

Production and Cost in the Short Run

Learning Objectives

After reading Chapter 8 and working the problems for Chapter 8 in the textbook and in this Student Workbook, you should be able to:

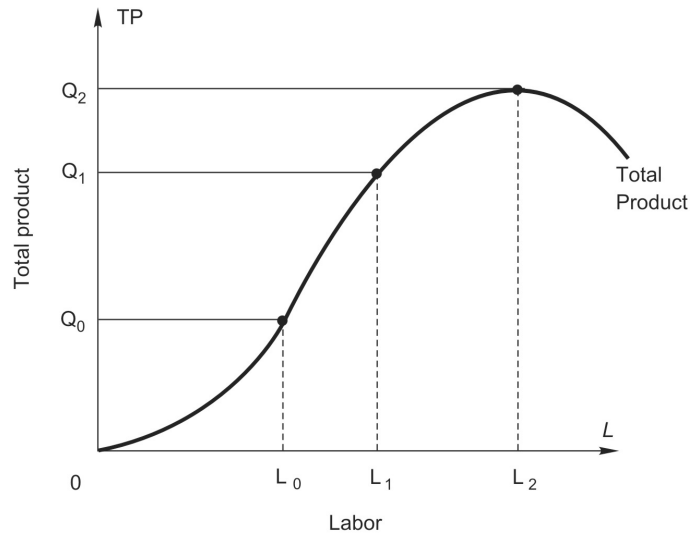
- Understand the information given by a production function.
- Explain two efficiency concepts: technical efficiency and economic efficiency.
- Define and give examples of three types of inputs used in production: variable inputs, fixed inputs, and quasi-fixed inputs.
- Explain the difference between long-run and short-run production time periods.
- Explain why sunk costs in production differ from avoidable costs.
- Distinguish between variable proportions production and fixed proportions production.
- Compute average product (AP) and marginal product (MP) and explain the relation among total, average, and marginal products.
- Define and explain the law of diminishing marginal product.
- Define and draw graphs of total fixed cost (TFC), total variable cost (TVC), total cost (TC), and short-run marginal cost (SMC).
- Define and draw graphs of average fixed cost (AFC), average variable cost (AVC), and average total cost (ATC).
- Relate short-run costs to the production function using the relations between (i) average variable cost and average product, and (ii) short-run marginal cost and marginal product.

Essential Concepts

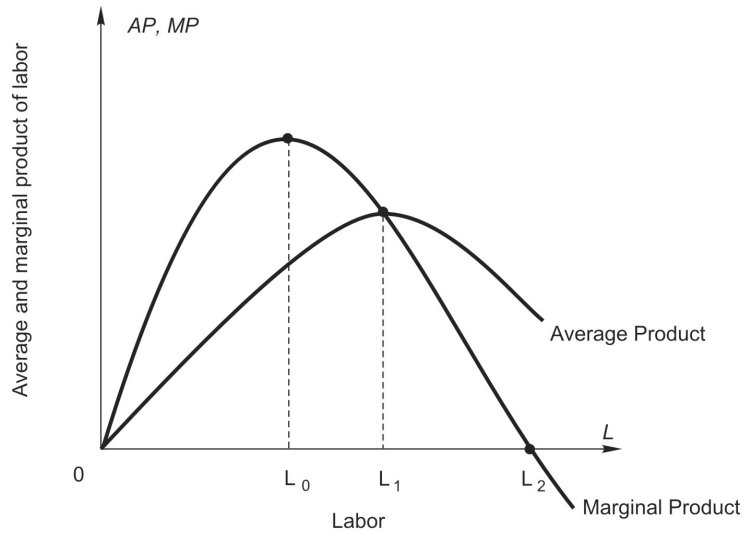
1. A *production function* shows the maximum amount of output that can be produced from any specified set of inputs, given the existing technology.
2. *Technical efficiency* is achieved when the maximum possible amount of output is being produced with a given combination of inputs. *Economic efficiency* is achieved when the firm is producing a given amount of output at the lowest possible total cost.

3. Production inputs can be either *variable* or *fixed*:
 - (a) *variable input*: an input for which the level of usage may be readily varied in order to change the level output. Payments for variable inputs are called *variable costs*. Examples of variable inputs are labor, raw materials, and energy.
 - (b) *fixed input*: an input for which the level of usage cannot be readily changed and which must be paid even if no output is produced. Payments for fixed inputs are called *fixed costs*. Examples of fixed inputs are buildings and other inputs that a firm leases and capital equipment that cannot be readily varied with changes in output.
 - (c) *quasi-fixed input*: A lumpy or indivisible input for which a fixed amount must be employed for any positive level of output, and none of the input must be purchased when output is zero. Payments for quasi-fixed inputs are called *quasi-fixed costs*. Fixed and quasi-fixed inputs are both used in constant amounts as output varies, but fixed inputs must be paid for even if output is zero while quasi-fixed inputs need *not* be purchased when output is zero. Examples of quasi-fixed inputs are railroad tracks, antenna towers for radio stations, and electricity for lighting an office.
5. The *short run* refers to a time span during which the firm employs at least one fixed input, which, by definition, must be paid even when output is zero in the short run. In the short run, *quasi-fixed* inputs may or *may not* be employed; *quasi-fixed* inputs have no bearing on the short-run nature of production.
6. The *long run*, also called the firm's *planning horizon*, refers to the time period just far enough in the future to allow all fixed inputs to become variable inputs. For any *quasi-fixed* inputs that might be needed, their levels are fixed in the long run at whatever lump amount is required.
7. A *sunk cost* of production is a payment for an input that, once made, cannot be recovered should the manager no longer wish to employ the input. Sunk input costs should be ignored for decision making purposes because sunk costs are not part of the economic cost of production. Once the sunk payment is made, the economic (opportunity) cost of using the input thereafter is zero.
8. In contrast to a sunk cost of production, an *avoidable cost* of production is a payment for an input that a firm can recover or avoid paying should the manager no longer wish to employ the input. Avoidable costs do matter in decision making and should not be ignored. Avoidable costs reflect the opportunity costs of resource use.
9. Average product of labor ($AP = Q/L$) and marginal product of labor ($MP = \Delta Q/\Delta L$) are related in the following way:

When AP is rising (falling), MP is greater (less) than AP . When AP reaches its maximum value, $AP = MP$.
10. The *law of diminishing marginal product* states that as the usage of a variable input increases, a point is reached beyond which its marginal product decreases.



Panel A



Panel B

11. Panel *A* in the preceding figure shows the typical total product curve (*TP*) when production occurs with only one variable input. The total product curve reflects the following relations:
- No output can be produced with zero workers.
 - Output increases at an increasing rate until L_0 workers are employed producing Q_0 units of output. Over this range marginal product is increasing.
 - Total product then increases but at a decreasing rate when the firm hires between L_0 and L_2 workers. Over this range *MP* is decreasing.
 - Average product reaches its maximum value at L_1 , where *AP* equals *MP*.
 - Finally a point will be reached beyond which output will decline, indicating a negative marginal product. In Panel *A*, this occurs for employment levels greater than L_2 . The maximum possible total product is thus Q_2 .

12. Panel *B* in the figure shows the *AP* and *MP* curves that correspond to *TP* in Panel *A*. Notice that
- both curves first rise, reach a maximum, then decline.
 - marginal product attains a maximum (at L_0) at a lower input level than the level at which average product attains its maximum (at L_1).
 - while *AP* is always positive, *MP* is zero at L_2 units of labor and is negative thereafter.
13. Short-run total cost (*TC*) is the sum of total variable cost (*TVC*) and total fixed cost (*TFC*):

$$TC = TVC + TFC$$

14. Average fixed cost (*AFC*) is equal to total fixed cost divided by output:

$$AFC = \frac{TFC}{Q}$$

15. Average variable cost (*AVC*) is equal to total variable cost divided by output:

$$AVC = \frac{TVC}{Q}$$

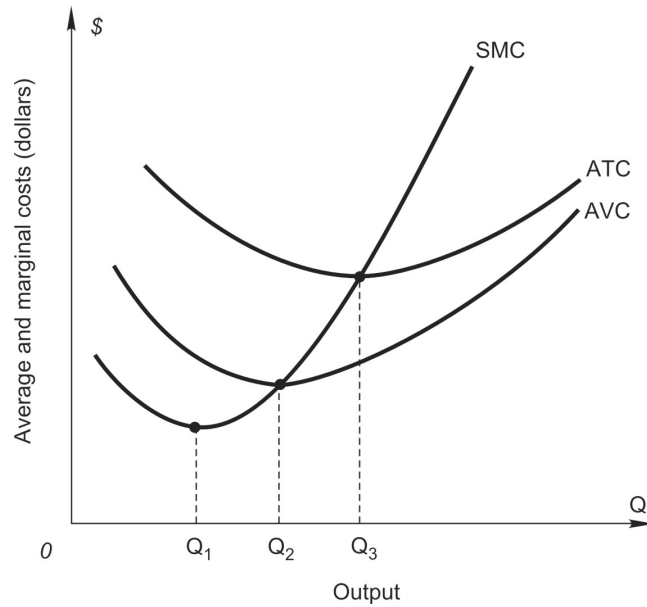
16. Average total cost is equal to total cost divided by output or the sum of average variable and average fixed cost:

$$ATC = \frac{TC}{Q} = AVC + AFC$$

17. Short-run marginal cost (*SMC*) measures the rate of change in *TC* as output varies:

$$SMC = \frac{\Delta TC}{\Delta Q} = \frac{\Delta TVC}{\Delta Q}$$

18. The following figure shows the typical set of short-run average and marginal cost curves. Note the following relations:
- AFC* decreases continuously as output increases (*AFC* is not shown in the figure above, but it is equal to vertical distance between *ATC* and *AVC*).
 - AVC* is U-shaped and *AVC* equals *SMC* at *AVC*'s minimum.
 - ATC* is U-shaped and *ATC* equals *SMC* at *ATC*'s minimum.
 - SMC* is U-shaped and intersects *AVC* and *ATC* at their minimum points. *SMC* lies below (above) *ATC* and *AVC* when *ATC* and *AVC* are falling (rising).



19. In the case of a single variable input, short-run costs are related to the production function by the two relations:

$$AVC = \frac{w}{AP} \quad \text{and} \quad SMC = \frac{w}{MP}$$

where w is the price of the variable input. Since AP and MP first increase, reach a peak and then decrease, AVC and SMC first fall, reach a minimum value and then rise.

Matching Definitions

average fixed cost	production function
average product of labor	quasi-fixed input
average total cost	short run
average variable cost	short-run marginal cost
avoidable cost of production	sunk cost of production
economic efficiency	technical efficiency
fixed input	total cost
fixed proportions production	total fixed cost
law of diminishing marginal product	total variable cost
long run	variable input
marginal product of labor	variable proportions production
production	

1. _____ The creation of goods and services from inputs or resources.
2. _____ A table or mathematical equation showing the maximum amount of output that can be produced from any specified set of inputs, given the existing technology.
3. _____ Production of the maximum level of output that can be obtained from a given combination of inputs.
4. _____ Production of a given amount of output at the lowest possible total cost.
5. _____ An input for which the level of usage cannot readily be changed.
6. _____ An input for which the level of usage may be changed quite readily.
7. _____ An input that must be used in a lump amount for any positive amount of output produced.
8. _____ That period of time in which the level of usage of one or more inputs is fixed.
9. _____ That period of time in which all inputs are variable, which is sometimes called the *planning horizon*.
10. _____ Production in which a given level of output can be produced with more than one combination of inputs.
11. _____ Production in which one, and only one, ratio or mix of inputs can be used to produce a good.
12. _____ Total product divided by the number of units of labor employed.
13. _____ An input payment firms can recover or avoid paying should the manager no longer wish to employ the input.
14. _____ Additional output attributable to using one more worker holding the use of all other inputs constant.

15. _____ As the level of usage of the variable input increases, other inputs held constant, a point will be reached beyond which the marginal product decreases.
16. _____ Total amount paid for fixed inputs.
17. _____ Total amount paid for variable inputs.
18. _____ The sum of total fixed and total variable costs.
19. _____ Fixed cost per unit of output (i.e., total fixed cost divided by output).
20. _____ Variable cost per unit of output (i.e., total variable cost divided by output).
21. _____ Total cost per unit of output (i.e., total cost divided by output).
22. _____ A nonrecoverable input payment that should be ignored in managerial decision making.
23. _____ The change in either total cost or total variable cost per unit change in output.

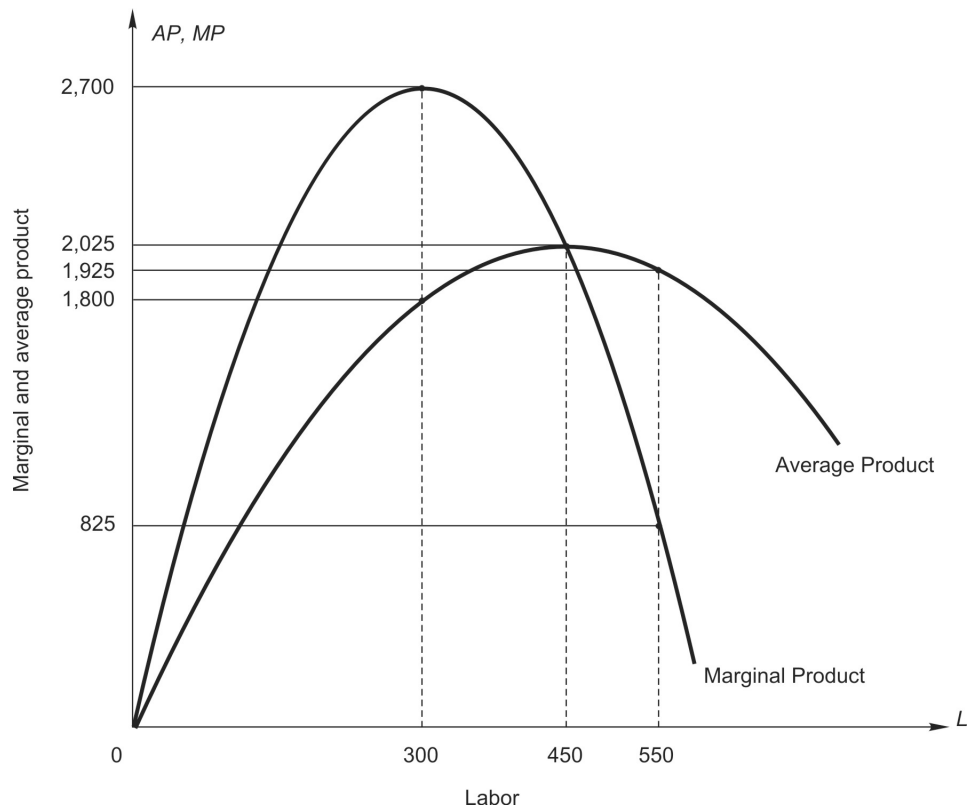
Study Problems

1. For each of the firm's decisions, determine whether the manager is making a decision in the short run or the long run.
- _____ a. Eckerd's decides to stay open 24 hours a day rather than 16 hours a day.
- _____ b. Harley Davidson builds another production facility.
- _____ c. American Airlines restructures its flight schedules to increase the percentage of seats filled on each of its flights.
- _____ d. Dell Computer adds more workers in its shipping department to speed delivery of new PC orders.
2. Fill in the blanks in the following table:

<i>Usage of Variable Input</i>	<i>Total Product</i>	<i>Marginal Product</i>	<i>Average Product</i>
1.....	_____	_____	4
2.....	_____	8	_____
3.....	18	_____	_____
4.....	_____	_____	5
5.....	_____	-5	_____

The wage rate is \$12 per unit of labor. After completing the table, answer the following questions:

- a. After _____ units of labor usage, the firm experiences diminishing returns.
 - b. At _____ units of labor, $SMC = AVC$.
 - c. The level of output at which $SMC = AVC$ is _____ units of output.
 - d. Minimum average variable cost = \$_____.
 - e. At the level of labor usage and associated output for which $SMC = AVC$, marginal cost = \$_____.
3. Consider a firm using a single variable input and a single fixed input, capital. When the amount of capital is increased:
- a. the total product curve will _____.
 - b. the average product curve will _____.
 - c. the marginal product curve will _____.
4. Assume labor—the only variable input of a firm—has average and marginal product curves shown in the following figure. The price of labor is \$1,000 per unit (i.e., $w = \$1,000$).



- a. At minimum average variable cost, the firm employs _____ units of labor.
- b. Minimum average variable cost is reached at _____ units of output.
- c. At its minimum value, average variable cost is \$_____.
- d. Marginal cost reaches its minimum value at _____ units of labor usage,

- which corresponds to _____ units of output.
- e. At its minimum value, marginal cost is \$_____.
- f. The average variable cost when 550 units of labor are employed is \$_____.
- g. The marginal cost when 550 units of labor are employed is \$_____.

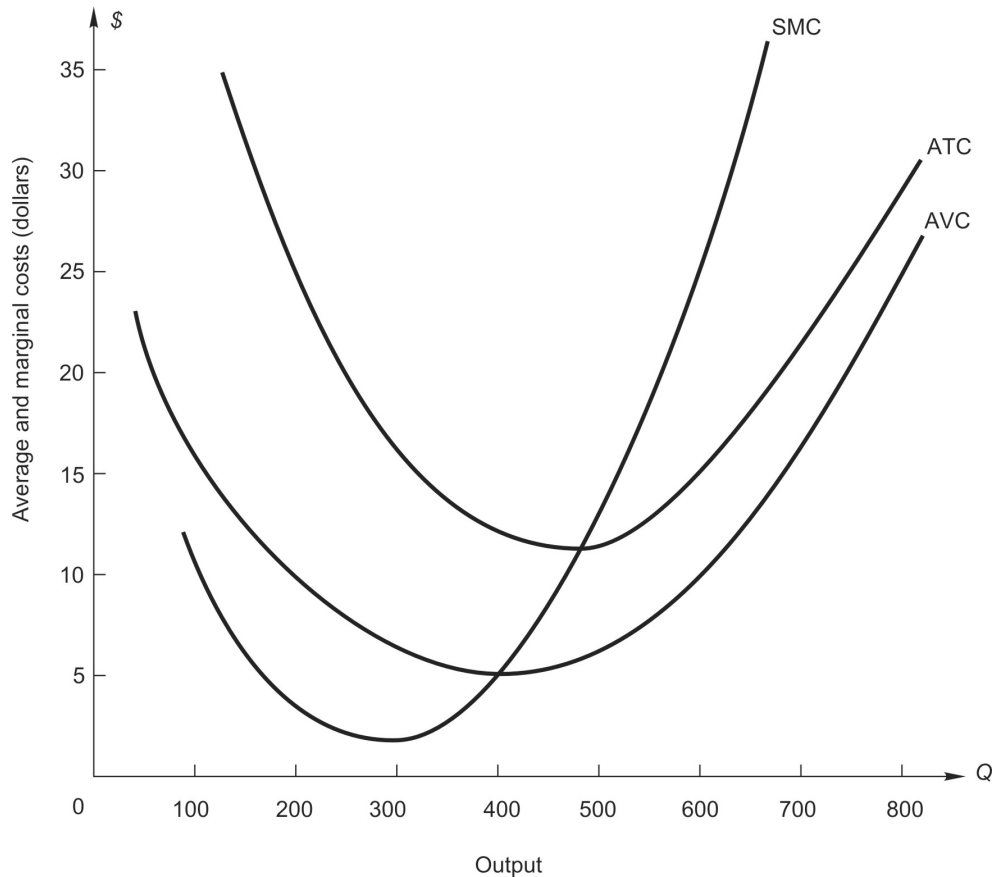
5. Use the figure below to answer these questions:

At 200 units of output, find the following costs:

- a. AFC = _____ e. TVC = _____
- b. AVC = _____ f. TC = _____
- c. ATC = _____ g. SMC = _____
- d. TFC = _____

At 600 units of output, find the following costs:

- h. AFC = _____ l. TVC = _____
- i. AVC = _____ m. TC = _____
- j. ATC = _____ n. SMC = _____
- k. TFC = _____



6. Total fixed cost is \$150 per week and the price per week of labor is \$500 per worker. Fill in the blanks in the table below:

Labor	Product			Total Cost			Average Cost			Marginal Cost
	Total	Average	Marginal	Fixed	Variable	Total	Fixed	Variable	Total	
0	0	XX	XX	_____	_____	_____	XX	XX	XX	XX
1	2	_____	_____	_____	_____	_____	_____	_____	_____	_____
2	5	_____	_____	_____	_____	_____	_____	_____	_____	_____
3	10	_____	_____	_____	_____	_____	_____	_____	_____	_____
4	16	_____	_____	_____	_____	_____	_____	_____	_____	_____
5	25	_____	_____	_____	_____	_____	_____	_____	_____	_____
6	30	_____	_____	_____	_____	_____	_____	_____	_____	_____
7	34	_____	_____	_____	_____	_____	_____	_____	_____	_____
8	37	_____	_____	_____	_____	_____	_____	_____	_____	_____
9	39	_____	_____	_____	_____	_____	_____	_____	_____	_____
10	40	_____	_____	_____	_____	_____	_____	_____	_____	_____

Multiple Choice / True-False

- Marginal product equals average product
 - when marginal product equals zero.
 - when average product equals zero.
 - at the inflection point of the total product curve.
 - at the maximum value of marginal product.
 - at the maximum value of average product.
- The economically efficient input combination for producing a given level of output
 - minimizes the average cost of producing the given level of output.
 - occurs at the maximum value of the total product curve.
 - can produce that level of output at the lowest possible total cost.
 - is determined entirely by the production function.
- Which of the following could NOT be an example of a quasi-fixed cost:
 - raw material costs
 - lights and security guards in the parking lots
 - local phone service for administrative operations
 - railroad track for CSX, a rail freight company
- If average product is rising, then marginal product
 - cannot be falling.
 - can be either rising or falling, but it must lie above average product.
 - must lie below average product.
 - must be rising.

In questions 5–8, suppose that the short-run production function is given by:

<i>Labor</i>	<i>Quantity</i>
0	0
1	3
2	10
3	21
4	24
5	25
6	24
7	14

5. The average product of labor when 3 units of labor are employed is
 - a. 3.
 - b. 5.
 - c. 7.
 - d. 11.
 - e. -1.

6. The marginal product of the 6th laborer is
 - a. 3.
 - b. 5.
 - c. 7.
 - d. 11.
 - e. -1.

7. Diminishing marginal returns begin with the
 - a. 2nd unit of labor.
 - b. 4th unit of labor.
 - c. 5th unit of labor.
 - d. 6th unit of labor.

8. Marginal product is negative when more than
 - a. 3 units of labor are employed.
 - b. 4 units of labor are employed.
 - c. 5 units of labor are employed.
 - d. 6 units of labor are employed.

9. Fixed costs
 - a. must be considered in any decision-making process.
 - b. do not exist in the long run.
 - c. decrease as output rises.
 - d. *a* and *b*.
 - e. *b* and *c*.

Fill in the missing values and answer questions 10–14.

Q	Total Cost	Fixed Cost	Variable Cost	Average		Total Cost	Marginal Cost
				Fixed Cost	Variable Cost		
0.....	20	_____	_____	xx	xx	xx	xx
1.....	_____	_____	_____	_____	_____	_____	20
2.....	_____	_____	_____	_____	15	_____	_____
3.....	_____	_____	_____	_____	_____	19	_____
4.....	_____	_____	48	_____	_____	_____	_____

10. What is total fixed cost?
 - a. 10
 - b. 15
 - c. 20
 - d. cannot be determined
 - e. none of the above
11. What is total cost when $Q = 1$?
 - a. 30
 - b. 35
 - c. 40
 - d. 20
 - e. none of the above
12. What is average total cost when $Q = 2$?
 - a. 10
 - b. 20
 - c. 30
 - d. 40
 - e. none of the above
13. What is marginal cost when $Q = 3$?
 - a. 7
 - b. 8
 - c. 9
 - d. 10
14. What is marginal cost when $Q = 4$?
 - a. 5
 - b. 10
 - c. 11
 - d. 15
 - e. 20

15. When the average product of the variable input is equal to the marginal product,
- marginal cost reaches its minimum value.
 - average variable cost reaches its minimum value.
 - marginal cost is rising.
 - both *a* and *c*.
 - both *b* and *c*.
16. If a firm is producing 5 units of output and the marginal cost for the fifth unit is \$7 and the average variable cost for the fifth unit is \$3, then the average variable cost for the fourth unit is _____.
- 1
 - 2
 - 4
 - 8
 - none of the above
17. If short-run marginal cost is U-shaped, then
- total cost increases at an increasing rate, then increases at a decreasing rate.
 - total variable cost increases at a decreasing rate then increases at an increasing rate.
 - total variable cost must be S-shaped.
 - all of the above.
 - both *b* and *c*.
18. Average total cost
- increases as output increases.
 - decreases as output increases.
 - increases if marginal cost is increasing.
 - increases if marginal cost is greater than average total cost.
 - both *c* and *d*.
19. Average fixed cost
- increases as output increases.
 - decreases as output increases.
 - increases if marginal cost is increasing.
 - increases if marginal cost is greater than average fixed cost.
20. Quasi-fixed costs DIFFER from fixed costs because
- only fixed costs can be avoided if output is zero.
 - only quasi-fixed costs can be avoided if output is zero.
 - quasi-fixed cost vary directly with the level of output while fixed costs do not vary with the level of output.
 - only fixed costs are sunk costs.
21. A fixed cost is
- the cost of any input with a fixed price per unit.
 - a cost which increases in a fixed proportion as output increases.
 - a cost the firm must pay even if output is zero.
 - a cost that does not vary with the amount of good or service produced.
 - both *c* and *d*

22. T F A firm that operates in an economically efficient way is also operating in a technically efficient way.
23. T F Average fixed cost is not usually graphed with the other average cost curves because average fixed cost can be obtained from average total cost and average variable cost.
24. T F If average variable cost is rising, marginal cost must be rising.
25. T F Marginal cost measures the change in total variable cost as output changes.
26. T F The payments to quasi-fixed inputs should be ignored in decision making since they are not opportunity costs.
27. T F The long run period of production can be thought of as the set of all possible short run situations.
28. T F Two reasons for input fixity are (1) the costs of adjusting the level of an input is prohibitively high, and (2) a required input can only be purchased in lumpy, indivisible amounts.

Answers

MATCHING DEFINITIONS

1. production
2. production function
3. technical efficiency
4. economic efficiency
5. fixed input
6. variable input
7. quasi-fixed input
8. short run
9. long run
10. variable proportions production
11. fixed proportions production
12. average product of labor
13. avoidable cost
14. marginal product of labor
15. law of diminishing marginal product
16. total fixed cost
17. total variable cost
18. total cost
19. average fixed cost
20. average variable cost
21. average total cost
22. sunk cost
23. short-run marginal cost

STUDY PROBLEMS

1.
 - a. short run; This decision involves increasing the usage of a fixed input, the store.
 - b. long run; A new plant allows increased usage of capital inputs that are fixed in the short run.
 - c. short run; American Airlines is still using the same number of planes (presumably a fixed input in the short run), but using the planes more intensively.
 - d. short run; Dell did not increase the capital resources employed by the shipping department; it is just using more of the variable input labor.
2. The table should look like this:

<i>Usage of Variable Input</i>	<i>Total Product</i>	<i>Marginal Product</i>	<i>Average Product</i>
1.....	4	4	4
2.....	12	8	6
3.....	18	6	6
4.....	20	2	5
5.....	15	-5	3

- a. 2; *MP* begins to fall after 2 units of labor are employed.
- b. 3; *SMC* will equal *AVC* when $MP = AP$.
- c. 18; *TP* is 18 at $L = 3$
- d. \$2; $AVC = w/AP = 12/6$
- e. \$2; $SMC = w/MP = 12/6$
3.
 - a. increase (shift upward)
 - b. increase (shift upward)
 - c. increase (shift upward)
4.
 - a. 450; *AVC* is minimized when *AP* is maximized.
 - b. 911,250; Since $AP = Q/L$, $2,025 = Q/450 \Rightarrow Q = 911,250$.
 - c. \$0.49; $AVC = w/AP \Rightarrow \$1,000/2,025$.
 - d. 300; 540,000; *SMC* is minimized at the level of labor usage where *MP* is maximized. Since $AP = Q/L$ and $AP = 1,800$ at $L = 300$, then $1,800 = Q/300 \Rightarrow Q = 540,000$.
 - e. \$0.37; $SMC = w/MP = \$1,000/2,700$
 - f. \$0.52; $AVC = w/AP = \$1,000/1,925$
 - g. \$1.21; $SMC = w/MP = \$1,000/825$
5.
 - a. \$15; the vertical distance between *ATC* and *AVC* at $Q = 200$.
 - b. \$10; read this off the *AVC* curve at $Q = 200$
 - c. \$25; read this off the *ATC* curve at $Q = 200$
 - d. \$3,000; $TFC = AFC \times Q = 15 \times 200$
 - e. \$2,000; $TVC = AVC \times Q = 10 \times 200$
 - f. \$5,000; $TC = ATC \times Q = 25 \times 200$ or $TC = TVC + TFC = 3,000 + 2,000$
 - g. about \$4; read this off the *SMC* curve at $Q = 200$
 - h. \$5; the vertical distance between *ATC* and *AVC* at $Q = 600$

- i. \$10; read this off the *AVC* curve at $Q = 600$
- j. \$15; read this off the *ATC* curve at $Q = 600$
- k. \$3,000; $TFC = AFC \times Q = 5 \times 600$
- l. \$6,000; $TVC = AVC \times Q = 10 \times 600$
- m. \$9,000; $TC = ATC \times Q = 15 \times 600$ or $TC = TVC + TFC = 3,000 + 6,000$
- n. \$25; read this off the *SMC* curve at $Q = 600$

6. Your table should look like this:

Labor	Product			Total Cost			Average Cost			Marginal Cost
	Total	Average	Marginal	Fixed	Variable	Total	Fixed	Variable	Total	
0	0	0	xx	150	0	150	xx	xx	xx	xx
1	2	2	2	150	500	650	75	250	325	250
2	5	2.5	3	150	1,000	1,150	30	200	230	166.67
3	10	3.3	5	150	1,500	1,650	15	150	165	100
4	16	4	6	150	2,000	2,150	9.37	125	134.37	83.33
5	25	5	9	150	2,500	2,650	6	100	106	55.55
6	30	5	5	150	3,000	3,150	5	100	105	100
7	34	4.85	4	150	3,500	3,650	4.41	102.94	107.35	125
8	37	4.62	3	150	4,000	4,150	4.05	108.11	112.16	166.67
9	39	4.33	2	150	4,500	4,650	3.85	115.38	119.23	250
10	40	4	1	150	5,000	5,150	3.75	125	128.75	500

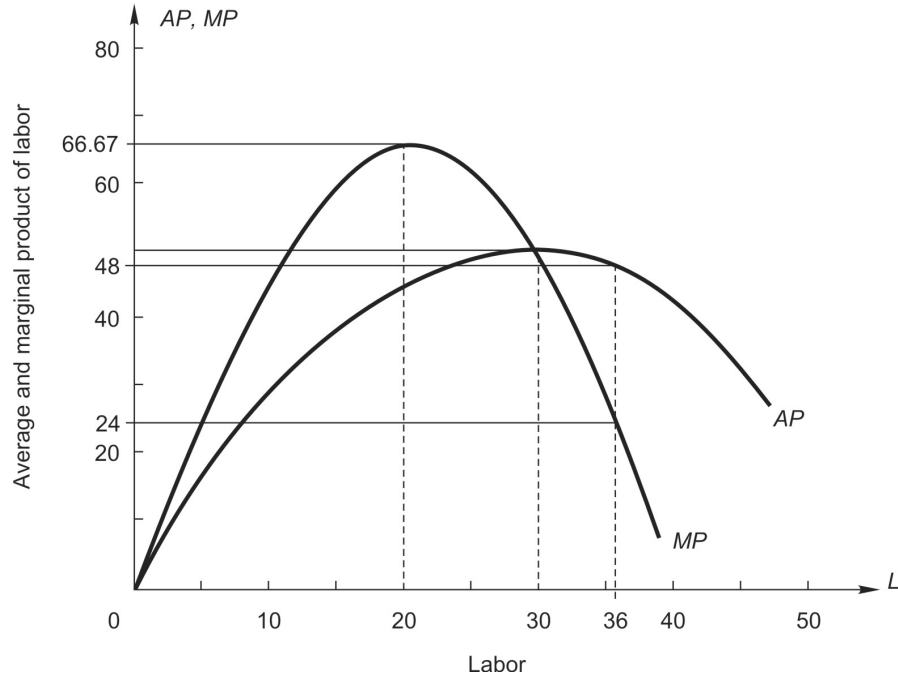
MULTIPLE CHOICE / TRUE-FALSE

1. e *MP = AP* at *AP*'s maximum point. Note that answer *c* is wrong because the inflection point on *TP* is where *MP* (not *AP*) reaches its maximum.
2. c The efficient input combination is the one that minimizes *total*, not average, cost.
3. a Raw material costs vary directly with the amount of output, and therefore cannot be a quasi-fixed input. The other three choices are all inputs for which the usage could be constant as output rises and the firm could avoid paying for the input if output is zero.
4. b *MP* both rises and falls over the range of labor usage for which *AP* is rising.
5. c $AP_3 = 21/3 = 7$
6. e $TP_5 = 25$ and $TP_6 = 24 \Rightarrow TP$ falls by one unit. *MP* for the sixth unit of labor is 1.
7. b *MP* is smaller for the fourth unit of labor than it is for the third unit of labor.
8. c $MP < 0$ after 5 units of labor are employed.
9. b Fixed costs are the payment to the fixed inputs. Since all inputs are variable in the long run, there are no fixed costs in the long run.

10. c You can see that fixed cost is \$20 by noting that when $Q = 0$, $TC = \$20$.
11. c Since SMC for unit 1 is \$20, TC for the first unit must be \$20 greater than TC when $Q = 0$. Therefore, $TC = 20 + 20 = 40$.
12. e Since $AVC = \$15$, $TVC = \$30 (= 2 \times 15)$. $TC = TVC + TFC = 30 + 20 = 50$. Therefore, $ATC = TC/Q = 50/2 = \$25$.
13. a $ATC = \$19$ and $TC = \$57 (= 3 \times 19)$. Since TC is \$50 for 2 units, and TC is \$57 for 3 units, the marginal cost of the 3rd unit must be \$7.
14. c $TC_{Q=4} = TVC + TFC = 48 + 20 = 68$. Since $TC_{Q=3} = \$57$, the marginal cost of the 4th unit must be \$11.
15. e When $AP = MP$, AP is at its maximum value. MP is *falling* when $AP = MP$, and thus $SMC (= w/MP)$ is rising.
16. b Since $AVC_5 = \$3$, $TVC_5 = \$15$. Given marginal cost of the 5th unit is \$7, the total variable cost of 4 units must be \$8. Thus $AVC_4 = \$8/4 = \2 .
17. e If SMC is U-shaped, then the slope of TVC first falls, then rises. The only way this can occur is if TVC is S-shaped (i.e., TVC first increases at a decreasing rate, then increases at an increasing rate).
18. d If marginal exceeds average, then average rises.
19. b While TFC is constant, AFC declines as Q gets larger.
20. b Quasi-fixed costs can be avoided in the event the manager decides to cease production, while fixed costs must continue to be paid.
21. e Both c and d are correct.
22. T All economically efficient firms are technically efficient. The converse is *not* true.
23. T $AFC = ATC - AVC$
24. T When AVC is rising, SMC exceeds AVC and is rising.
25. T $SMC = \Delta TC / \Delta Q$. Since $\Delta TC = \Delta TVC$ (only TVC varies as Q changes), $SMC = \Delta TVC / \Delta Q$.
26. F Quasi-fixed input payments are avoidable costs, and thus represent part of the economic cost of production.
27. T The long run is sometimes referred to as the planning horizon.
28. T These are indeed the two reason for input fixity. When the first one holds, the input is a fixed input, and when the second one holds, the input is a quasi-fixed input.

Homework Exercises

1. The following figure shows a firm's marginal and average product curves for labor, the only variable input employed by the firm. The wage rate of labor is \$200 and the fixed cost is \$6,000.



When average variable cost reaches its minimum:

- Output is _____ units.
- AVC is \$_____ and SMC is \$_____.
- ATC is \$_____.

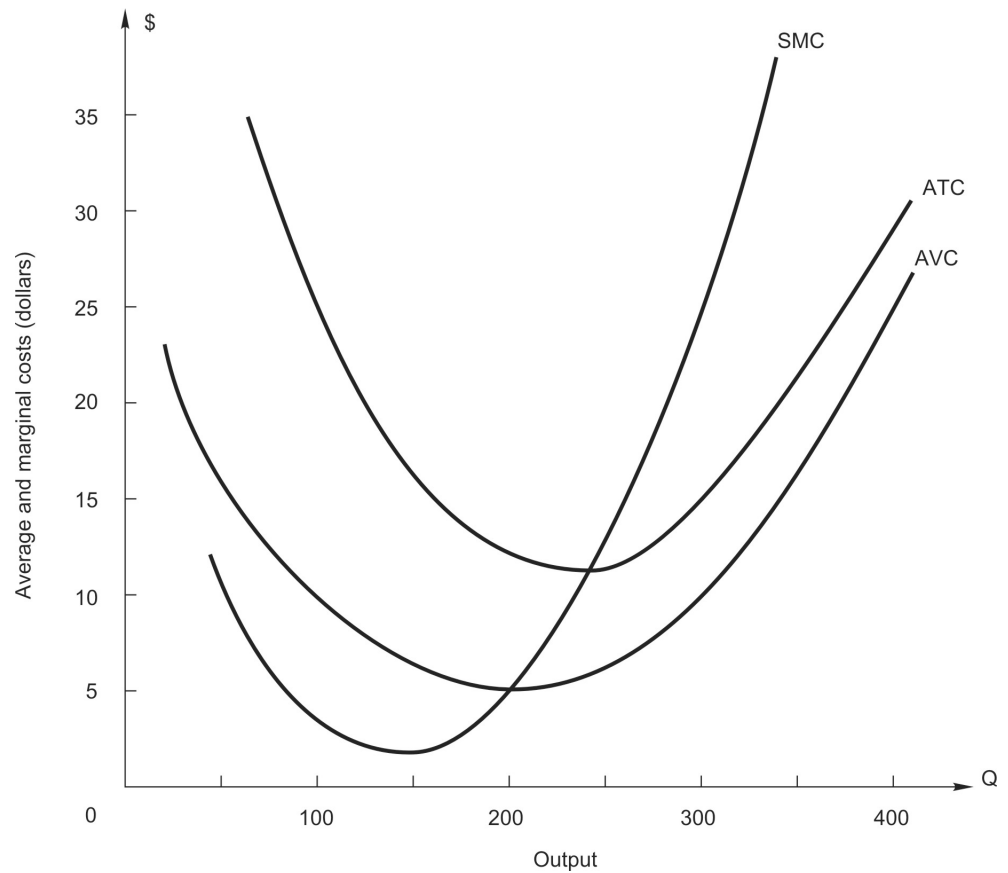
When 36 workers are hired:

- Output is _____ units.
- AVC is \$_____ and SMC is \$_____ at this output.
- At the level of output associated with 36 workers, AVC is _____ (increasing, decreasing) and SMC is _____ (increasing, decreasing).

2. Fill in the blanks in the table below:

Output	TC	TFC	TVC	AFC	AVC	ATC	SMC
0	—	—	0	xx	xx	xx	xx
10	—	—	—	—	—	—	5.0
20	—	—	—	—	4.50	—	—
30	215	—	—	2.00	—	—	—
40	—	—	—	—	—	—	7.2
50	—	—	—	—	6.14	—	8.0
60	452	—	—	—	—	—	—
70	—	—	—	—	—	—	9.0
80	—	—	582	—	—	—	—

3. Use the figure below to answer the questions on the next page.



At 100 units of output, find the following costs:

- a. $AFC =$ _____
- b. $AVC =$ _____
- c. $ATC =$ _____
- d. $TFC =$ _____
- e. $TVC =$ _____
- f. $TC =$ _____
- g. $SMC =$ _____

At 300 units of output, find the following costs:

- h. $AFC =$ _____
- i. $AVC =$ _____
- j. $ATC =$ _____
- k. $TFC =$ _____
- l. $TVC =$ _____
- m. $TC =$ _____
- n. $SMC =$ _____