunity costs are nearly always present. First, you quit a job (you were working, weren't you?), so you have given up that salary and benefits. Second, you put some of your savings (capital) that could have earned interest in the bank into the business. Adding these two opportunity costs to the explicit costs of running your business gives your economic costs. You will not earn an economic profit until all economic costs are covered. Your firm will earn a normal profit if the business *just* covers your economic costs.

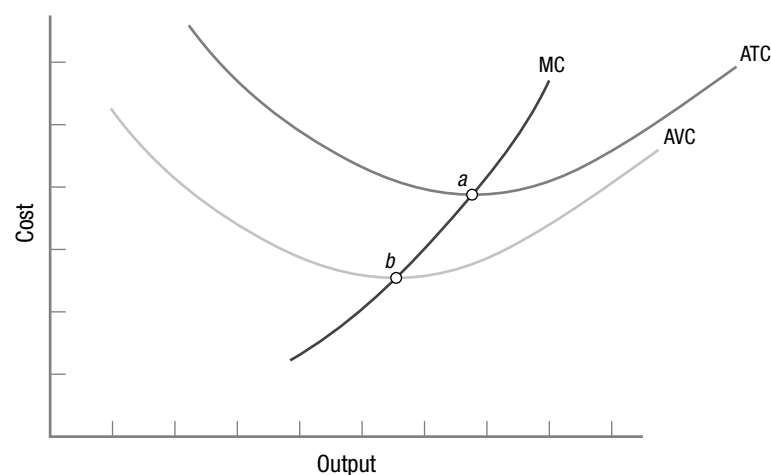
- The cost curves that economists draw include opportunity costs and therefore represent economic costs. Thus, when economists assume that total costs are equal to X , this X includes a reasonable return on the firm's capital invested in the business.

So when you see some report that says Company ABC earned an "obscene" accounting profit of so many billions of dollars, you should ask yourself, How much capital does this firm have invested, and after subtracting a reasonable return on its capital, how big is the resulting profit? Keep in mind that any profit that remains is economic profit.

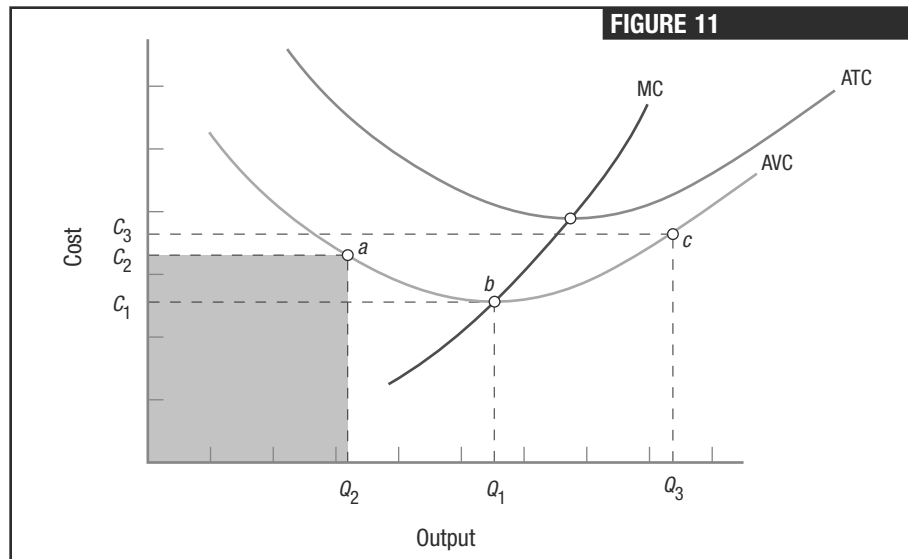
- The most important cost curves you learned about in this chapter are ATC, AVC, and MC. You will see and use these curves in the next three chapters. You need to be able to draw the curves fairly precisely, so remember: Both ATC and AVC are bowl-shaped, and MC passes through the minimum points on both curves.
- The best way to draw the ATC, AVC, and MC curves is to draw a positively sloped MC curve first, then draw the ATC and AVC curves. Figure 10 shows step by step how to construct the curves.
- You will need to become proficient with computing TVC from AVC and TC from ATC. Since $AVC = TVC/Q$, the relationship is straightforward: $TVC = AVC \times Q$. Similarly, $ATC = TC/Q$, so $TC = ATC \times Q$.

FIGURE 10

- Draw a positively sloped MC curve.
- Plot two points a and b that will represent the minimum points on the two average cost curves.
- Point a will be the minimum point on the ATC; and point b , the minimum point of the AVC curve. Point b will always occur at a lower output than point a , because $ATC = AVC + AFC$. As long as there are some fixed costs, point b on AVC will always be at a lower output than point a on ATC.
- Draw two bowl-shaped curves through these two points. The right tail on the AVC curve gets closer to the ATC curve, but never touches it because of the spreading of fixed costs. Label the curves and axes.



This is shown graphically in Figure 11. For the points a , b , and c on the AVC curve, TVC is just equal to $AVC \times Q$. For point a , this is $C_2 \times Q_2$, which is equal to the shaded area. For point b , TVC would be $C_1 \times Q_1$, and for point c it would be $C_3 \times Q_3$. These areas are not shaded. The exact same process applies for ATC and TC.



6. The LRAC curve exhibits economies of scale up to Q_0 , constant returns to scale from Q_0 to Q_1 , and diseconomies of scale after Q_1 .



Do the Homework for Chapter 7 Production and Cost

STEP 5

Instructor _____ Time _____ Student _____

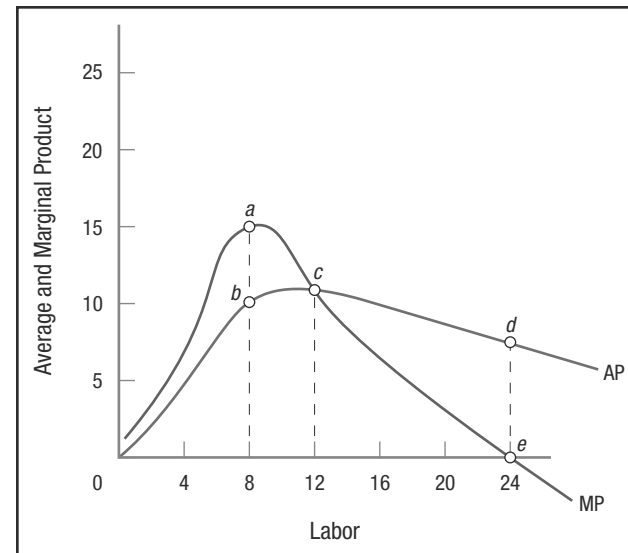
Use these blanks to record your answers to the homework questions.

- | | | | |
|----------|-----------|-----------|-----------|
| 1. _____ | 6. _____ | 11. _____ | 16. _____ |
| 2. _____ | 7. _____ | 12. _____ | 17. _____ |
| 3. _____ | 8. _____ | 13. _____ | 18. _____ |
| 4. _____ | 9. _____ | 14. _____ | 19. _____ |
| 5. _____ | 10. _____ | 15. _____ | 20. _____ |

1. Economic costs for the entrepreneur include:
 - a. rent on buildings.
 - b. utility and communications bills.
 - c. interest income forgone on the capital in the business.
 - d. All of the answers are correct.
2. Which of the following costs are usually assumed to be fixed?
 - a. leases on buildings
 - b. utility bills
 - c. wages and salaries
 - d. All of the answers are correct.
3. Which of the following differentiates the short run from the long run?
 - a. the time it takes the firm to hire another CEO
 - b. one variable factor of production
 - c. the rate at which firms can vary labor
 - d. one fixed factor of production
4. Total profits are defined as:
 - a. the difference between total costs and variable costs.
 - b. what is left after variable costs are subtracted from total revenues.
5. Normal profits are:
 - a. explicit costs plus implicit costs.
 - b. necessary to keep investors willing to put capital into a firm.
 - c. a rate of return on capital just equal to the average for the industry.
 - d. zero as reported to the Internal Revenue Service.
6. The long run is defined by the fact that:
 - a. firms inevitably earn losses.
 - b. firms continue to change production techniques to earn economic profits.
 - c. firms are able to vary all of the factors of production.
 - d. the plant capacity of firms is fixed.
7. Subtracting total costs from total revenues yields:
 - a. fixed costs.
 - b. variable costs.
 - c. the rate of return to the firm.
 - d. profit.
8. The difference between total revenues and total costs is:
 - a. profit.
 - b. implicit costs.
 - c. explicit costs.
 - d. economic profit.
9. The difference between total revenues and total costs is:
 - a. profit.
 - b. implicit costs.
 - c. explicit costs.
 - d. economic profit.
10. The difference between total revenues and total costs is:
 - a. profit.
 - b. implicit costs.
 - c. explicit costs.
 - d. economic profit.
11. The difference between total revenues and total costs is:
 - a. profit.
 - b. implicit costs.
 - c. explicit costs.
 - d. economic profit.
12. The difference between total revenues and total costs is:
 - a. profit.
 - b. implicit costs.
 - c. explicit costs.
 - d. economic profit.
13. The difference between total revenues and total costs is:
 - a. profit.
 - b. implicit costs.
 - c. explicit costs.
 - d. economic profit.
14. The difference between total revenues and total costs is:
 - a. profit.
 - b. implicit costs.
 - c. explicit costs.
 - d. economic profit.
15. The difference between total revenues and total costs is:
 - a. profit.
 - b. implicit costs.
 - c. explicit costs.
 - d. economic profit.
16. The difference between total revenues and total costs is:
 - a. profit.
 - b. implicit costs.
 - c. explicit costs.
 - d. economic profit.
17. The difference between total revenues and total costs is:
 - a. profit.
 - b. implicit costs.
 - c. explicit costs.
 - d. economic profit.
18. The difference between total revenues and total costs is:
 - a. profit.
 - b. implicit costs.
 - c. explicit costs.
 - d. economic profit.
19. The difference between total revenues and total costs is:
 - a. profit.
 - b. implicit costs.
 - c. explicit costs.
 - d. economic profit.
20. The difference between total revenues and total costs is:
 - a. profit.
 - b. implicit costs.
 - c. explicit costs.
 - d. economic profit.

Use Figure HW-1 to answer questions 8–11.

8. At which point will hiring a new worker add the most to total output of the firm?
9. At which point will each worker produce the most output?
10. Point *a* to point *e* on the marginal product (MP) curve illustrates:
 - a. the law of increasing returns.
 - b. constant returns to scale.
 - c. the law of diminishing returns.
 - d. falling average product.
11. When 12 workers are hired, which of the following is *not* true?
 - a. Marginal product is higher than average product.
 - b. Marginal product is declining.
 - c. Average product is equal to marginal product.
 - d. Average product is at its maximum.

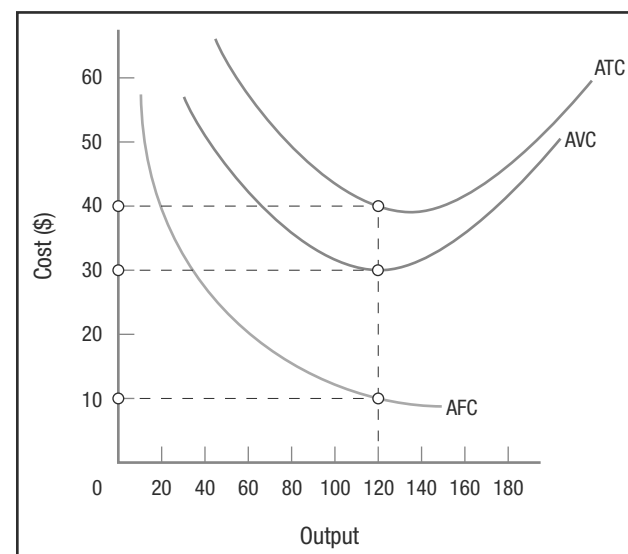


HW-1

12. Marginal cost equals the change in:
 - a. average total costs divided by the change in output.
 - b. total variable costs divided by the change in output.
 - c. total fixed costs divided by the change in output.
 - d. total costs minus the change in fixed costs.

Use Figure HW-2 to answer questions 13–16.

13. At output 120, total fixed costs are equal to:
14. At output 120, total variable costs are equal to:
15. At output 120, total costs are equal to:
16. At output 120, marginal cost is equal to:



HW-2

-
17. When the average total cost curve is rising, the marginal cost curve will be:
- falling.
 - above the average total cost curve.
 - rising more slowly than the average variable cost curve.
 - rising more slowly than the average total cost curve.
18. Which of the following helps generate economies of scale as firms grow larger?
- A growing rift between management and workers.
 - The inability of large firms to efficiently use their natural resources.
 - Larger firms are able to purchase and implement more advanced equipment.
 - The labor force becomes too large to efficiently manage.
19. Firms that are so large that they are difficult to manage in an efficient manner exhibit (economies of, constant returns to, diseconomies of) _____ scale.
20. The firm's long-run average total cost curve is derived from:
- the short-run marginal cost curves of the firm.
 - the summation of the firm's average variable cost and average fixed cost curves.
 - the firm's short-run average cost curves for different plant sizes.



Use the ExamPrep to Get Ready for Exams

STEP 6

This sheet (front and back) is designed to help you prepare for your exams. The chapter has been boiled down to its key concepts. You are asked to answer questions, define terms, draw graphs, and, if you wish, add summaries of class notes.

Firms, Profits, and Economic Costs

Define each of the following terms.

Firm:

Sole proprietorship:

Partnership:

Corporation:

Profit:

Explicit costs:

Accounting profit:

Normal profit:

Economic profit:

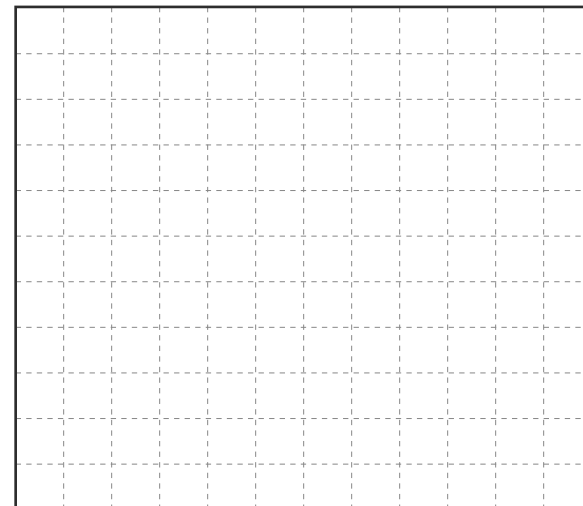
Short run:

Long run:

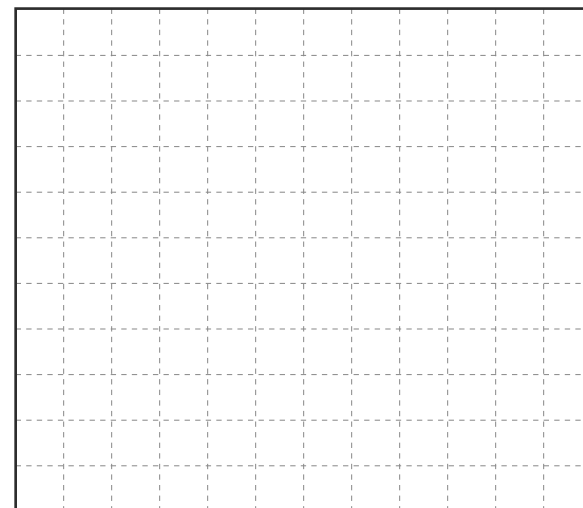
Production in the Short Run

Use the grids at right for the following:

- Draw a total product curve in panel A.
- In panel B, draw marginal and average product curves.
- Label the areas of increasing returns, diminishing returns, and negative returns.



Panel A



Panel B

Costs of Production

Define the following, using formulas where appropriate.

Fixed costs:

Variable costs:

Average fixed costs:

Average variable costs:

Average total costs:

Marginal costs:

Use the grid to illustrate the following short-run curves.

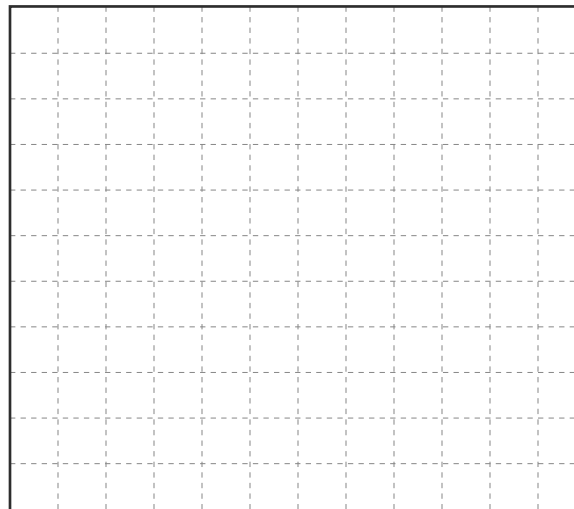
Average fixed costs

Average variable costs

Average total costs

Marginal costs

(*Hint:* Keep in mind that the minimum point on the AVC curve comes at a lower output than the minimum point on the ATC curve. Also, the marginal cost curve goes through both minimum points.)



Describe the long-run average total cost curve:

Describe economies and diseconomies of scale:

Describe the role technology plays in reducing long-run average cost:

Additional Study Help: Chapter-wide Practice Questions

Matching

Match the description with the corresponding term.

- ___ 1. Firms
- ___ 2. Total revenue
- ___ 3. Economic costs
- ___ 4. Explicit costs
- ___ 5. Implicit costs
- ___ 6. Economic profits
- ___ 7. Normal profits
- ___ 8. Short run
- ___ 9. Long run
- ___ 10. Production
- ___ 11. Average product
- ___ 12. Marginal product
- ___ 13. Fixed costs
- ___ 14. Variable costs
- ___ 15. Marginal costs
- ___ 16. Economies of scale
- ___ 17. Diseconomies of scale
- ___ 18. Constant returns to scale

- a. Costs a firm pays in the course of doing business, including both explicit and implicit costs.
- b. The period over which one production factor, usually plant capacity, is fixed.
- c. A firm's output per unit of labor input.

- d. Costs that change with the level of production.
- e. The profit level at which revenue exceeds both implicit and explicit costs.
- f. Costs that do not change with the level of production in the short run.
- g. A range of production output at which long-run average total costs remain the same.
- h. The range of production output at which long-run average total cost goes up as output goes up.
- i. The minimum level of profits necessary to keep investors willing to put capital in a firm.
- j. A period over which all production variables, including plant capacity and number of firms in the market, can change.
- k. Institutions or organizations that produce goods and services by transforming inputs into outputs.
- l. The money a firm actually pays out while doing business.
- m. A firm's output.
- n. The amount of additional output produced by adding one more worker.
- o. The opportunity costs of doing business.
- p. The cost to a firm to produce one more unit of output.
- q. The money a firm brings in from selling its goods or services.
- r. The range of production output at which long-run average total cost goes down as output goes up.

Fill-In

Choose the word(s) in parentheses that complete the sentence.

1. The risks associated with production are assumed by (labor, capital, entrepreneurs) _____.
2. Price times units sold is equal to (explicit costs, total revenue, implicit costs, sunk costs, normal profits, economic profits) _____. Out-of-pocket expenses are (explicit costs, total revenue, implicit costs, sunk costs, normal profits, economic profits) _____. Opportunity costs are (explicit costs, total revenue, implicit costs, sunk costs, normal profits, economic profits) _____. Profits that just equal a normal rate of return are (explicit costs, total revenue, implicit costs, sunk costs, normal profits, economic profits) _____. Profits in excess of a normal return are called (explicit costs, total revenue, implicit costs, sunk costs, normal profits, economic profits) _____.
3. Total output divided by number of workers is equal to (marginal, average, total) _____ product. The change in total output divided by the change in the number of employees is equal to (marginal, average, total) _____ product.
4. Costs that do not change in the short run are called (fixed, variable, average, marginal) _____ costs. Labor and wages are an example of (fixed, variable, average, marginal) _____ costs. The costs that change when additional labor is hired are (fixed, variable, average, marginal) _____. Cost per unit is (fixed, variable, average, marginal) _____.

5. As output increases, marginal cost first passes through the minimum point on the (average total, average variable) _____ cost curve, then passes through the minimum point on the (average total, average variable) _____ cost curve.
6. When long-run average total costs are rising, firms are encountering (economies, diseconomies) _____ of scale, and when long-run average total costs are falling, firms are facing (economies, diseconomies) _____ of scale.

True / False

Circle the correct answer.

- T / F 1. Firms located in areas with high labor costs tend to use labor-intensive production methods.
- T / F 2. A firm's primary goal is to maximize its profits.
- T / F 3. Explicit costs include all out-of-pocket expenses.
- T / F 4. Total revenue is the amount of money a firm receives from the sale of its products or services.
- T / F 5. Investors will remove capital from a firm earning zero economic profit.
- T / F 6. In the short run, plant capacity is generally assumed to be fixed.
- T / F 7. In the long run, all factors of production may vary, but the number of firms remains fixed.
- T / F 8. Marginal product remains the same no matter what the level of output.
- T / F 9. Marginal product is the change in profit that results from adding one worker.
- T / F 10. The law of diminishing returns states that adding additional workers adds to total output, but at a diminishing rate.
- T / F 11. In the long run, all costs are fixed.
- T / F 12. Variable costs include wages and expenditures for raw materials.
- T / F 13. Average total cost is equal to average fixed cost minus average variable cost.
- T / F 14. Marginal cost equals change in output plus change in total variable costs over change in output.
- T / F 15. The marginal cost curve will always intersect the maximum points of both the average variable cost curve and the average total cost curve.
- T / F 16. Firms encounter constant returns to scale indefinitely as they grow.
- T / F 17. Diseconomies of scale are caused by inefficiency once a firm grows past a certain point.

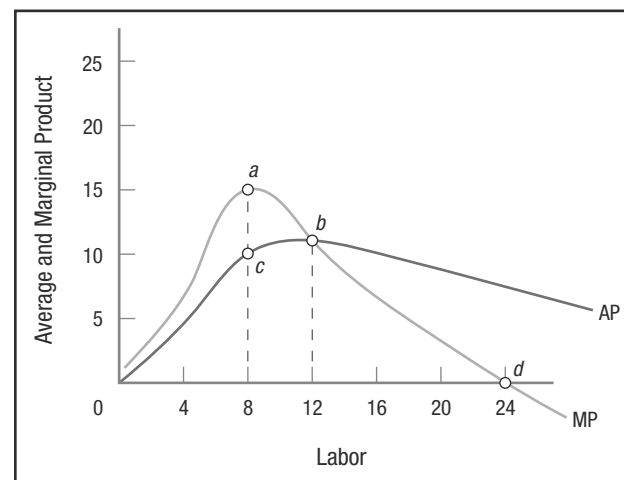
Multiple-Choice

Circle the correct answer.

1. Firms:
- operate in only one market.
 - produce goods and services.
 - try to achieve zero profits.
 - transform products into inputs.
2. Firms use low-technology, labor-intensive production methods in areas where:
- labor is scarce and expensive.
 - technology is advanced and inexpensive.
 - labor is plentiful and cheap.
 - product inputs are expensive.
3. The difference between a firm's total revenue and its total cost is:
- profit.
 - operating margin.
 - marginal income.
 - marginal return.
4. As a rule, firms try to maximize:
- sales.
 - market share.
 - customer satisfaction.
 - profits.
5. Number of units sold times price per unit equals:
- marginal revenue.
 - net profit.
 - total revenue.
 - gross profit.

6. A firm's out-of-pocket expenses are:
- explicit costs.
 - implicit costs.
 - marginal costs.
 - fixed costs.
7. Which of the following is an explicit cost?
- opportunity costs
 - forgone interest earned on financial capital
 - depreciation
 - wages
8. An implicit cost is:
- a direct out-of-pocket expense.
 - an opportunity cost of doing business.
 - a onetime expense.
 - offset by explicit costs.
9. To keep investors willing to put capital into a firm, that firm must:
- earn more than zero economic profit.
 - earn more than normal economic profit.
 - earn at least zero economic profit, or normal profit.
 - have a positive marginal profit.
10. Zero economic profit is considered:
- a normal profit.
 - a sign of a failing firm.
 - an excess profit.
 - insufficient profit.
11. Total revenue minus explicit and implicit costs equals:
- economic profit or loss.
 - zero profit.
 - normal economic profit.
 - marginal profit.
12. The number of firms in an industry can change:
- only in the long run.
 - in the short run if there is a market shortage.
 - in the short run if there is a market surplus.
 - only in the short run.
13. The change in output from adding one more worker is:
- marginal product.
 - total product.
 - marginal profit.
 - total income.
14. Total output divided by the number of workers employed equals:
- marginal product.
 - marginal return.
 - total product.
 - average product.
15. When hiring one more worker increases output by an amount less than the average output of existing workers, hiring this additional worker will:
- decrease average productivity.
 - decrease total productivity.
 - increase average productivity.
 - have no effect on productivity.
16. If hiring an additional worker actually reduces total output, the result is:
- increasing returns.
 - positive marginal return.
 - negative marginal return.
 - diseconomies of scale.

Use Figure MC-1 to answer questions 17 and 18.



MC-1

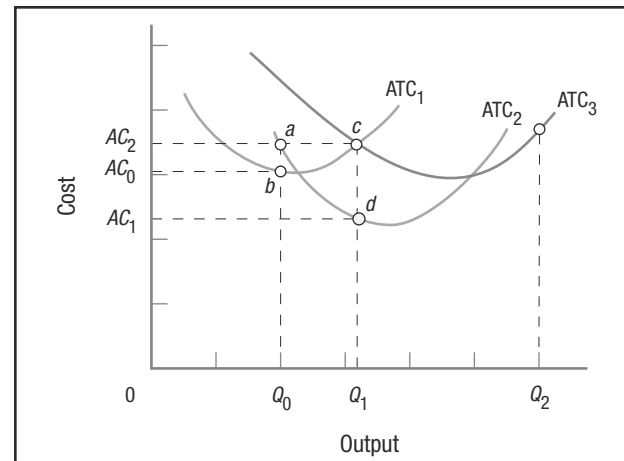
17. After the eighth worker, this short-run production function illustrates:
- constant return.
 - diminishing returns.
 - increasing returns.
 - economy of scale.
18. At which point are workers, on average, producing the most output?
- a*
 - b*
 - c*
 - d*
19. In the short run, total cost equals:
- total fixed cost.
 - total variable cost.
 - total variable cost minus total fixed cost.
 - total variable cost plus total fixed cost.

20. Which of the following is typically regarded as a fixed cost?
- shipping
 - insurance payments
 - raw material
 - wages
21. Change in output does *not* cause changes in:
- variable cost.
 - average fixed cost.
 - marginal cost.
 - total fixed cost.
22. $TFC/Q + TVC/Q$ is the formula for:
- average total cost.
 - marginal cost.
 - total cost.
 - variable cost.
23. Marginal cost equals change in total:
- variable cost divided by change in total fixed cost.
 - variable cost divided by change in quantity.
 - fixed cost divided by change in quantity.
 - variable cost minus change in total fixed cost.
24. If a firm can produce 100 DVDs for \$100 and 200 DVDs for \$150, what is the marginal cost of each of the additional 100 DVDs?
- \$1.00
 - \$0.75
 - \$0.50
 - \$0.25
25. The long-run average total cost (LRATC) curve is able to portray the lowest unit cost at which any specific output can be produced in the long run because:
- fixed costs are stable in the long run.
 - it takes into account changes in plant size.
 - it ignores changes in plant size.
 - it ignores changes in variable costs.
26. The long-run average total cost (LRATC) curve shows:
- the lowest unit cost for any level of output.
 - the highest unit cost for any level of output.

Essay Problem

Answer in the space provided.

Learning and applying cost and production concepts can be challenging. Don't get discouraged if your answers are not always the same as those we suggest. Use these as guidelines, but more important, to help you learn some of the difficult issues surrounding firms, production, and costs.



MC-2

- the marginal cost for any level of output.
 - the variable cost for any level of output.
27. When a firm grows so large that it becomes difficult to manage in an efficient manner, the outcome is:
- economies of scale.
 - constant returns to scale.
 - diseconomies of scale.
 - increasing returns to scale.
- Use Figure MC-2 to answer questions 28 and 29.
28. ATC_1 , ATC_2 , and ATC_3 represent different levels of output in relation to:
- worker productivity.
 - demand.
 - cost.
 - plant size.
29. If you wanted to produce output Q_1 , you would operate:
- plant 1 associated with ATC_1 .
 - plant 2 associated with ATC_2 .
 - plant 3 associated with ATC_3 .
 - plant 1 associated with ATC_1 , but add more capital.

- Why are entrepreneurs important for any economy?

2. To get a porch built on your house, you have to apply for a permit, go before the local zoning board and explain your request, and hire a contractor to do the work. Why is appearing before the zoning board an implicit cost in this case?

3. If interest rates go up, will existing normal profits be sufficient to keep investors in the firm happy?

4. Explain why, although fixed costs are irrelevant to profit-maximizing decisions, it is important for small businesses to have an accurate estimate of fixed costs.

5. In the short run, why is marginal cost so much more important for average variable cost than for average fixed cost?

6. Will the LRATC curve for an oil refinery be bumpy or smooth?

7. Hotrod Skateboards has the following costs:
 wages
 rent
 wheels
 boards
 paint
 insurance

 Which of these are fixed costs, and which are variable costs?

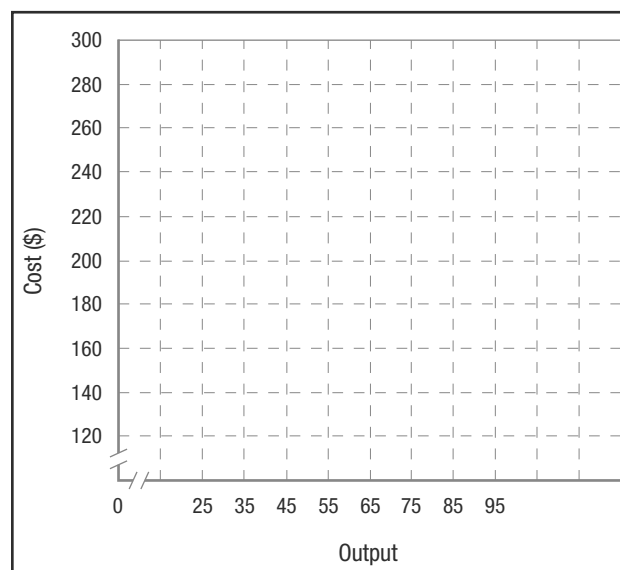
8. In the long run, would you categorize the personal computer industry as a(n) decreasing cost, constant cost, or increasing cost industry?

9. Fill in the following table.

Number of Workers	Total Product	Marginal Product	Average Product
50	100	_____	_____
55	120	_____	_____
60	150	_____	_____
65	200	_____	_____
70	225	_____	_____
75	235	_____	_____
80	240	_____	_____

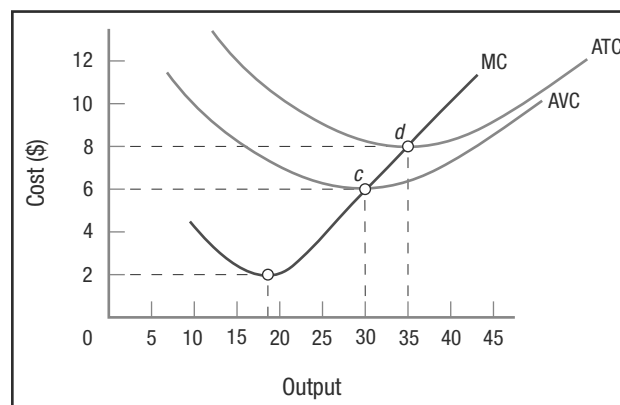
10. Complete the following production and cost table. Plot the ATC, AVC, and MC curves in Figure EP-1.

L	Q	MP	AP	TFC	TVC	TC	AFC	ATC	AVC	MC
0	0	—	—	—	—	—	—	—	—	—
1	7	—	—	—	—	—	—	—	—	—
2	15	—	—	—	—	—	—	—	—	—
3	25	—	—	—	—	—	—	—	—	—
4	40	—	—	—	—	—	—	—	—	—
5	54	—	—	—	—	—	—	—	—	—
6	65	—	—	—	—	—	—	—	—	—
7	75	—	—	—	—	—	—	—	—	—
8	84	—	—	—	—	—	—	—	—	—
9	90	—	—	—	—	—	—	—	—	—
10	95	—	—	2,000	20,000	—	—	—	—	—



EP-1

11. Use Figure EP-2 to answer the following questions.



EP-2

- a. What output level has the lowest average variable cost?
- b. At what point is marginal cost equal to average variable cost?
- c. Minimum average total cost is equal to _____.
- d. Why is the minimum point on the ATC curve at 35 units above the minimum point on the AVC curve at 30 units?
- e. Why does the marginal cost curve cross through the minimum points on the ATC and AVC curves?

What's Next

You now should have a good understanding of what lies behind supply curves. Firms seek out profitable business opportunities. Once they gauge a business need, they have to determine how they are going to produce the good or service, then determine the cost. With this information in hand, they can determine whether there is a profit to be made.

In the next chapter, we look at competitive markets and see the forces that shape supply and demand in these markets. We also give the assumption of profit maximization a much clearer analytical base.

Answers to Chapter-wide Practice Questions

Matching

- | | | | |
|------|-------|-------|-------|
| 1. k | 6. e | 11. c | 15. p |
| 2. q | 7. i | 12. n | 16. r |
| 3. a | 8. b | 13. f | 17. h |
| 4. l | 9. j | 14. d | 18. g |
| 5. o | 10. m | | |

Fill-In

- entrepreneurs
- total revenue, explicit costs, implicit costs, normal profits, economic profits
- average, marginal
- fixed, variable, marginal, average
- average variable, average total
- diseconomies, economies

True / False

- | | | | |
|------|------|-------|-------|
| 1. F | 6. T | 10. F | 14. T |
| 2. T | 7. F | 11. F | 15. F |
| 3. T | 8. F | 12. T | 16. F |
| 4. T | 9. F | 13. F | 17. T |
| 5. F | | | |

Multiple-Choice

- | | | | |
|------|-------|-------|-------|
| 1. b | 9. c | 16. c | 23. b |
| 2. c | 10. a | 17. b | 24. c |
| 3. a | 11. a | 18. b | 25. b |
| 4. d | 12. a | 19. d | 26. a |
| 5. c | 13. a | 20. b | 27. c |
| 6. a | 14. d | 21. d | 28. d |
| 7. d | 15. a | 22. a | 29. b |
| 8. b | | | |

Essay Problem

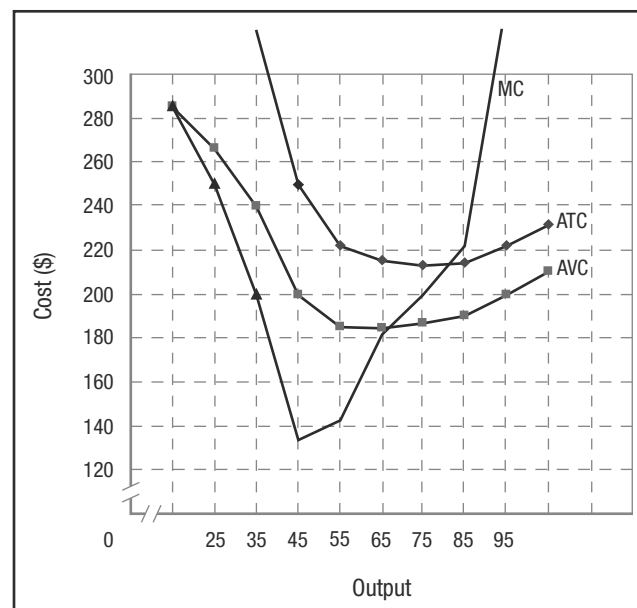
- Entrepreneurs see new business opportunities by finding unmet market needs. Meeting these needs helps economies to grow.
- It is not an explicit cost because you do not pay yourself anything to go before the board. It is an opportunity cost and so should be included in the total costing for the project because you could have done other things with your time. Now, if your alternative was to play golf, then the opportunity cost may be low. But if you had to take time off from work, the cost is the wages forgone or the personal day taken.
- No. Economists link normal profits to the cost of capital. If interest rates go up, the cost of capital will go up. Therefore, what previously was considered normal profit will have to increase to meet the new cost of capital rate. Think of it this way: If you could get 5% interest from the bank, the cost of capital would have to be at least this rate to get you to invest your money in something else; when the interest rate the bank pays you goes up, you will need a higher rate from an investment to even consider taking the money out of the bank and investing it in an enterprise.
- Small businesses often have widely fluctuating sales and, therefore, fluctuating income. Fixed costs are the minimum a small business has to pay in a given period (often called “the nut”). Without accurate estimates of what these fixed costs are, owners of small businesses may be surprised to find that they do not have the cash to pay these costs at various times of the year.
- In the short run, marginal costs have no bearing on fixed costs.
- The LRATC is constructed by combining the ATC curves for a firm for various plant sizes, with the lowest possible production costs at every possible level of production. An oil-refining firm may have only a few options for the size of its refineries, with the building of new refineries requiring investments of hundreds of millions of dollars. With only a few options for plant size being realistically available, any change in plant size can be expected to have a major impact on average costs, thus resulting in a bumpy LRATC curve for this firm.
- Fixed: rent, insurance. Variable: wages, wheels, boards, paint.
- Because, despite increasing demand, the price of personal computers has fallen consistently over the years and is still falling, we would expect the industry as a whole to be operating as a decreasing-cost industry. Individual companies, however, could be operating at any one of the three places on the LRATC.

9.

Number of Workers	Total Product	Marginal Product	Average Product
50	100	—	2.00
55	120	4	2.18
60	150	6	2.50
65	200	10	3.08
70	225	5	3.21
75	235	2	3.13
80	240	1	3.00

10. See the following table and Figure EPA-1.

L	Q	MP	AP	TFC	TVC	TC	AFC	ATC	AVC	MC
0	0	0	—	2,000	0	2,000	—	—	—	—
1	7	7	7	2,000	2,000	4,000	285.71	571.43	285.71	285.71
2	15	8	7.50	2,000	4,000	6,000	133.33	400.00	266.67	250.00
3	25	10	8.33	2,000	6,000	8,000	80.00	320.00	240.00	200.00
4	40	15	10.00	2,000	8,000	10,000	50.00	250.00	200.00	133.33
5	54	14	10.80	2,000	10,000	12,000	37.04	222.22	185.19	142.86
6	65	11	10.83	2,000	12,000	14,000	30.77	215.38	184.62	181.82
7	75	10	10.71	2,000	14,000	16,000	26.67	213.33	186.67	200.00
8	84	9	10.50	2,000	16,000	18,000	23.81	214.29	190.48	222.22
9	90	6	10.00	2,000	18,000	20,000	22.22	222.22	200.00	333.33
10	95	5	9.50	2,000	20,000	22,000	21.05	231.58	210.53	400.00



EPA-1

11. a. 30
 b. c
 c. \$8
 d. Because fixed costs are included in ATC. This spreading of overhead means that ATC reaches a minimum after AVC.
 e. Marginal cost is the cost to produce one more unit of output. If MC is less than ATC, then ATC must fall. (Adding a smaller number to the average will bring the average down.) Similarly, if MC is higher than ATC, ATC must be rising. (Again, adding a larger number to the average will increase the average.) Only when MC equals ATC is ATC at its minimum. The same analysis applies to AVC.