Answers to the Problems – Chapter 10

1. a. To draw the total product curve measure *labor* on the *x*-axis and output on the *y*-axis. The total product curve is upward sloping.

   b. The average product of *labor* is equal to total product divided by the quantity of *labor* employed. For example, when 3 workers are employed, they produce 120 surfboards a week, so average product is 40 surfboards per worker.
   The average product curve is upward sloping when up to 3 workers are hired and the average product curve is downward sloping when more than 4 workers are hired.

   c. The marginal product of *labor* is equal to the increase in total product when an additional worker is employed. For example, when 3 workers are employed, total product is 120 surfboards a week. When a fourth worker is employed, total product increases to 160 surfboards a day. The marginal product of going from 3 to 4 workers is 40 surfboards.
   The marginal product curve is upward sloping when up to 2.5 workers a week and it is downward sloping when more than 2.5 workers a week are employed.

   d. The firm has the benefits of increased specialization and division of labor over the range of output for which the marginal cost decreases. This range of output is the same range over which the marginal product of labor rises. For Sue's Surfboards, the benefits of increased specialization and division of labor occur until 2.5 workers are employed.

   e. The marginal product of labor decreases after 2.5 workers are employed.

   f. The marginal product of labor decreases and the average product of labor rises between 2.5 and 3.5 workers.

   g. As long as the marginal product of labor exceeds the average product of labor, the average product of labor rises. So for a range of output, the marginal product of labor, while decreasing, remains greater than the average product of labor so the average product of labor rises.

2. a. Total cost is the sum of the costs of all the factors of production that Sue's Surfboards uses in production. Total variable cost is the total cost of the variable factors. Total fixed cost is the total cost of the fixed factors.
   For example, the total variable cost of producing 160 surfboards a week is the total cost of the workers employed, which is 4 workers at $500 a week, which equals $2,000. Total fixed cost is $1,000, so the total cost of producing 160 surfboards a week is $3,000.

   To draw the short-run total cost curves, plot output on the *x*-axis and the total cost on the *y*-axis. The total fixed cost curve is a horizontal line at $1,000. The total variable cost curve and the total cost curve have shapes similar to those in Fig. 10.4, but the vertical distance between the total variable cost curve and the total cost curve is $1,000.

   b. Average fixed cost is total fixed cost per unit of output. Average variable cost is total variable cost per unit of output. Average total cost is the total cost per unit of output.
   For example, when the firm makes 160 surfboards a week: Total fixed cost is $1,000, so average fixed cost is $6.25 per surfboard; total variable cost is $2,000, so average variable cost is $12.50 per surfboard; and total cost is $3,000, so average total cost is $18.75 per surfboard.

   Marginal cost is the increase in total cost divided by the increase in output. For example, when output increases from 120 to 160 surfboards a week, total cost increases from $2,500 to $3,000, an increase of $500. That is, the increase in output of 40 surfboards increases total cost by $500. Marginal cost is equal to $500 divided by 40 surfboards, which is $12.50 a surfboard.

   The short-run average and marginal cost curves are similar to those in Fig. 10.5.

c. The table sets out the data to use to draw the curves.

Labor (workers)	Output (surfboards)	AP (surfboards per worker)	MP (surfboards per worker)	TC (dollars)	MC (dollars per surfboard)	AVC (dollars per surfboard)
1	30	30.0		1,500		16.67
			40.0		12.50	
2	70	35.0		2,000		14.29
			50.0		10.00	
3	120	40.0		2,500		12.50
			40.0		12.50	
4	160	40.0		3,000		12.50
			30.0		16.67	
5	190	38.0		3,500		13.16
			20.0		25.00	
6	210	35.0		4,000		14.29
			10.0		50.00	
7	220	31.4		4,500		15.91

3.   The rent is a fixed cost, so the total fixed costs increase. The increase in total fixed cost increases total cost but does not change total variable cost. Average fixed cost is total fixed cost per unit of output. The average fixed cost curve shifts upward. Average total cost is total cost per unit of output. The average total cost curve shifts upward. The marginal cost and average variable cost do not change.

4.   The increase in the wage rate is a variable cost, so the total variable costs increase. The increase in total variable costs increases total cost but total fixed cost does not change. Average variable cost is total variable cost per unit of output. The average variable cost curve shifts upward. Average total cost is total cost per unit of output. The average total cost curve shifts upward. The marginal cost curve shifts upward. The average fixed cost curve does not change.

5.   *A* is the average fixed cost, *AFC*, when the output is 20. Average fixed cost equals total fixed cost divided by output, or $AFC = FC \div Q$. Rearranging gives $FC = AFC \times Q$. So the total fixed cost for the problem equals 120×10, which is $1,200. *A* equals $1,2000, *FC*, divided by 20, *Q*, which is $60.

B is the average variable cost, *AVC*, when output is 20. Use the result that $AFC + AVC = ATC$ by rearranging to give $AVC = ATC - AFC$, so average variable cost for the problem equals $150 − $60, which is $90.

D is the average total cost, *ATC*, when output, *Q*, equals 40. Average total cost equals total cost divided by output, or $ATC = TC \div Q$. Rearranging gives $TC = ATC \times Q$. So the total cost when 30 are produced is 130×30, which is $3,900. Marginal cost, *MC*, equals the change in total cost divided by the change in quantity, or $MC = \Delta TC \div \Delta Q$. Rearranging gives $\Delta TC = MC \times \Delta Q$, so the change in total cost between $Q = 30$ and $Q = 40$ is 130×10, or $1,300. Therefore the total

cost when Q equals 40 is $3,900 + $1,300, or $5,200. The average total cost when Q is 40 is $5,200 ÷ 40, or $130.

C is the average variable cost, AVC, when output, Q, equals 40. Use the result that $AFC + AVC = ATC$ by rearranging to give $AVC = ATC - AFC$. As a result, average variable cost for the problem equals $130 − $30, which is $100.

E is the marginal cost, MC, between outputs of 40 and 50. Marginal cost, MC, equals the change in total cost divided by the change in quantity, or $MC = \Delta TC ÷ \Delta Q$. To calculate marginal cost, the total cost when output is 40 and the total cost when output is 50 are needed. Average total cost equals total cost divided by output, or $ATC = TC ÷ Q$. Rearranging gives $TC = ATC × Q$. So the total cost when 40 are produced is $130 × 40, which is $5,200 and total cost when 50 are produced is $132 × 50, which is $6,600. So the marginal cost equals ($6,600 − $5,200) ÷ 10, which equals $140.

6. a. Total cost is the cost of all the factors of production. For example, when 4 workers are employed they now produce 240 surfboards a week. With 4 workers, the total variable cost is $2,000 a week and the total fixed cost is (coincidentally also) $2,000 a week. The total cost is $4,000 a week. The average total cost of producing 24 surfboards is $16.67 a surfboard. The remainder of the *ATC*s are calculated similarly.

    b. The long-run average cost curve is made up of the lowest parts of the firm's short-run average total cost curves when the firm operates one plant and two plants. The long-run average cost curve is similar to Fig. 10.8.

    c. It is efficient to operate the number of plants that has the lower average total cost of a surfboard. It is efficient to operate one plant when output is less than (approximately) 200 surfboards a week, and it is efficient to operate two plants when the output is more than 200 surfboards a week.

       Over the output range 1 to 200 surfboards a week, average total cost is less with one plant than with two, but if output exceeds 200 surfboards a week, average total cost is less with two plants than with one.

7. a. For example, the average total cost of producing a balloon ride when Bonnie rents 2 balloons and employs 40 workers equals the total cost ($1,000 rent for the balloons plus $1,000 for the workers) divided by the 20 balloon rides produced. The average total cost equals $2,000/20, which is $100 a ride.

       The average total cost curve is U-shaped, as in Fig. 10.5.

    b. The long-run average cost curve is similar to that in Fig. 10.8.

    c. Bonnie's minimum efficient scale is 13 balloon rides when Bonnie rents 1 balloon. The minimum efficient scale is the smallest output at which the long-run average cost is a minimum. To find the minimum efficient scale, plot the average total cost curve for each plant and then check which plant has the lowest minimum average total cost.

    d. Bonnie will choose the plant (number of balloons to rent) that gives her minimum average total cost for the normal or average number of balloon rides that people buy.

8. a. If the firm is producing where it experiences economies of scale, then by increasing its plant size the firm moves along its long-run average cost to a lower long-run average cost. As a result, the firm's minimum average total cost falls with its new, larger plant size.

    b. If the firm is producing where it experiences diseconomies of scale, then by decreasing its plant size the firm moves along its long-run average cost to a lower long-run average cost. As a result, the firm's minimum average total cost falls with its new, smaller plant size.

    c. If the firm is producing where it has constant returns to scale, then if the firm increases or decreases its plant size its long-run average cost does not change. As a result, the firm's

average total cost curve is the same whether or not the firm increases or decreases its plant size.

9.   a.   The curves have their standard shapes, illustrated in Figure 10.5. The *AFC* curve for the gas turbine plant lies below the *AFC* curves for the other types of plants. Lying above the gas *AFC* curve and below the other curves is the *AFC* curve for hydroelectric plants. The minimum point of the *AVC* curve for the gas turbine plant lies above the minimum points of the *AVC* curves for the other types of plants. The minimum point of the *AVC* curve for the hydroelectric plant lies below the minimum points of the *AVC* curves for the other plants. The *ATC* curve for the hydroelectric plant has the lowest minimum point and the *ATC* curve of the gas turbine plant has the highest minimum point.

    b.   The *MC* curves for all the plants go through the minimum points of the plants' *ATC* curves. The *MC* curve for hydroelectric power has the lowest minimum point and the *MC* curve for the gas turbine plant has the highest minimum point.

    c.   We use more than one type of plant for at least three reasons. First, hydroelectric plants might be the least expensive to operate, but they must be near rapidly flowing rivers. Second, the scale of the electricity that is demanded needs to be examined. For instance, at some locations so much electricity is demanded that hydroelectric plants (or other type of plants) are operating where there are diseconomies of scale that raise their long-run average cost. In these locations, some other plant, perhaps gas or nuclear, might have lower average costs for the quantity of electricity demanded. Third, the price of natural gas, coal, oil, and nuclear fuel can vary tremendously. By having different types of plants some protection is gained against having a concentration in a type of plant whose costs happened to soar.

Critical Thinking

1.   a.   GM and Ford could decrease their average total cost if they could increase their sales so that they produce more cars and thereby move downward along their average total cost curve. They can also try to shift their average total cost curve downward by closing factories and laying off workers. But the contracts they have negotiated require them to continue paying laid off workers almost the same wage they paid them when they were working, so neither GM nor Ford can gain much cost saving in this fashion.

    b.   Most of the costs are fixed costs because GM and Ford's contacts with their workers require that GM and Ford continue to pay the workers even if they are laid off. Therefore these costs are fixed costs because they o not change when GM or Ford decreases its production.

    c.   GM and Ford are probably producing where they have economies of scale.

    d.   GM and Ford's average total cost probably would not shift downward by any large amount if plants were closed. So both GM and Ford would move upward along their average total cost curves and their average total cost would rise.

    e.   If GM or Ford could increase production, they would move down along their average total cost curve and their average total costs would fall.

    f.   If GM or Ford decrease production, they would move up along their average total cost curve and their average total costs would rise.

    g.   If the firms merge, there are no apparent cost savings. They would still face the same contacts that force them to pay wages to laid off workers, so any workers that were in duplicate positions and were laid off would create no cost savings for the merged firms.

Web Exercises

1. a. The costs fall into 5 categories: 1) land preparation; 2) planting; 3) fertilization; 4) fungicide-insecticide applications; and, 5) harvest costs. Details of what these costs include are in answer (b) below.

    b. The issue of what is a fixed cost and what is a variable cost depends on when the costs are being considered, so your students' answers might vary. Assume we are studying a farmer who, in the spring, is determining what to grow on an acre of soil. So the farmer has already prepared the ground but has not yet purchased any seed. In this case, the land preparation cost, $72.36 an acre, is a fixed cost; the planting cost, $313.38 an acre and which includes the seed and actual planting, is a variable cost; the fertilization cost, $166 an acre, is a variable cost; the pest control cost, $744.85 per acre, is a variable cost; and, the harvesting cost, $291 an acre, is a variable cost. Any cost to rent the land is a fixed cost and was not specifically given on the web page.

    c. Your students' answers will vary, depending on the assumptions they make. The web page mentions 5 ton, 8 ton, and 10 ton crops. The assumption I make is that if the farmer does not fertilize or spray, the harvest is 5 tons; if the farmer fertilizes 1/3 the recommended amount and does 1/3 the recommended spraying, the harvest is 8 tons; and if the farmer fertilizes the recommended amount and does all the recommended spraying, the harvest is 10 tons. With these assumptions, for 5 tons, *TFC* is $72, *TVC* is $604, *TC* is $676, *AFC* is $14, *AVC* is $121, and *ATC* is $135. For 8 tons, *TFC* is $72, *TVC* is $907, *TC* is $979, *AFC* is $9, *AVC* is $113, and *ATC* is $122. For 10 tons, *TFC* is $72, *TVC* is $1,513, *TC* is $1,585, *AFC* is $7, *AVC* is $151, and *ATC* is $158. The *MC* between 5 and 8 tons is $101 a ton and between 8 and 10 tons is $303. The minimum point on the *AVC* curve is at about 7 tons of pumpkins and the minimum point on the *ATC* curve is at about 8 tons of pumpkins.

2. a. Your students' answers will vary depending on the vegetable they select.

    b. Your students' answers will vary depending on the vegetable they select.

    c. Your students' answers will vary depending on the vegetable they select.

    d. Your students' answers will vary depending on the vegetable they select.