Long-Run Cost

We are now going to study the firm's long-run costs. In the long run, a firm can vary both the quantity of labor and the quantity of capital, so in the long run, all the firm's costs are variable.

The behavior of long-run cost depends on the firm's *production function*, which is the relationship between the maximum output attainable and the quantities of both labor and capital.

The Production Function

Table 11.3 shows Campus Sweaters' production function. The table lists total product schedules for four different quantities of capital. The quantity of capital identifies the plant size. The numbers for plant 1 are for a factory with 1 knitting machine—the case we've just studied. The other three plants have 2, 3, and 4 machines. If Campus Sweaters uses plant 2 with 2 knitting machines, the various amounts of labor can produce the outputs shown in the second column of the table. The other two columns show the outputs of yet larger quantities of capital. Each column of the table could be graphed as a total product curve for each plant.

Diminishing Returns Diminishing returns occur with each of the four plant sizes as the quantity of labor increases. You can check that fact by calculating the marginal product of labor in each of the plants with 2, 3, and 4 machines. With each plant size, as the firm increases the quantity of labor employed, the marginal product of labor (eventually) diminishes.

Diminishing Marginal Product of Capital
Diminishing returns also occur with each quantity of labor as the quantity of capital increases. You can check that fact by calculating the marginal product of capital at a given quantity of labor. The *marginal product of capital* is the change in total product divided by the change in capital when the quantity of labor is constant—equivalently, the change in output resulting from a one-unit increase in the quantity of capital. For example, if Campus Sweaters has 3 workers and increases its capital from 1 machine to 2 machines, output increases from 13 to 18 sweaters a day. The marginal product of the second machine is 5 sweaters a day. If Campus Sweaters continues to employ 3 workers and increases the number of machines from 2 to 3, output increases from 18 to 22 sweaters a day. The marginal product of the third machine is 4 sweaters a day, down from 5 sweaters a day for the second machine.

Let's now see what the production function implies for long-run costs.

TABLE 11.3 The Production Function

Labor (workers per day)	Output (sweaters per day)			
	Plant 1	Plant 2	Plant 3	Plant 4
1	4	10	13	15
2	10	15	18	20
3	13	18	22	24
4	15	20	24	26
5	16	21	25	27
Knitting machines (number)	1	2	3	4

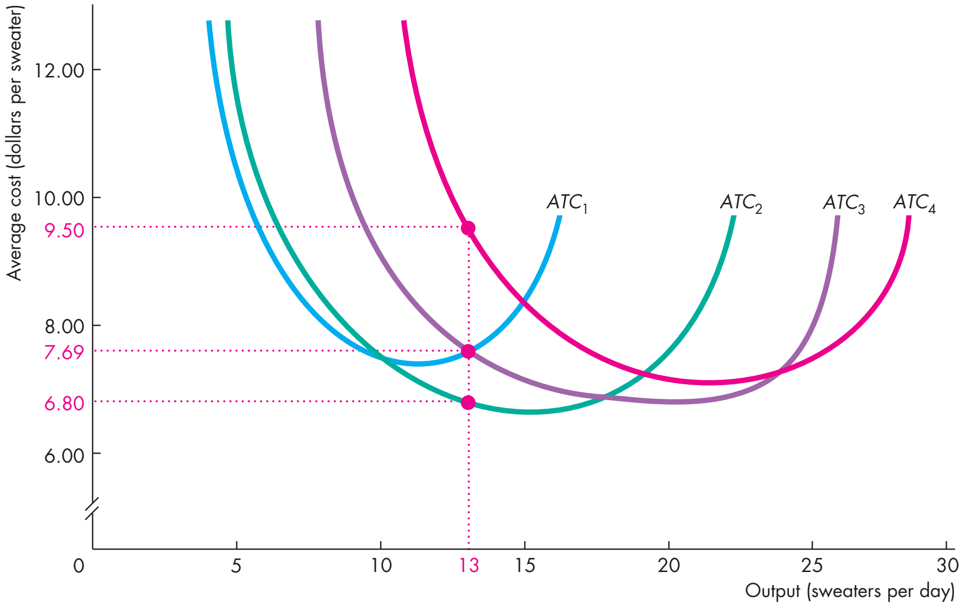
The table shows the total product data for four quantities of capital (plant sizes). The greater the plant size, the larger is the output produced by any given quantity of labor. For a given plant size, the marginal product of labor diminishes as more labor is employed. For a given quantity of labor, the marginal product of capital diminishes as the quantity of capital used increases.

Short-Run Cost and Long-Run Cost

As before, Campus Sweaters can hire workers for $25 a day and rent knitting machines for $25 a day. Using these factor prices and the data in Table 11.3, we can calculate the average total cost and graph the *ATC* curves for factories with 1, 2, 3, and 4 knitting machines. We've already studied the costs of a factory with 1 machine in Figs. 11.4 and 11.5. In Fig. 11.7, the average total cost curve for that case is ATC_1. Figure 11.7 also shows the average total cost curve for a factory with 2 machines, ATC_2, with 3 machines, ATC_3, and with 4 machines, ATC_4.

You can see, in Fig. 11.7, that the plant size has a big effect on the firm's average total cost.

FIGURE 11.7 Short-Run Costs of Four Different Plants



The figure shows short-run average total cost curves for four different quantities of capital at Campus Sweaters. The firm can produce 13 sweaters a day with 1 knitting machine on ATC_1 or with 3 knitting machines on ATC_3 for an average cost of $7.69 a sweater. The firm can produce 13 sweaters a day by using 2 machines on ATC_2 for $6.80 a sweater or by using 4 machines on ATC_4 for $9.50 a sweater.

If the firm produces 13 sweaters a day, the least-cost method of production, *the long-run method*, is with 2 machines on ATC_2.

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In Fig. 11.7, two things stand out:

1. Each short-run *ATC* curve is U-shaped.
2. For each short-run *ATC* curve, the larger the plant, the greater is the output at which average total cost is at a minimum.

Each short-run *ATC* curve is U-shaped because, as the quantity of labor increases, its marginal product initially increases and then diminishes. This pattern in the marginal product of labor, which we examined in some detail for the plant with 1 knitting machine on pp. 254–255, occurs at all plant sizes.

The minimum average total cost for a larger plant occurs at a greater output than it does for a smaller plant because the larger plant has a higher total fixed cost and therefore, for any given output, a higher average fixed cost.

Which short-run *ATC* curve a firm operates on depends on the plant it has. In the long run, the firm can choose its plant and the plant it chooses is the one that enables it to produce its planned output at the lowest average total cost.

To see why, suppose that Campus Sweaters plans to produce 13 sweaters a day. In Fig. 11.7, with 1 machine, the average total cost curve is ATC_1 and the average total cost of 13 sweaters a day is $7.69 a sweater. With 2 machines, on ATC_2, average total cost is $6.80 a sweater. With 3 machines, on ATC_3, average total cost is $7.69 a sweater, the same as with 1 machine. Finally, with 4 machines, on ATC_4, average total cost is $9.50 a sweater.

The economically efficient plant for producing a given output is the one that has the lowest average total cost. For Campus Sweaters, the economically efficient plant to use to produce 13 sweaters a day is the one with 2 machines.

In the long run, Cindy chooses the plant that minimizes average total cost. When a firm is producing a given output at the least possible cost, it is operating on its *long-run average cost curve*.

The **long-run average cost curve** is the relationship between the lowest attainable average total cost and output when the firm can change both the plant it uses and the quantity of labor it employs.

The long-run average cost curve is a planning curve. It tells the firm the plant and the quantity of labor to use at each output to minimize average cost. Once the firm chooses a plant, the firm operates on the short-run cost curves that apply to that plant.

The Long-Run Average Cost Curve

Figure 11.8 shows how a long-run average cost curve is derived. The long-run average cost curve *LRAC* consists of pieces of the four short-run *ATC* curves. For outputs up to 10 sweaters a day, average total cost is the lowest on ATC_1. For outputs between 10 and 18 sweaters a day, average total cost is the lowest on ATC_2. For outputs between 18 and 24 sweaters a day, average total cost is the lowest on ATC_3. And for outputs in excess of 24 sweaters a day, average total cost is the lowest on ATC_4. The piece of each *ATC* curve with the lowest average total cost is highlighted in dark blue in Fig. 11.8. This dark blue scallop-shaped curve made up of the pieces of the four *ATC* curves is the *LRAC* curve.

Economies and Diseconomies of Scale

Economies of scale are features of a firm's technology that make average total cost *fall* as output increases. When economies of scale are present, the *LRAC* curve slopes downward. In Fig. 11.8, Campus Sweaters has economies of scale for outputs up to 15 sweaters a day.

Greater specialization of both labor and capital is the main source of economies of scale. For example, if GM produces 100 cars a week, each worker must perform many different tasks and the capital must be general-purpose machines and tools. But if GM produces 10,000 cars a week, each worker specializes in a small number of tasks, uses task-specific tools, and becomes highly proficient.

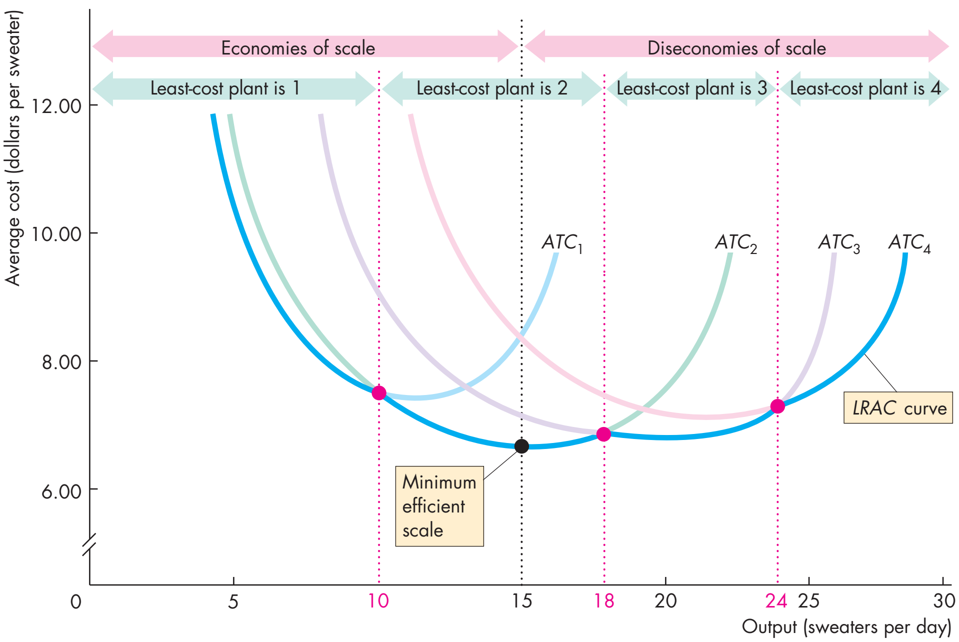
Diseconomies of scale are features of a firm's technology that make average total cost *rise* as output increases. When diseconomies of scale are present, the *LRAC* curve slopes upward. In Fig. 11.8, Campus Sweaters experiences diseconomies of scale at outputs greater than 15 sweaters a day.

The challenge of managing a large enterprise is the main source of diseconomies of scale.

Constant returns to scale are features of a firm's technology that keep average total cost constant as output increases. When constant returns to scale are present, the *LRAC* curve is horizontal.

Economies of Scale at Campus Sweaters The economies of scale and diseconomies of scale at Campus Sweaters arise from the firm's production function in Table 11.3. With 1 machine and 1 worker, the firm produces 4 sweaters a day. With 2 machines and 2 workers, total cost doubles but out-

FIGURE 11.8 Long-Run Average Cost Curve



The long-run average cost curve traces the lowest attainable *ATC* when both labor and capital change. The green arrows highlight the output range over which each plant achieves the lowest *ATC*. Within each range, to change the quantity produced, the firm changes the quantity of labor it employs.

Along the *LRAC* curve, economies of scale occur if average cost falls as output increases; diseconomies of scale occur if average cost rises as output increases. Minimum efficient scale is the output at which average cost is lowest, 15 sweaters a day.

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Economics in Action

Produce More to Cut Cost

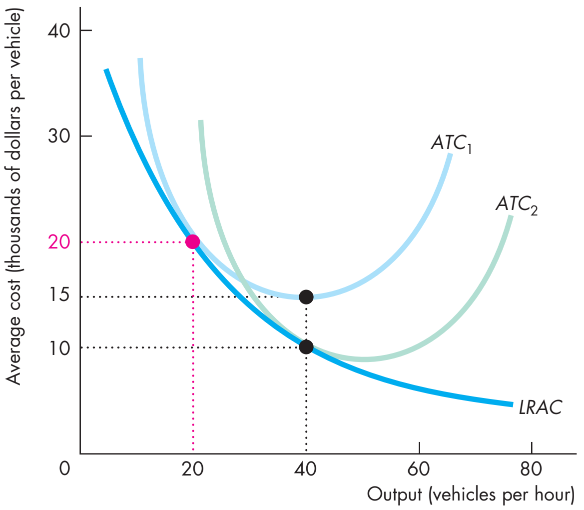
Why do GM, Ford, and the other automakers have expensive equipment lying around that isn't fully used? You can answer this question with what you've learned in this chapter.

The basic answer is that auto production enjoys economies of scale. A larger output rate brings a lower long-run average cost—the firm's *LRAC* curve slopes downward.

An auto producer's average total cost curves look like those in the figure. To produce 20 vehicles an hour, the firm installs the plant with the short-run average total cost curve ATC_1. The average cost of producing a vehicle is $20,000.

Producing 20 vehicles an hour doesn't use the plant at its lowest possible average total cost. If the firm could sell enough cars for it to produce 40 vehicles an hour, the firm could use its current plant and produce at an average cost of $15,000 a vehicle.

But if the firm planned to produce 40 vehicles an hour, it would not stick with its current plant. The firm would install a bigger plant with the short-run average total cost curve ATC_2, and produce 40 vehicles an hour for $10,000 a car.



Automobile Plant Average Cost Curves

put more than doubles to 15 sweaters a day, so average cost decreases and Campus Sweaters experiences economies of scale. With 4 machines and 4 workers, total cost doubles again but output less than doubles to 26 sweaters a day, so average cost increases and the firm experiences diseconomies of scale.

Minimum Efficient Scale A firm's **minimum efficient scale** is the *smallest* output at which long-run average cost reaches its lowest level. At Campus Sweaters, the minimum efficient scale is 15 sweaters a day.

The minimum efficient scale plays a role in determining market structure. In a market in which the minimum efficient scale is small relative to market demand, the market has room for many firms, and the market is competitive. In a market in which the minimum efficient scale is large relative to market demand, only a small number of firms, and possibly only one firm, can make a profit and the market is either an oligopoly or monopoly. We will return to this idea in the next three chapters.

REVIEW QUIZ

1. What does a firm's production function show and how is it related to a total product curve?
2. Does the law of diminishing returns apply to capital as well as labor? Explain why or why not.
3. What does a firm's *LRAC* curve show? How is it related to the firm's short-run *ATC* curves?
4. What are economies of scale and diseconomies of scale? How do they arise? What do they imply for the shape of the *LRAC* curve?
5. What is a firm's minimum efficient scale?

You can work these questions in Study Plan 11.4 and get instant feedback. myeconlab

Reading Between the Lines on pp. 266–267 applies what you've learned about a firm's cost curves. It looks at the cost of producing electricity and explains how the use of smart meters can lower average variable cost.

Cutting the Cost of Producing Electricity

Here Come the "Smart" Meters

http://www.wsj.com

May 21, 2010

One of modern life's most durable features—fixed-price electricity—is slowly being pushed to the sidelines, a creeping change that will influence such things as what time millions of Americans cook dinner and what appliances they buy.

Driving the change is the rollout of so-called smart meters, which can transmit data on how much power is being used at any given time. That gives utilities the ability to charge more for electricity at peak times and less during lulls. Spreading out electricity consumption more evenly across the day leads to more efficient use of power plants and lower emissions. ...

The new system uses digital meters to charge prices that vary during the day.

Though fewer than 10 percent of U.S. homes have smart meters now, the Department of Energy is funding efforts that will boost that number to nearly a third by 2015. The majority of homes in California and Texas, the two most populous states, will have smart meters by 2013.

Smart meters lie at the heart of efforts to get Americans to use less electricity. Power generation accounts for about 40 percent of greenhouse-gas emissions in the United States. A 2009 federal study found that smart meters could help cut peak electricity use by 20 percent.

In California, power plants totaling 30,000 to 35,000 megawatts of capacity are needed on a typical day. But 50,000 megawatts or more are needed on hot days. That forces generators to turn on their least efficient and most polluting plants to meet demand. In New York, average demand is 42 percent less than peak-time demand. Flatten peak use, experts say, and system costs drop, as does pollution. ...

ESSENCE OF THE STORY

- Fixed-price electricity is being replaced by time-of-day pricing.
- Smart meters make it possible for utilities to charge more for electricity at peak times and less at off-peak times.
- Fewer than 10 percent of U.S. homes had smart meters in 2010, but the majority of homes in California and Texas will have them by 2013 and almost a third of all U.S. homes will have them by 2015.
- Time-of-day pricing makes electricity consumption more even across the day.
- A 2009 federal study found that smart meters could help cut peak electricity use by 20 percent.
- Making electricity consumption more even across the day lowers the cost of electricity generation.
- In California, power plants produce 30,000 to 35,000 megawatts on a typical day and 50,000 megawatts or more on a hot day.
- In New York, average production is 42 percent less than peak-time production.

ECONOMIC ANALYSIS

- The average variable cost of producing electricity depends on the technology used and on the quantity of electricity produced.
- Figure 1 shows some of the cost differences that arise from using different technologies.
- The variable cost of using wind power is zero; nuclear is the next least costly; and a turbine has the highest cost.
- Electric power utilities use the lowest-cost technologies to meet normal demand and where possible to meet peak demand. At very high peak demand, they also use turbines that burn a high-cost gasoline fuel.
- For a given technology, average variable cost depends on the quantity produced, and Fig. 2 illustrates this relationship.
- In the example in Fig. 2 the plant is designed to have minimum *AVC* when it produces 60 percent of its physical maximum output.
- If production could be held steady at 60 percent of the plant's physical maximum output, the cost of producing electricity is minimized.
- But if production increases to meet peak demand at the physical limit of the plant, the cost of production increases along the rising *AVC* curve and *MC* curve.
- When electricity is sold for a single price, consumers have no incentive to limit their peak-hour usage.

A smart meter being installed

- By introducing smart meters that enable time-of-day pricing of electricity, consumers can be confronted with the marginal cost of their choices.
- By raising the price during the peak hours and lowering the price during off-peak hours, electricity consumption can be kept more even over the day and closer to the quantity at minimum average variable cost.

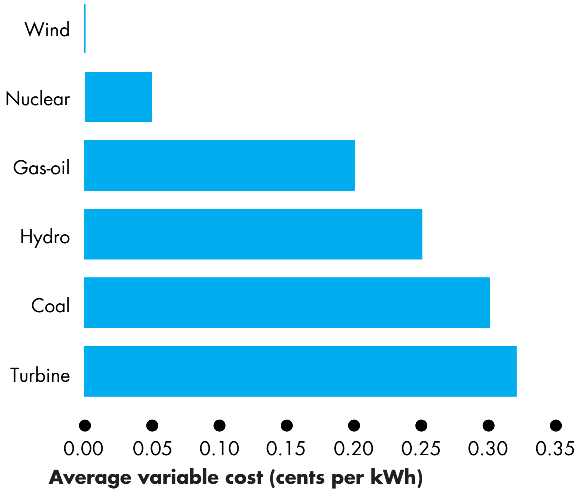


Figure 1 Average variable costs of alternative technologies

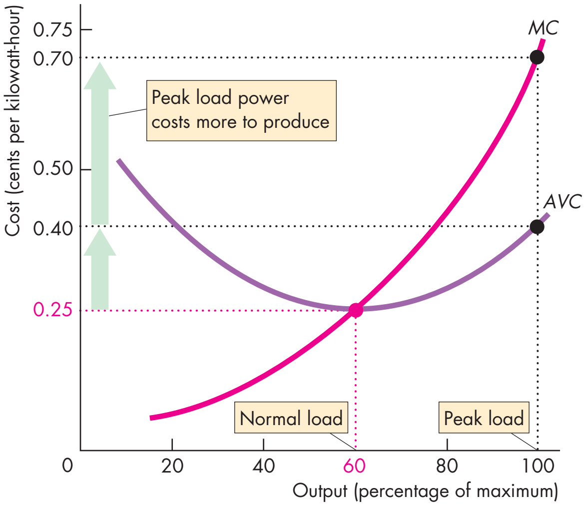


Figure 2 Cost curves for generating electricity

SUMMARY

Key Points

Decision Time Frames (p. 252)

- In the short run, the quantity of at least one factor of production is fixed and the quantities of the other factors of production can be varied.
- In the long run, the quantities of all factors of production can be varied.

Working Problems 1 and 2 will give you a better understanding of a firm's decision time frames.

Short-Run Technology Constraint (pp. 253–256)

- A total product curve shows the quantity a firm can produce with a given quantity of capital and different quantities of labor.
- Initially, the marginal product of labor increases as the quantity of labor increases, because of increased specialization and the division of labor.
- Eventually, marginal product diminishes because an increasing quantity of labor must share a fixed quantity of capital—the law of diminishing returns.
- Initially, average product increases as the quantity of labor increases, but eventually average product diminishes.

Working Problems 3 to 8 will give you a better understanding of a firm's short-run technology constraint.

Short-Run Cost (pp. 257–261)

- As output increases, total fixed cost is constant, and total variable cost and total cost increase.
- As output increases, average fixed cost decreases and average variable cost, average total cost, and marginal cost decrease at low outputs and increase at high outputs. These cost curves are U-shaped.

Working Problems 9 to 14 will give you a better understanding of a firm's short-run cost.

Long-Run Cost (pp. 262–265)

- A firm has a set of short-run cost curves for each different plant. For each output, the firm has one least-cost plant. The larger the output, the larger is the plant that will minimize average total cost.
- The long-run average cost curve traces out the lowest attainable average total cost at each output when both capital and labor inputs can be varied.
- With economies of scale, the long-run average cost curve slopes downward. With diseconomies of scale, the long-run average cost curve slopes upward.

Working Problems 15 to 20 will give you a better understanding of a firm's long-run cost.

Key Terms

Average fixed cost, 258
Average product, 253
Average total cost, 258
Average variable cost, 258
Constant returns to scale, 264
Diminishing marginal returns, 255
Diseconomies of scale, 264
Economies of scale, 264
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Long run, 252
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Short run, 252
Sunk cost, 252
Total cost, 257
Total fixed cost, 257
Total product, 253
Total variable cost, 257

STUDY PLAN PROBLEMS AND APPLICATIONS

myeconlab You can work Problems 1 to 21 in MyEconLab Chapter 11 Study Plan and get instant feedback.

Decision Time Frames (Study Plan 11.1)

1. Which of the following news items involves a short-run decision and which involves a long-run decision? Explain.
   January 31, 2008: Starbucks will open 75 more stores abroad than originally predicted, for a total of 975.
   February 25, 2008: For three hours on Tuesday, Starbucks will shut down every single one of its 7,100 stores so that baristas can receive a refresher course.
   June 2, 2008: Starbucks replaces baristas with vending machines.
   July 18, 2008: Starbucks is closing 616 stores by the end of March.
2. **Maryland Farmers Turn from Tobacco to Flowers**
   Maryland tobacco farmers will be subsidized if they switch from growing tobacco to growing crops such as flowers and organic vegetables.
   Source: *The New York Times*, February 25, 2001
   a. How does offering farmers a payment to exit tobacco growing influence the opportunity cost of growing tobacco?
   b. What is the opportunity cost of using the equipment owned by a tobacco farmer?

Short-Run Technology Constraint (Study Plan 11.2)

Use the following table to work Problems 3 to 7. The table sets out Sue's Surfboards' total product schedule.

Labor (workers per week)	Output (surfboards per week)
1	30
2	70
3	120
4	160
5	190
6	210
7	220

3. Draw the total product curve.
4. Calculate the average product of labor and draw the average product curve.
5. Calculate the marginal product of labor and draw the marginal product curve.
6. a. Over what output range does Sue's Surfboards enjoy the benefits of increased specialization and division of labor?
   b. Over what output range does the firm experience diminishing marginal product of labor?
   c. Over what output range does the firm experience an increasing average product of labor but a diminishing marginal product of labor?
7. Explain how it is possible for a firm to experience simultaneously an increasing *average* product but a diminishing *marginal* product.
8. **Business Boot Camp**
   At a footwear company called Caboots, sales rose from $160,000 in 2000 to $2.3 million in 2006, but in 2007 sales dipped to $1.5 million. Joey and Priscilla Sanchez, who run Caboots, blame the decline partly on a flood that damaged the firm's office and sapped morale.
   Source: CNN, April 23, 2008
   If the Sanchezes are correct in their assumptions and the prices of footwear didn't change
   a. Explain the effect of the flood on the total product curve and marginal product curve at Caboots.
   b. Draw a graph to show the effect of the flood on the total product curve and marginal product curve at Caboots.

Short-Run Cost (Study Plan 11.3)

Use the following data to work Problems 9 to 13.

Sue's Surfboards, in Problem 3, hires workers at $500 a week and its total fixed cost is $1,000 a week.

9. Calculate total cost, total variable cost, and total fixed cost of each output in the table. Plot these points and sketch the short-run total cost curves passing through them.
10. Calculate average total cost, average fixed cost, average variable cost, and marginal cost of each output in the table. Plot these points and sketch the short-run average and marginal cost curves passing through them.
11. Illustrate the connection between Sue's *AP*, *MP*, *AVC*, and *MC* curves in graphs like those in Fig. 11.6.

12. Sue's Surfboards rents a factory building. If the rent is increased by $200 a week and other things remain the same, how do Sue's Surfboards' short-run average cost curves and marginal cost curve change?
13. Workers at Sue's Surfboards negotiate a wage increase of $100 a week for each worker. If other things remain the same, explain how Sue's Surfboards' short-run average cost curves and marginal cost curve change.
14. **Grain Prices Go the Way of the Oil Price**

    Every morning millions of Americans confront the latest trend in commodities markets at their kitchen table. Rising prices for crops have begun to drive up the cost of breakfast.

    Source: *The Economist*, July 21, 2007

    Explain how the rising price of crops affects the average total cost and marginal cost of producing breakfast cereals.

Long-Run Cost (Study Plan 11.4)

Use the table in Problem 3 and the following information to work Problems 15 and 16.

Sue's Surfboards buys a second plant and the output produced by each worker increases by 50 percent. The total fixed cost of operating each plant is $1,000 a week. Each worker is paid $500 a week.

15. Calculate the average total cost of producing 180 and 240 surfboards a week when Sue's Surfboards operates two plants. Graph these points and sketch the *ATC* curve.
16. a. To produce 180 surfboards a week, is it efficient to operate one or two plants?
    b. To produce 160 surfboards a week, is it efficient for Sue's to operate one or two plants?

Use the following table to work Problems 17 to 20. The table shows the production function of Jackie's Canoe Rides.

Labor (workers per day)	Output (rides per day)			
	Plant 1	Plant 2	Plant 3	Plant 4
10	20	40	55	65
20	40	60	75	85
30	65	75	90	100
40	75	85	100	110
Canoes	10	20	30	40

Jackie's pays $100 a day for each canoe it rents and $50 a day for each canoe operator it hires.

17. Graph the *ATC* curves for Plant 1 and Plant 2. Explain why these *ATC* curves differ.
18. Graph the *ATC* curves for Plant 3 and Plant 4. Explain why these *ATC* curves differ.
19. a. On Jackie's *LRAC* curve, what is the average cost of producing 40, 75, and 85 rides a week?
    b. What is Jackie's minimum efficient scale?
20. a. Explain how Jackie's uses its *LRAC* curve to decide how many canoes to rent.
    b. Does Jackie's production function feature economies of scale or diseconomies of scale?

Economics in the News (Study Plan 11.N)

21. **Airlines Seek Out New Ways to Save on Fuel as Costs Soar**

    The financial pain of higher fuel prices is particularly acute for airlines because it is their single biggest expense. Airlines pump about 7,000 gallons into a Boeing 737 and about 60,000 gallons into the bigger 747 jet. Each generation of aircraft is more efficient: An Airbus A330 long-range jet uses 38 percent less fuel than the DC-10 it replaced, while the Airbus A319 medium-range jet is 27 percent more efficient than the DC-9 it replaced.

    Source: *The New York Times*, June 11, 2008

    a. Is the price of fuel a fixed cost or a variable cost for an airline?
    b. Explain how an increase in the price of fuel changes an airline's total costs, average costs, and marginal cost.
    c. Draw a graph to show the effects of an increase in the price of fuel on an airline's *TFC, TVC*, *AFC*, *AVC*, and *MC* curves.
    d. Explain how a technological advance that makes an airplane engine more fuel efficient changes an airline's total product, marginal product, and average product.
    e. Draw a graph to illustrate the effects of a more fuel-efficient aircraft on an airline's *TP*, *MP*, and *AP* curves.
    f. Explain how a technological advance that makes an airplane engine more fuel efficient changes an airline's average variable cost, marginal cost, and average total cost.
    g. Draw a graph to illustrate how a technological advance that makes an airplane engine more fuel efficient changes an airline's *AVC*, *MC*, and *ATC* curves.

ADDITIONAL PROBLEMS AND APPLICATIONS

myeconlab *These problems are available in MyEconLab if assigned by your instructor.*

Decision Time Frames

22. **A Bakery on the Rise**

    Some 500 customers a day line up to buy Avalon's breads, scones, muffins, and coffee. Staffing and management are worries. Avalon now employs 35 and plans to hire 15 more. Its payroll will climb by 30 percent to 40 percent. The new CEO has executed an ambitious agenda that includes the move to a larger space, which will increase the rent from $3,500 to $10,000 a month.

    Source: CNN, March 24, 2008

    a. Which of Avalon's decisions described in the news clip is a short-run decision and which is a long-run decision?

    b. Why is Avalon's long-run decision riskier than its short-run decision?

23. **The Sunk-Cost Fallacy**

    You have good tickets to a basketball game an hour's drive away. There's a blizzard raging outside, and the game is being televised. You can sit warm and safe at home and watch it on TV, or you can bundle up, dig out your car, and go to the game. What do you do?

    Source: *Slate*, September 9, 2005

    a. What type of cost is your expenditure on tickets?

    b. Why is the cost of the ticket irrelevant to your current decision about whether to stay at home or go to the game?

Short-Run Technology Constraint

24. Terri runs a rose farm. One worker produces 1,000 roses a week; hiring a second worker doubles her total product; hiring a third worker doubles her output again; hiring a fourth worker increased her total product but by only 1,000 roses. Construct Terri's marginal product and average product schedules. Over what range of workers do marginal returns increase?

Short-Run Cost

25. Use the events described in the news clip in Problem 22. By how much will Avalon's short-run decision increase its total variable cost? By how much will Avalon's long-run decision increase its monthly total fixed cost? Sketch Avalon's short-run *ATC* curve before and after the events described in the news clip.

26. **Coffee King Starbucks Raises Its Prices**

    Starbucks is raising its prices because the wholesale price of milk has risen 70 percent and there's a lot of milk in Starbucks lattes.

    Source: *USA Today*, July 24, 2007

    Is milk a fixed factor of production or a variable factor of production? Describe how the increase in the price of milk changes Starbucks' short-run cost curves.

27. Bill's Bakery has a fire and Bill loses some of his cost data. The bits of paper that he recovers after the fire provide the information in the following table (all the cost numbers are dollars).

TP	*AFC*	*AVC*	*ATC*	*MC*
10	120	100	220	
				80
20	***A***	***B***	150	
				90
30	40	90	130	
				130
40	30	***C***	***D***	
				E
50	24	108	132	

    Bill asks you to come to his rescue and provide the missing data in the five spaces identified as ***A***, ***B***, ***C***, ***D***, and ***E***.

Use the following table to work Problems 28 and 29.

ProPainters hires students at $250 a week to paint houses. It leases equipment at $500 a week. The table sets out its total product schedule.

Labor (students)	Output (houses painted per week)
1	2
2	5
3	9
4	12
5	14
6	15

28. If ProPainters paints 12 houses a week, calculate its total cost, average total cost, and marginal cost. At what output is average total cost a minimum?

29. Explain why the gap between ProPainters' total cost and total variable cost is the same no matter how many houses are painted.

Long-Run Cost

Use the table in Problem 28 and the following information to work Problems 30 and 31.

If ProPainters doubles the number of students it hires and doubles the amount of equipment it leases, it experiences diseconomies of scale.

30. Explain how the *ATC* curve with one unit of equipment differs from that when ProPainters uses double the amount of equipment.
31. Explain what might be the source of the diseconomies of scale that ProPainters experiences.

Use the following information to work Problems 32 and 33.

The table shows the production function of Bonnie's Balloon Rides. Bonnie's pays $500 a day for each balloon it rents and $25 a day for each balloon operator it hires.

Labor (workers per day)	Output (rides per day)			
	Plant 1	Plant 2	Plant 3	Plant 4
10	6	10	13	15
20	10	15	18	20
30	13	18	22	24
40	15	20	24	26
50	16	21	25	27
Balloons (number)	1	2	3	4

32. Graph the *ATC* curves for Plant 1 and Plant 2. Explain why these *ATC* curves differ.
33. Graph the *ATC* curves for Plant 3 and Plant 4 Explain why these *ATC* curves differ.
34. a. On Bonnie's *LRAC* curve, what is the average cost of producing 18 rides and 15 rides a day?
    b. Explain how Bonnie's uses its long-run average cost curve to decide how many balloons to rent.

Use the following news clip to work Problems 35 and 36.

Gap Will Focus on Smaller Scale Stores

Gap has too many stores that are 12,500 square feet. The target store size is 6,000 square feet to 10,000 square feet, so Gap plans to combine previously separate concept stores. Some Gap body, adult, maternity, baby and kids stores will be combined in one store.

Source: CNN, June 10, 2008

35. Thinking of a Gap store as a production plant, explain why Gap is making a decision to reduce the size of its stores. Is Gap's decision a long-run decision or a short-run decision?
36. How might combining Gap's concept stores into one store help better take advantage of economies of scale?

Economics in the News

37. After you have studied *Reading Between the Lines* on pp. 266–267 answer the following questions.
    a. Sketch the *AFC*, *AVC*, *ATC*, and *MC* curves for electricity production using the six technologies shown in Fig. 1 on p. 267.
    b. Given the cost differences among the different methods of generating electricity, why do you think we use more than one method? If we could use only one method, which would it be?
    c. Explain how time-of-day pricing that succeeds in smoothing out fluctuations in production across the day lowers the average variable cost and marginal cost of generating electricity.
    d Draw a graph to illustrate your answer to part (c).
38. **Starbucks Unit Brews Up Self-Serve Espresso Bars**

    Automated, self-serve espresso kiosks have appeared in many grocery stores. The machines, which grind their own beans, crank out lattes, and drip coffees take credit and debit cards, and cash. Coinstar buys the kiosks for just under $40,000 per unit, installs them, and provides maintenance. The self-serve kiosks remove the labor costs of having a barista. The kiosks use Starbucks' Seattle's Best Coffee and store personnel handle refills of coffee beans and milk.

    Source: MSNBC, June 1, 2008

    a. What is Coinstar's total fixed cost of operating one self-serve kiosk?
    b. What are Coinstar's variable costs of providing coffee at a self-serve kiosk?
    c. Assume that a coffee machine operated by a barista costs less than $40,000. Explain how the fixed costs, variable costs, and total costs of barista-served and self-served coffee differ.
    d. Sketch the marginal cost and average cost curves implied by your answer to part (c).