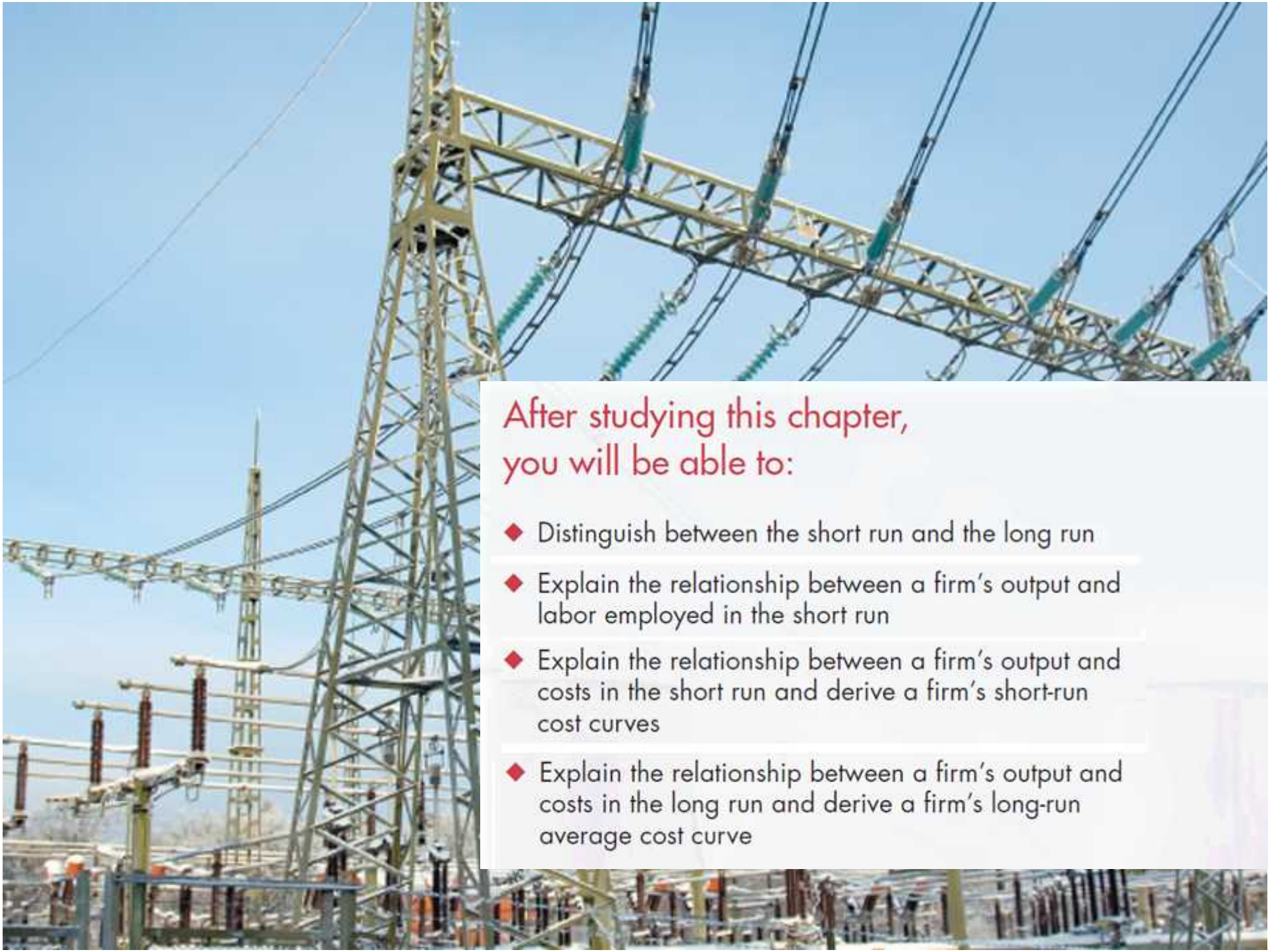
PARKIN
MICROECONOMICS
TENTH EDITION

11

OUTPUT AND COSTS



After studying this chapter, you will be able to:

- Distinguish between the short run and the long run
- Explain the relationship between a firm's output and labor employed in the short run
- Explain the relationship between a firm's output and costs in the short run and derive a firm's short-run cost curves
- Explain the relationship between a firm's output and costs in the long run and derive a firm's long-run average cost curve

What do General Motors, PennPower, and Campus Sweaters, have in common?

Like every firm,

- They must decide how much to produce.
- How many people to employ.
- How much and what type of capital equipment to use.

How do firms make these decisions?

Decision Time Frames

The firm makes many decisions to achieve its main objective: *profit maximization*.

Some decisions are critical to the survival of the firm.

Some decisions are irreversible (or very costly to reverse).

Other decisions are easily reversed and are less critical to the survival of the firm, but still influence profit.

All decisions can be placed in two time frames:

- The short run
- The long run

Decision Time Frames

The Short Run

The **short run** is a time frame in which the quantity of one or more resources used in production is fixed.

For most firms, the capital, called the firm's *plant*, is fixed in the short run.

Other resources used by the firm (such as labor, raw materials, and energy) can be changed in the short run.

Short-run decisions are easily reversed.

Decision Time Frames

The Long Run

The **long run** is a time frame in which the quantities of *all* resources—including the plant size—can be varied.

Long-run decisions are not easily reversed.

A **sunk cost** is a cost incurred by the firm and cannot be changed.

If a firm's plant has no resale value, the amount paid for it is a sunk cost.

Sunk costs are irrelevant to a firm's current decisions.

Short-Run Technology Constraint

To increase output in the short run, a firm must increase the amount of labor employed.

Three concepts describe the relationship between output and the quantity of labor employed:

1. Total product
2. Marginal product
3. Average product

Short-Run Technology Constraint

Product Schedules

Total product is the total output produced in a given period.

The **marginal product** of labor is the change in total product that results from a one-unit increase in the quantity of labor employed, with all other inputs remaining the same.

The **average product** of labor is equal to total product divided by the quantity of labor employed.

Short-Run Technology Constraint

Table 11.1 shows a firm's product schedules.

As the quantity of labor employed increases:

- Total product increases.
- Marginal product increases initially …

  but eventually decreases.
- Average product decreases.

TABLE 11.1 Total Product, Marginal Product, and Average Product

	Labor (workers per day)	Total product (sweaters per day)	Marginal product (sweaters per additional worker)	Average product (sweaters per worker)
A	0	0		
			4	
B	1	4		4.00
			6	
C	2	10		5.00
			3	
D	3	13		4.33
			2	
E	4	15		3.75
			1	
F	5	16		3.20

TABLE 11.1 Total Product, Marginal Product, and Average Product

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E	4	15		3.75
			1	
F	5	16		3.20

Short-Run Technology Constraint

Product Curves

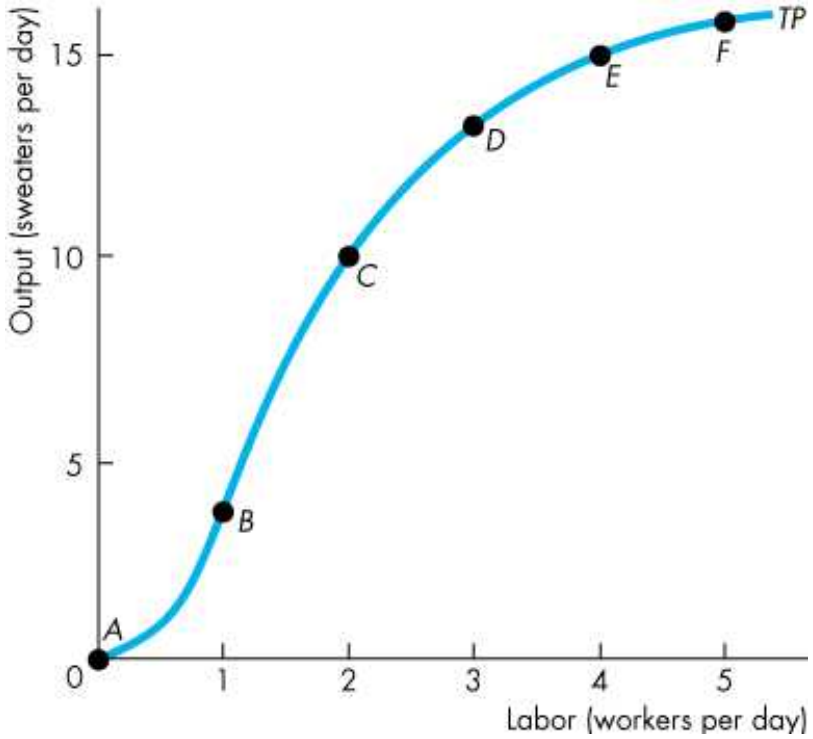
Product curves show how the firm's total product, marginal product, and average product change as the firm varies the quantity of labor employed.

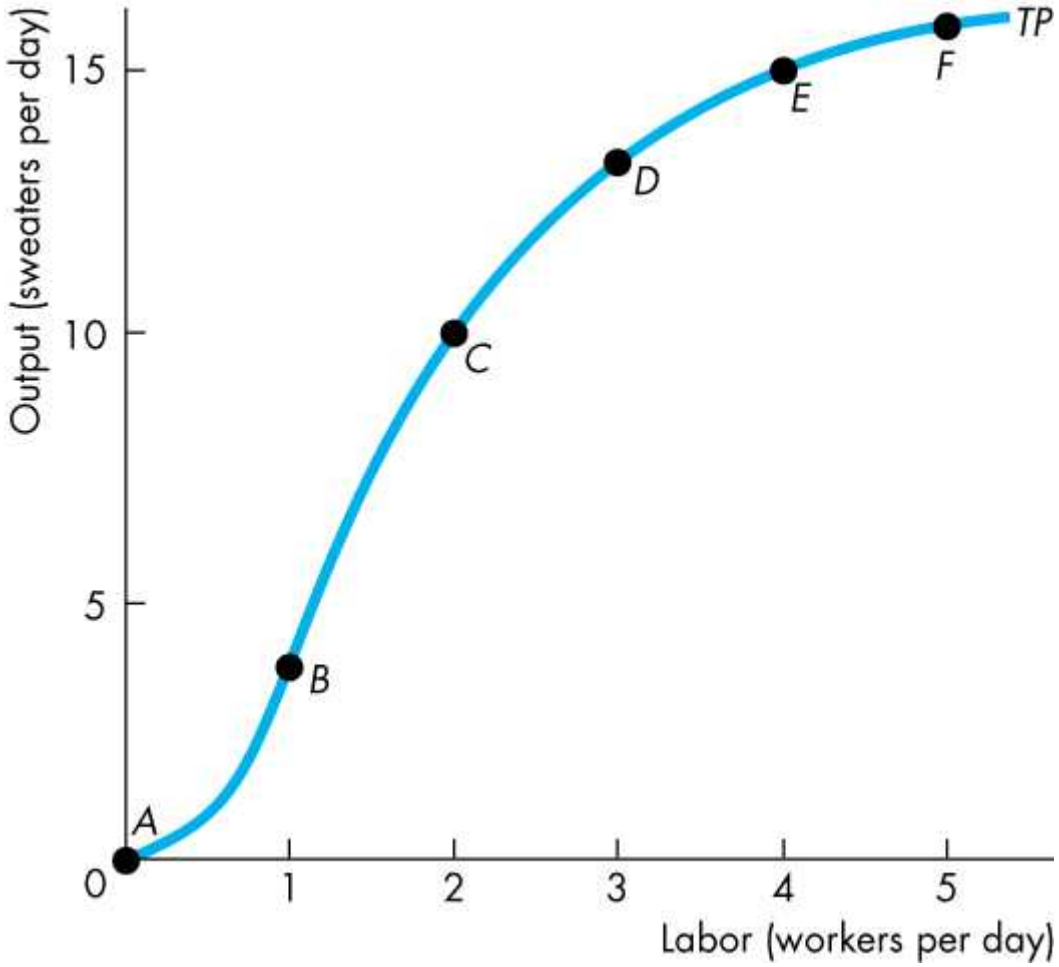
Short-Run Technology Constraint

Total Product Curve

Figure 11.1 shows a total product curve.

The total product curve shows how total product changes with the quantity of labor employed.

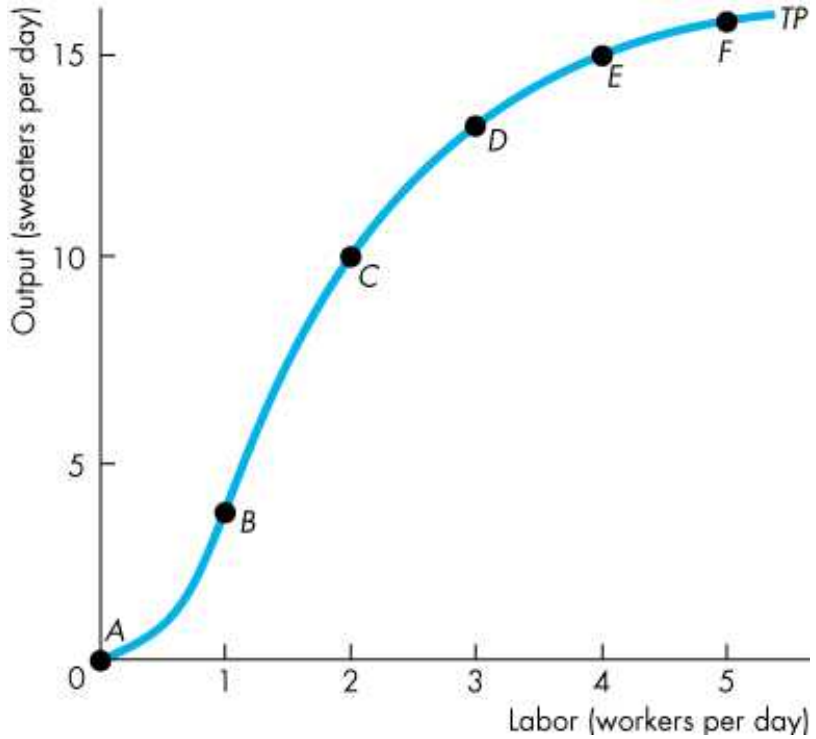




Short-Run Technology Constraint

The total product curve is similar to the *PPF.*

It separates attainable output levels from unattainable output levels in the short run.

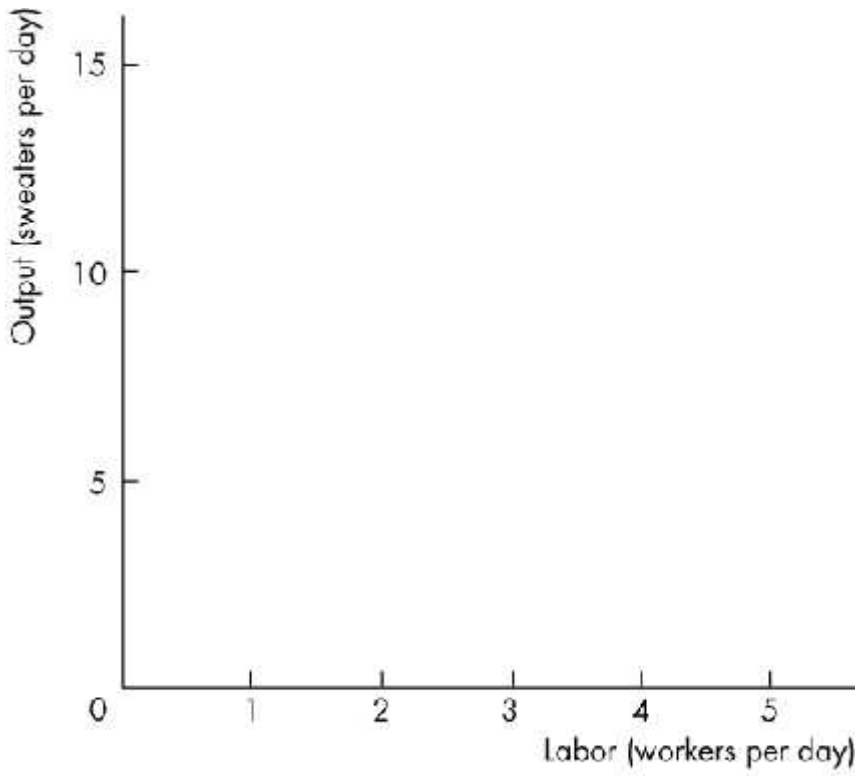


Short-Run Technology Constraint

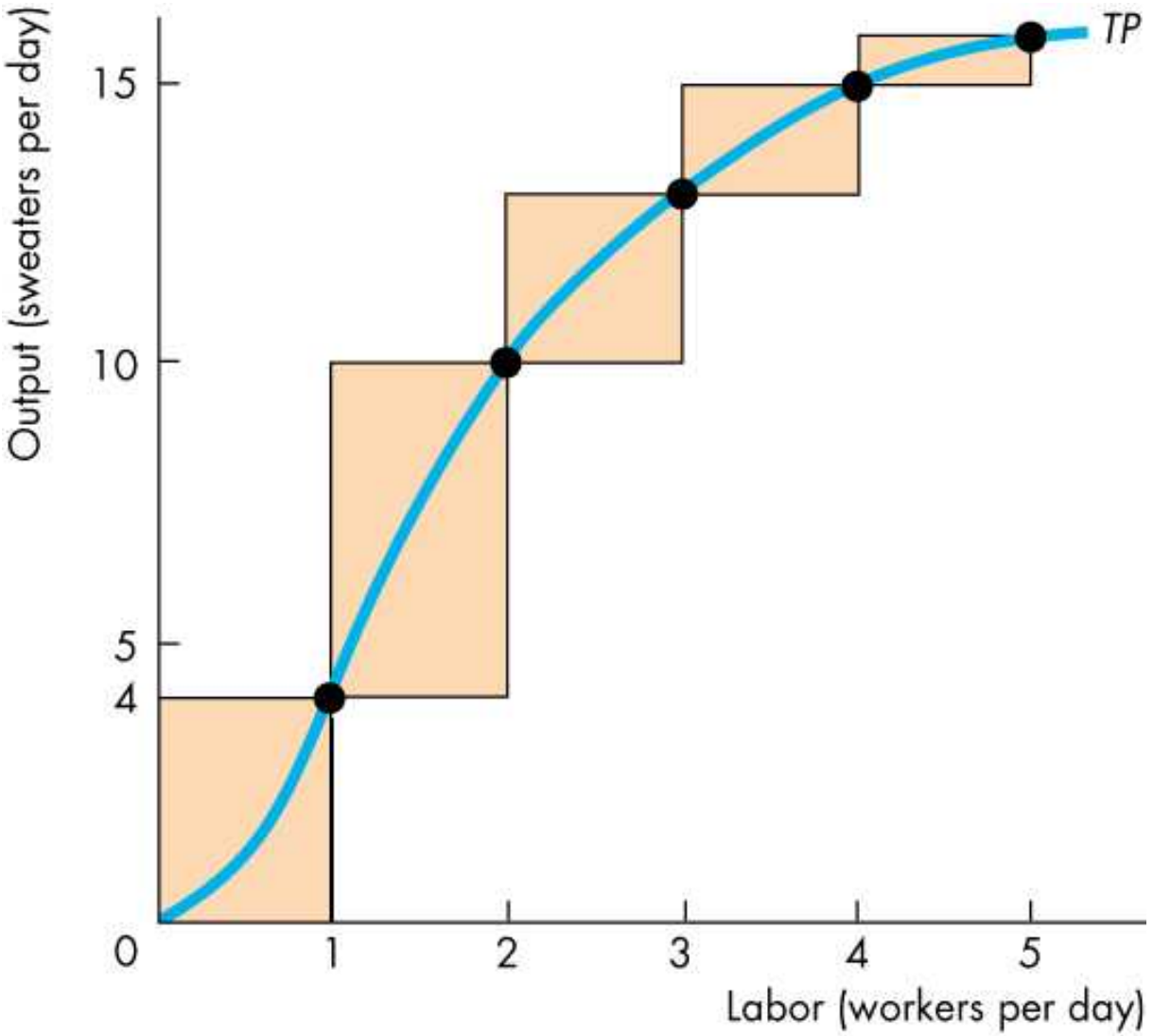
Marginal Product Curve

Figure 11.2 shows the marginal product of labor curve and how the marginal product curve relates to the total product curve.

The first worker hired produces 4 units of output.



(a) Total product



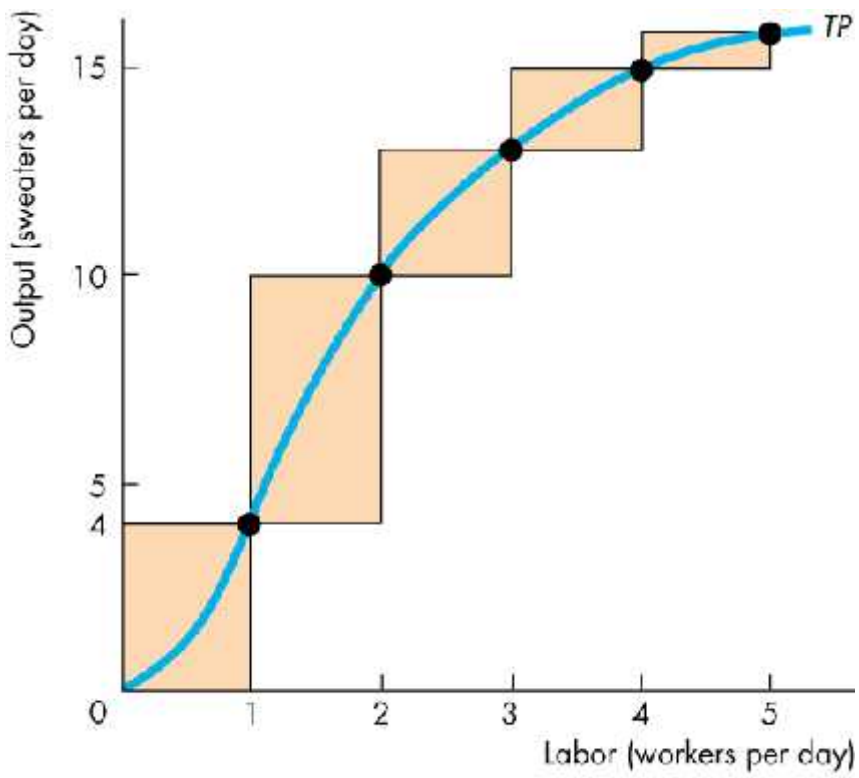
(a) Total product

Short-Run Technology Constraint

The second worker hired produces 6 units of output and total product becomes 10 units.

The third worker hired produces 3 units of output and total product becomes 13 units.

And so on.



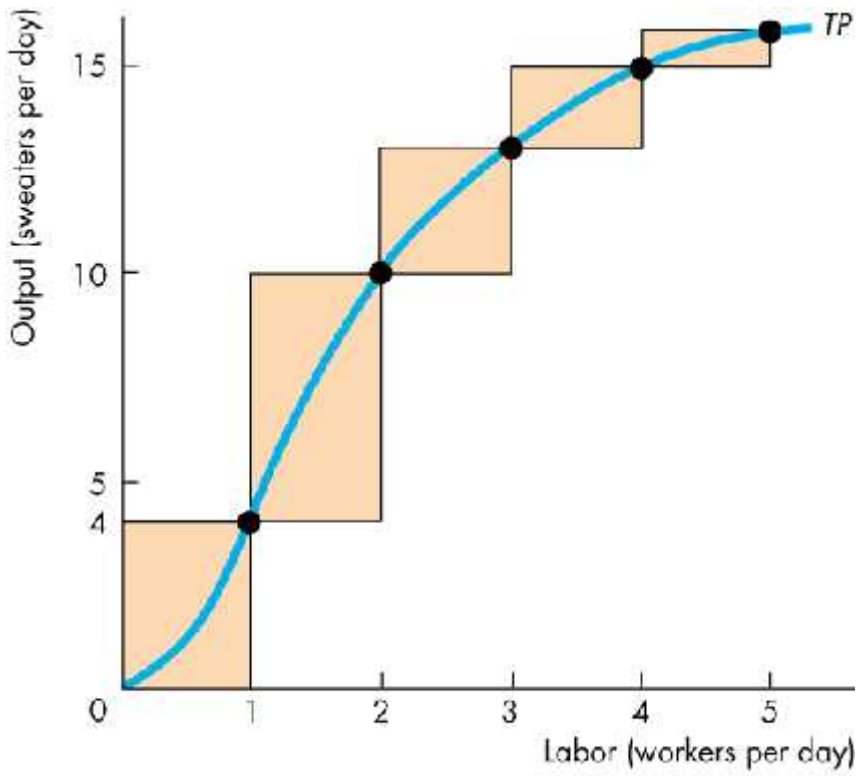
(a) Total product

Short-Run Technology Constraint

The height of each bar measures the marginal product of labor.

For example, when labor increases from 2 to 3, total product increases from 10 to 13,

so the marginal product of the third worker is 3 units of output.

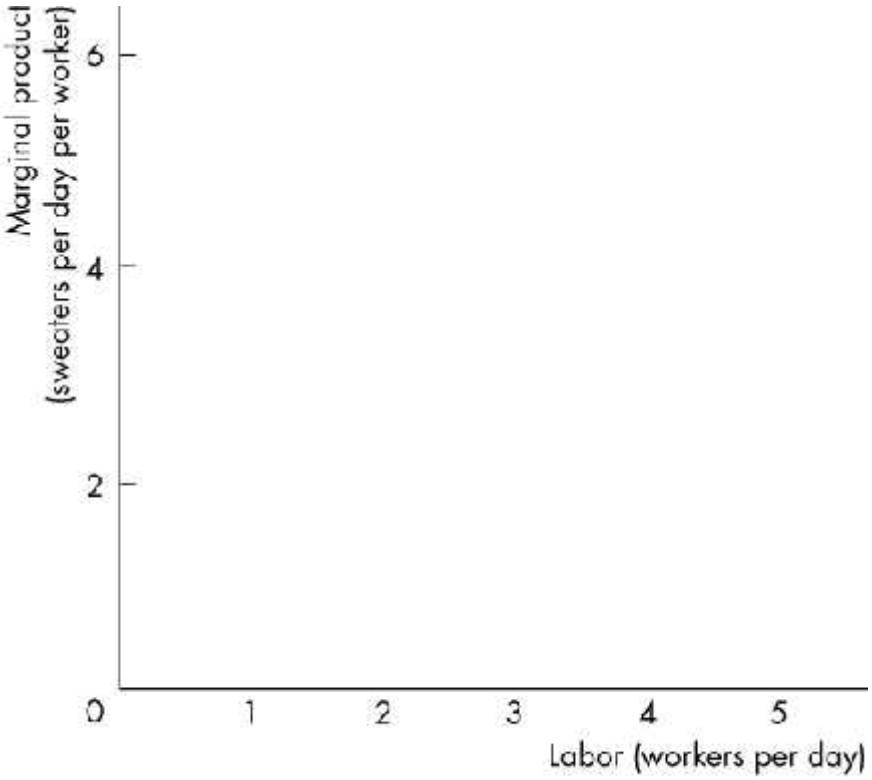


(a) Total product

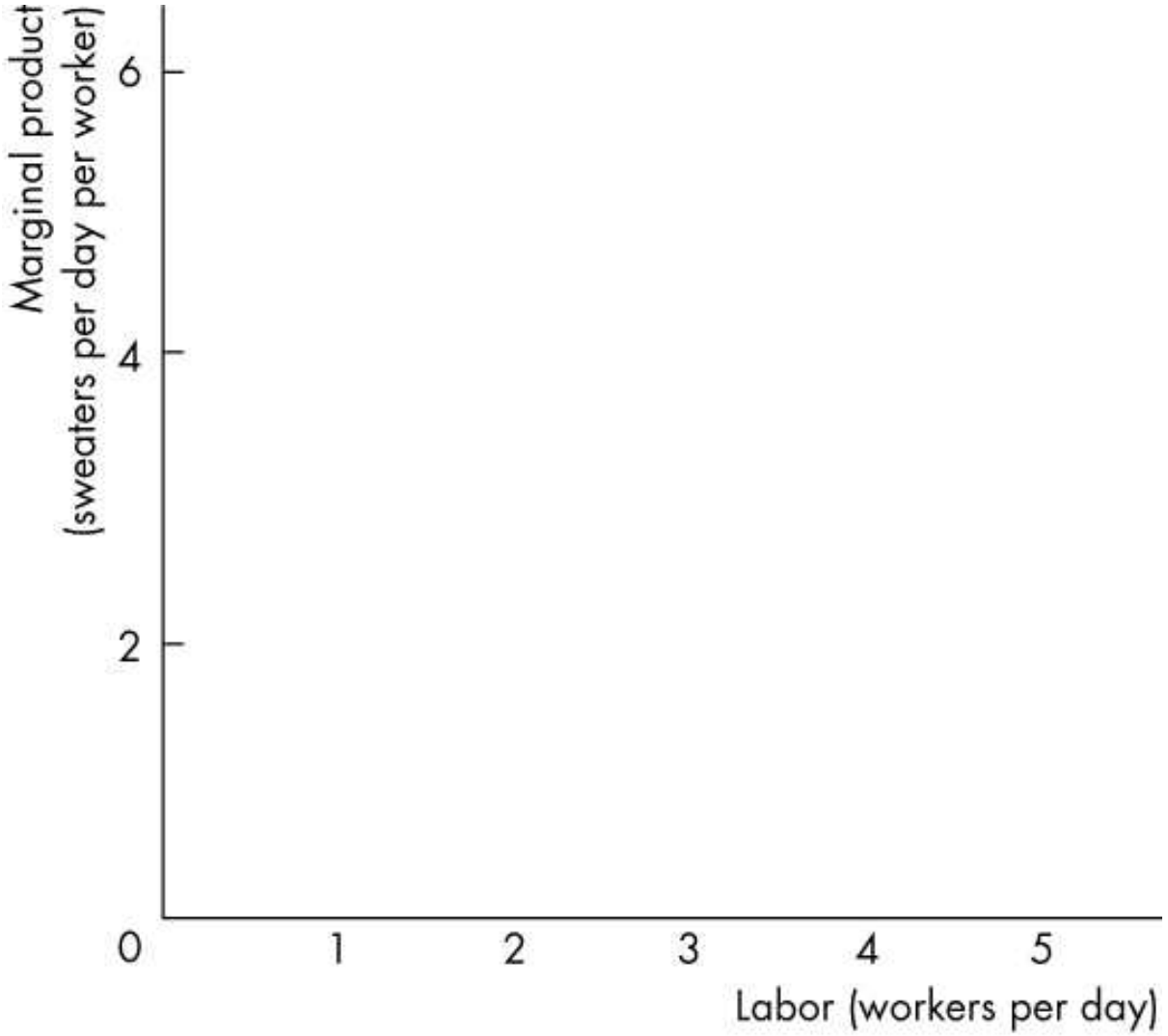
Short-Run Technology Constraint

To make a graph of the marginal product of labor, we can stack the bars in the previous graph side by side.

The marginal product of labor curve passes through the mid-points of these bars.



(b) Marginal product

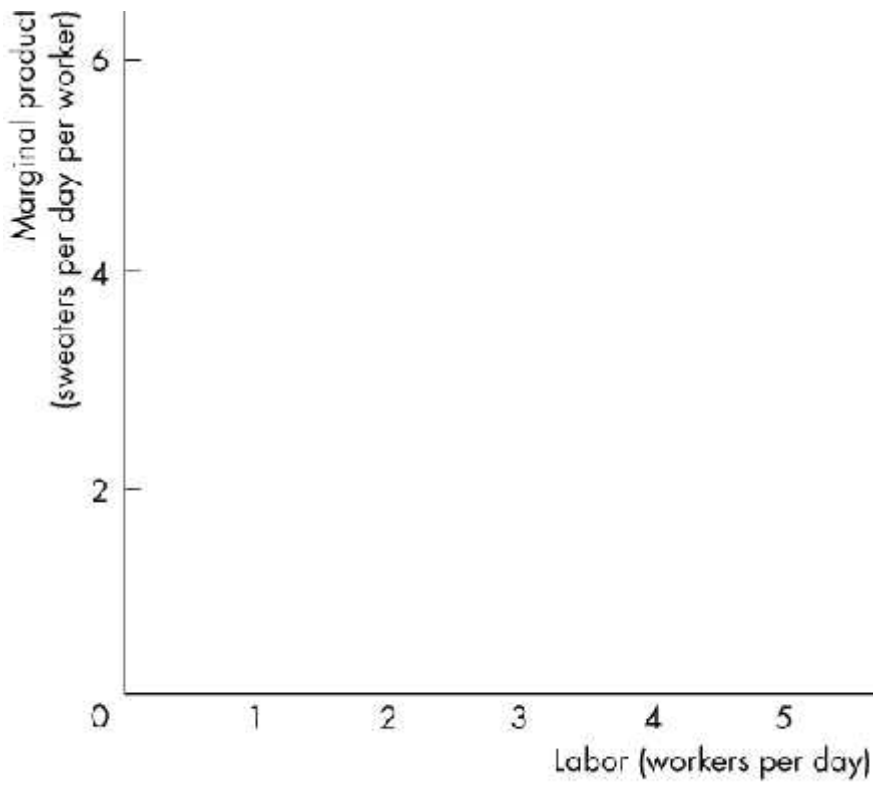


(b) Marginal product

Short-Run Technology Constraint

Almost all production processes are like the one shown here and have:

- Increasing marginal returns initially
- Diminishing marginal returns eventually



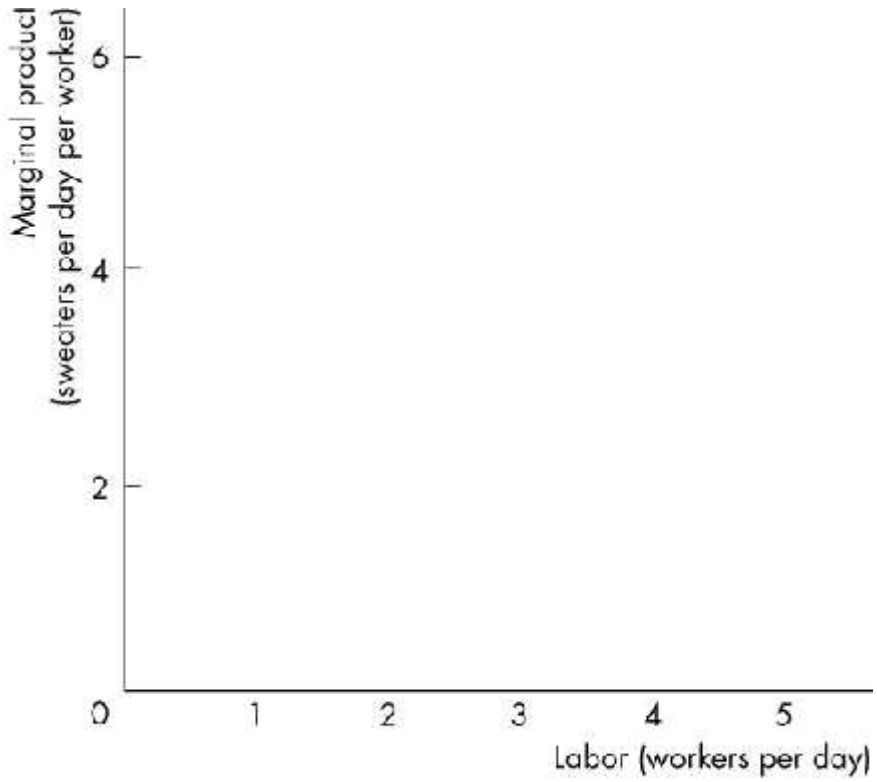
(b) Marginal product

Short-Run Technology Constraint

Increasing Marginal Returns

Initially, the marginal product of a worker *exceeds* the marginal product of the previous worker.

The firm experiences *increasing marginal returns*.



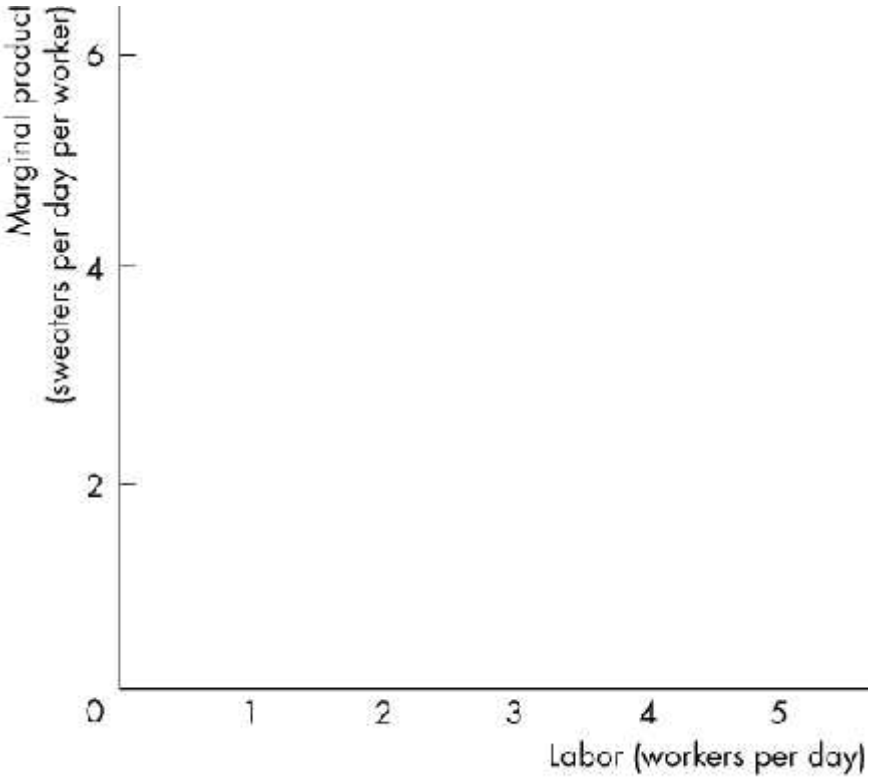
(b) Marginal product

Short-Run Technology Constraint

Diminishing Marginal Returns

Eventually, the marginal product of a worker is *less* than the marginal product of the previous worker.

The firm experiences **diminishing marginal returns**.



(b) Marginal product

Short-Run Technology Constraint

Increasing marginal returns arise from increased specialization and division of labor.

Diminishing marginal returns arises because each additional worker has less access to capital and less space in which to work.

Diminishing marginal returns are so pervasive that they are elevated to the status of a "law."

The **law of diminishing returns** states that:

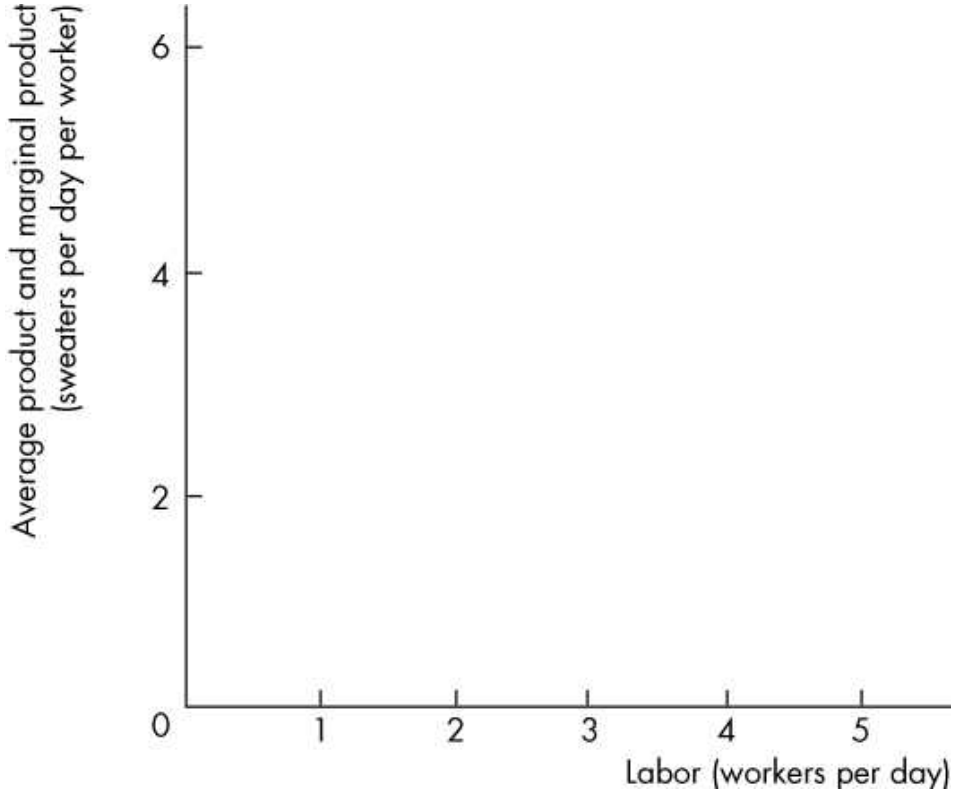
As a firm uses more of a variable input with a given quantity of fixed inputs, the marginal product of the variable input *eventually diminishes*.

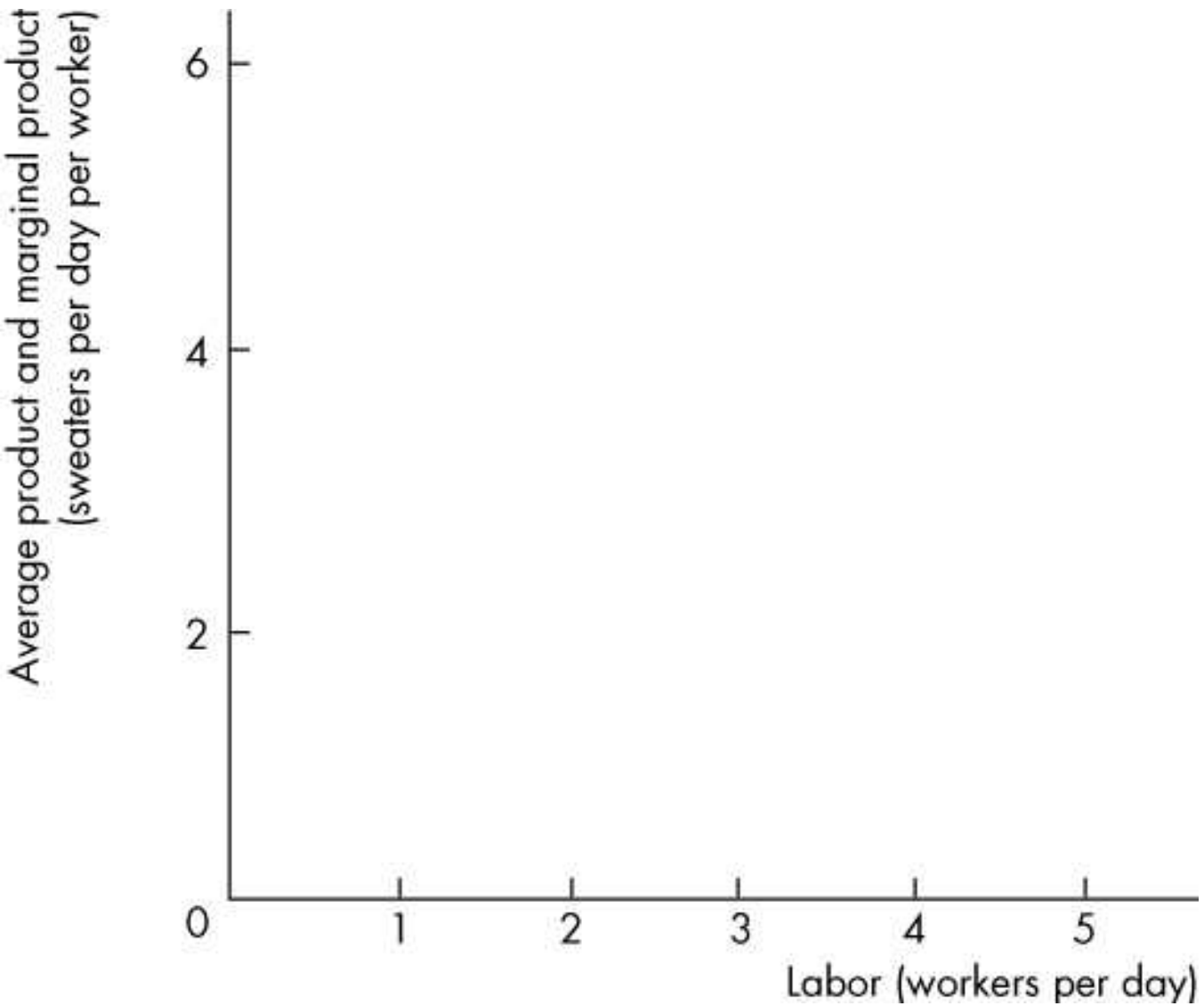
Short-Run Technology Constraint

Average Product Curve

Figure 11.3 shows the average product curve and its relationship with the marginal product curve.

When marginal product *exceeds* average product, average product increases.

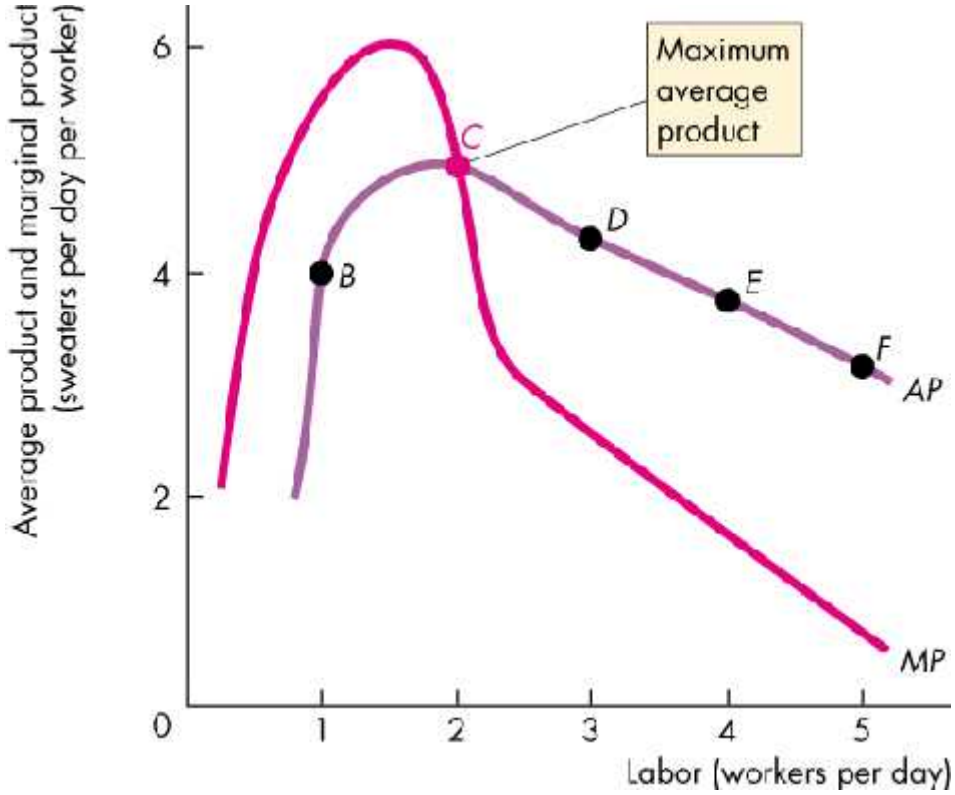




Short-Run Technology Constraint

When marginal product *is below* average product, average product decreases.

When marginal product *equals* average product, average product is at its maximum.



Short-Run Cost

To produce more output in the short run, the firm must employ more labor, which means that it must increase its costs.

Three cost concepts and three types of cost curves are

- Total cost
- Marginal cost
- Average cost

Short-Run Cost

Total Cost

A firm's **total cost** *(TC)* is the cost of *all* resources used.

Total fixed cost *(TFC)* is the cost of the firm's fixed inputs. Fixed costs do not change with output.

Total variable cost *(TVC)* is the cost of the firm's variable inputs. Variable costs do change with output.

Total cost equals total fixed cost plus total variable cost. That is:

$$TC = TFC + TVC$$

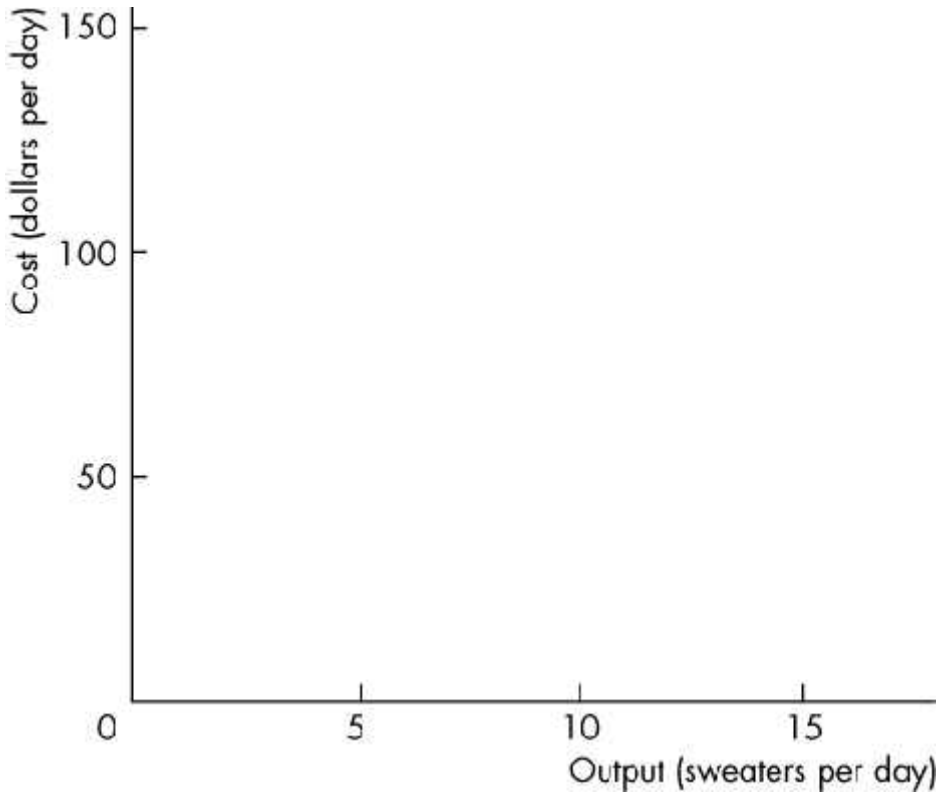
Short-Run Cost

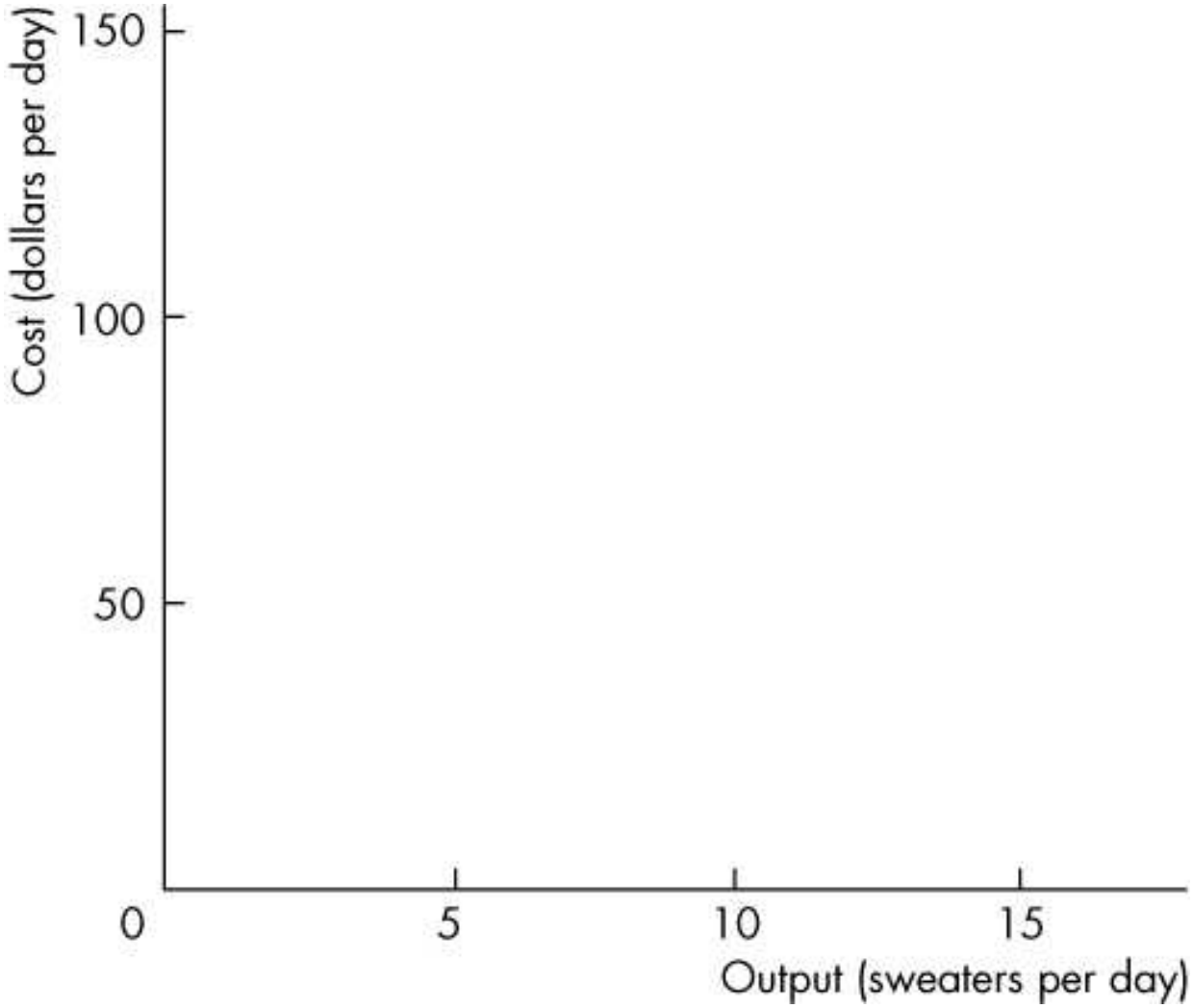
Figure 11.4 shows a firm's total cost curves.

Total fixed cost is the same at each output level.

Total variable cost increases as output increases.

Total cost, which is the sum of *TFC* and *TVC* also increases as output increases.



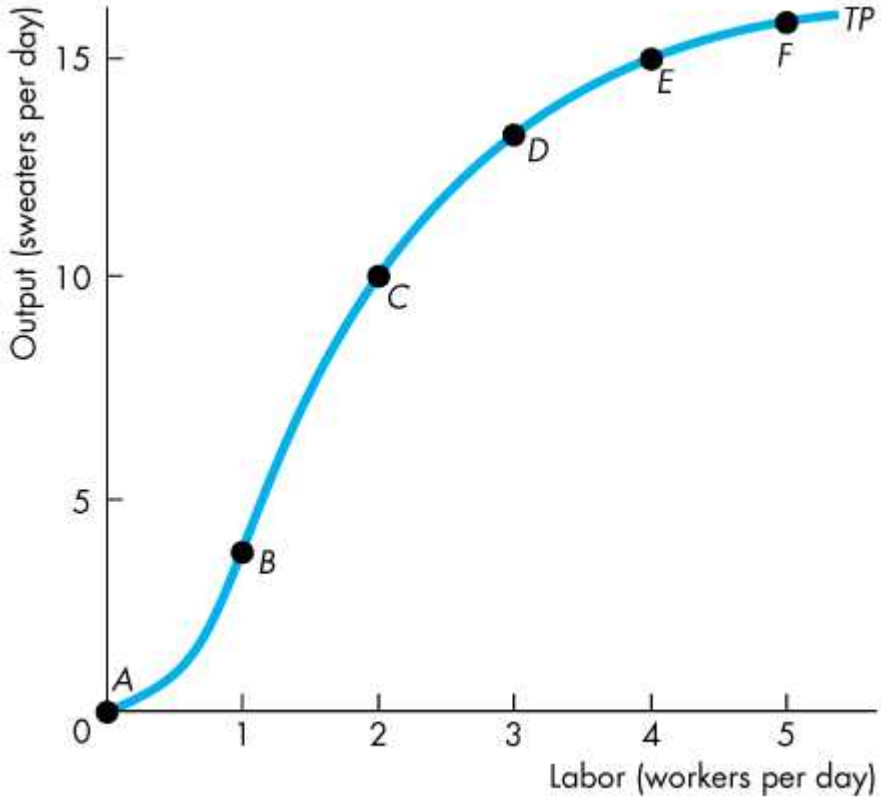


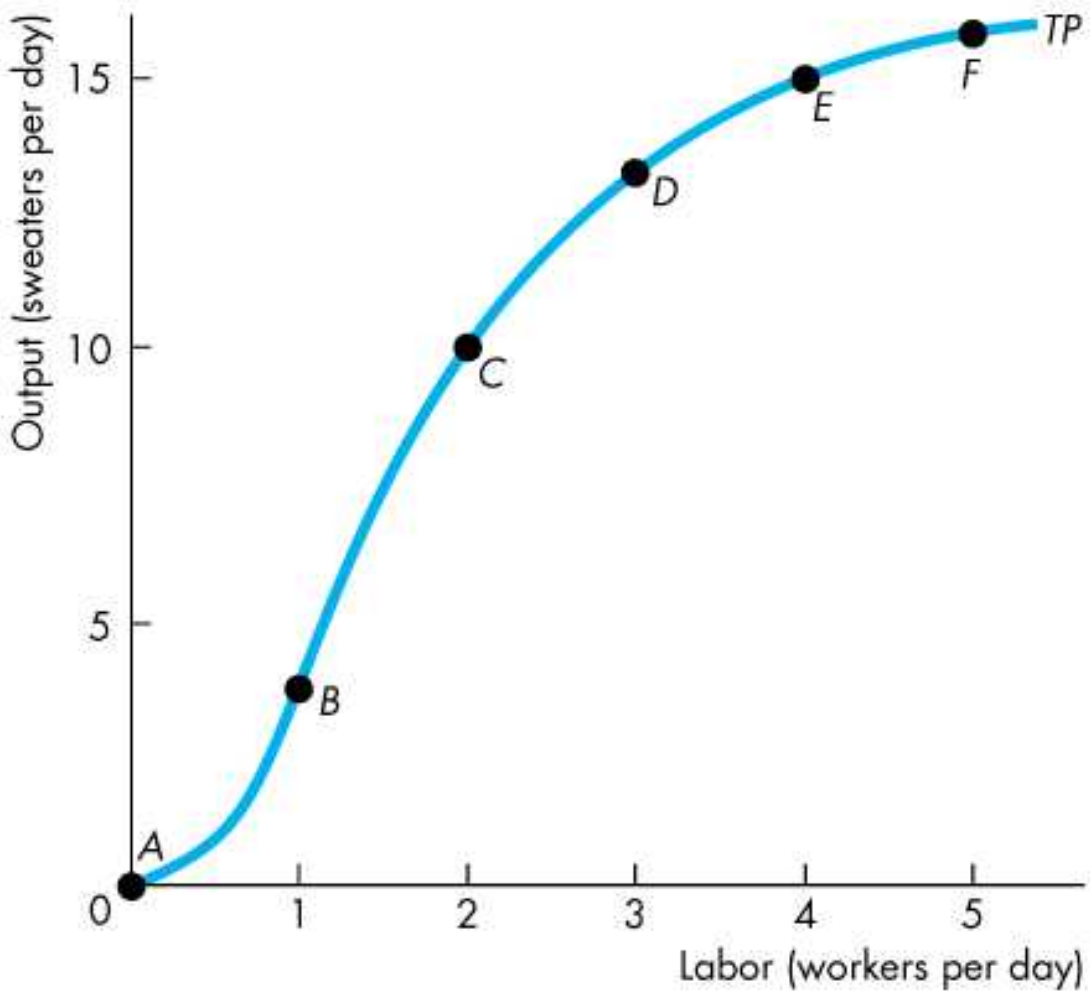
Short-Run Cost

The *AVC* curve gets its shape from the *TP* curve.

Notice that the *TP* curve becomes steeper at low output levels and then less steep at high output levels.

In contrast, the *TVC* curve becomes less steep at low output levels and steeper at high output levels.



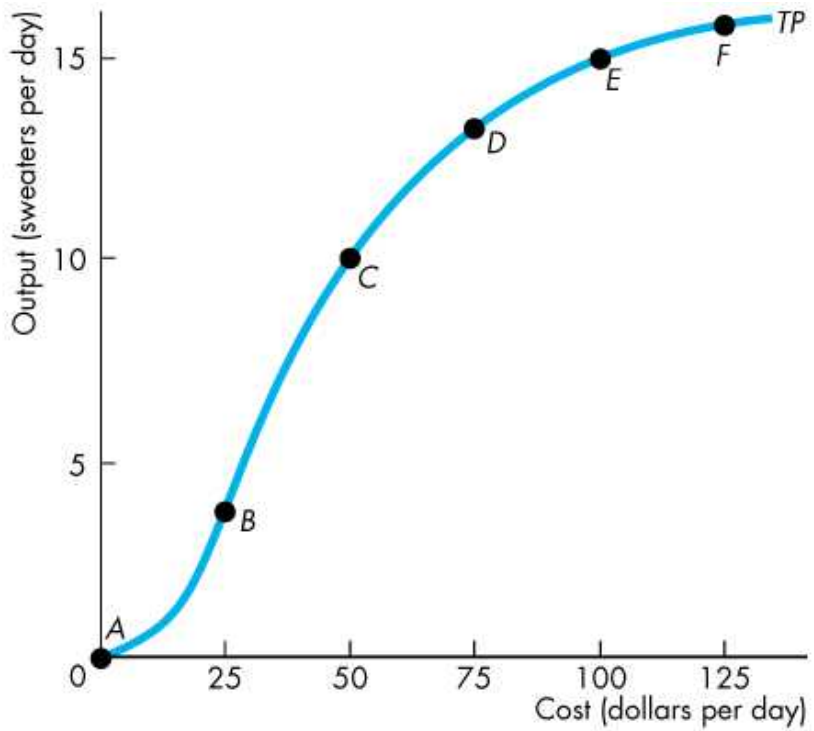


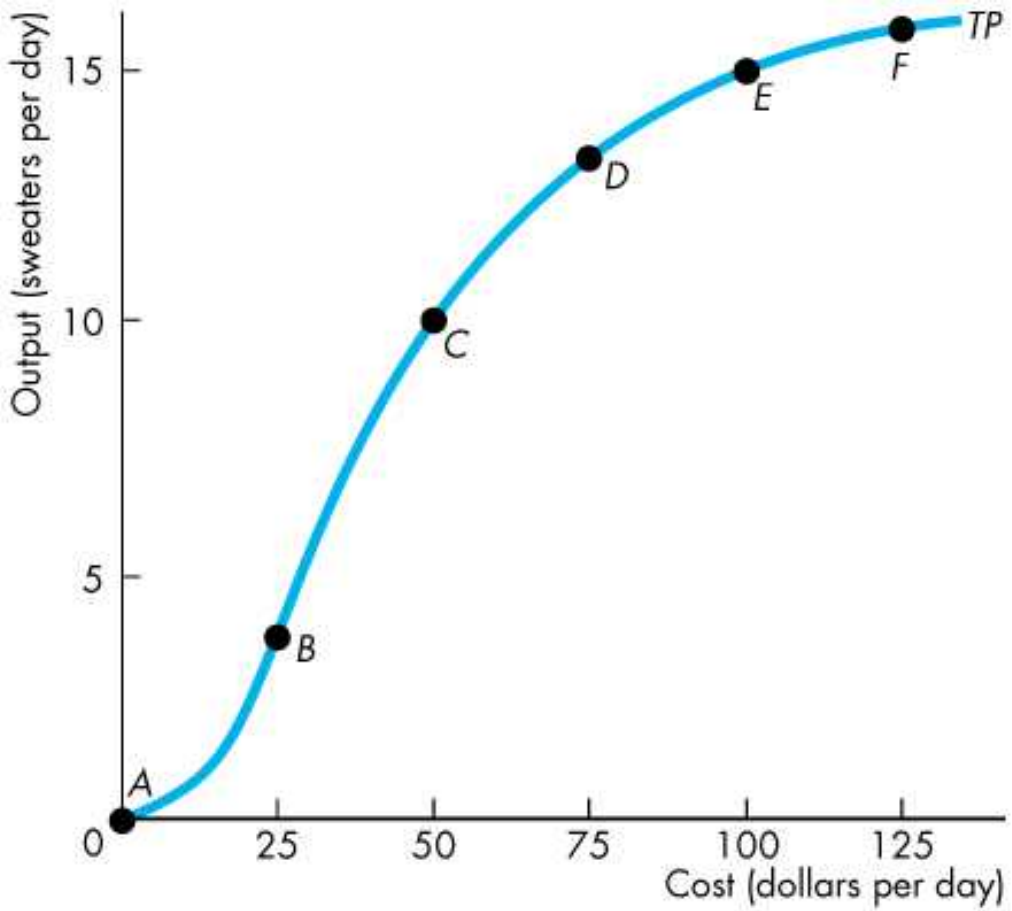
Short-Run Cost

To see the relationship between the *TVC* curve and the *TP* curve, lets look again at the *TP* curve.

But let us add a second *x*-axis to measure total variable cost.

1 worker costs $25;
2 workers cost $50: and so on, so the two *x*-axes line up.



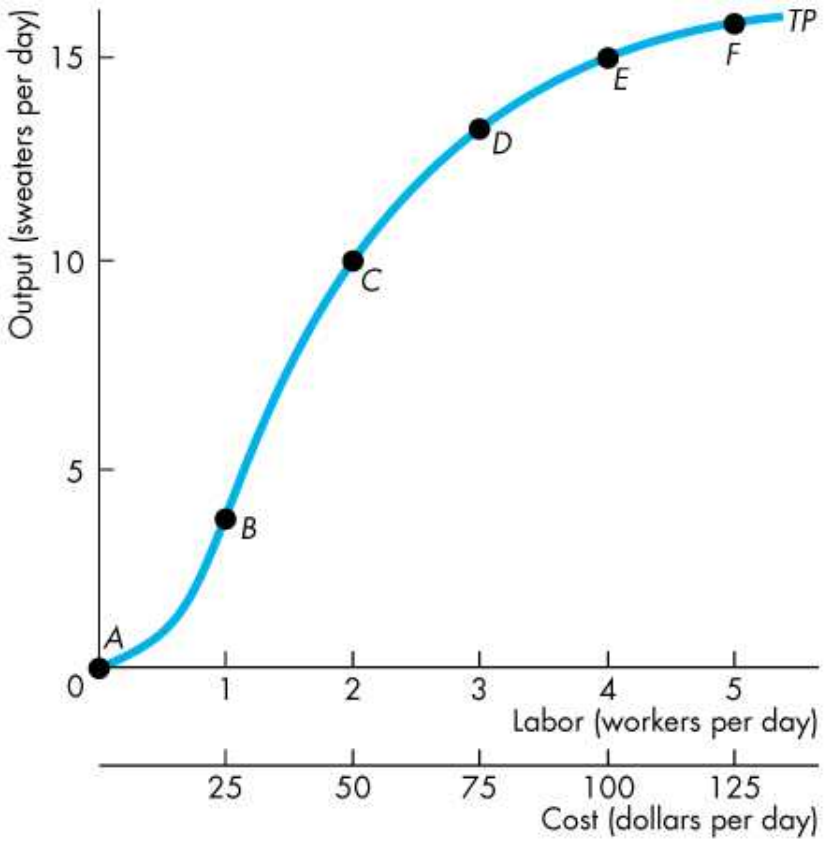


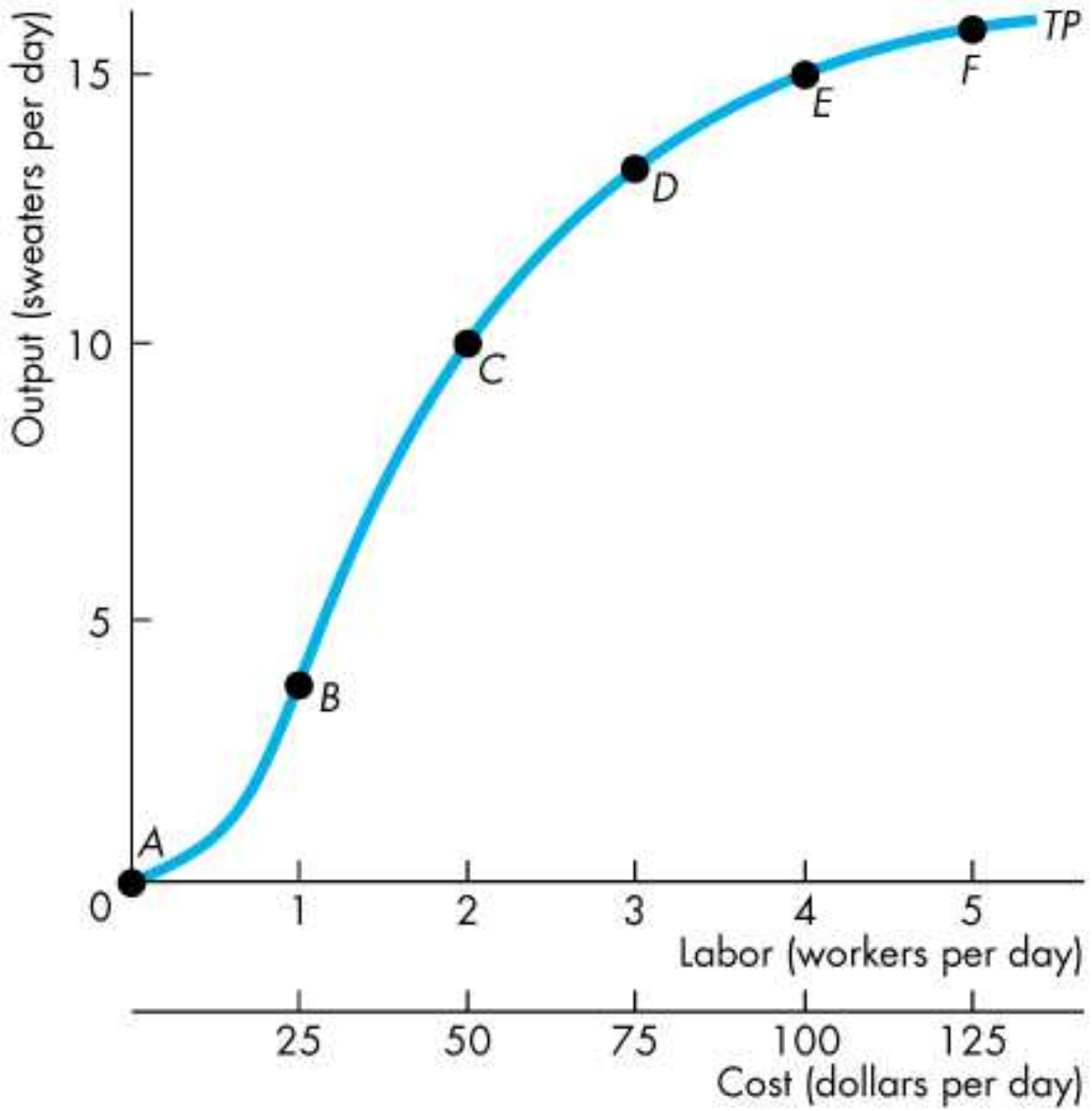
Short-Run Cost

We can replace the quantity of labor on the *x*-axis with total variable cost.

When we do that, we must change the name of the curve. It is now the *TVC* curve.

But it is graphed with cost on the *x*-axis and output on the *y*-axis.



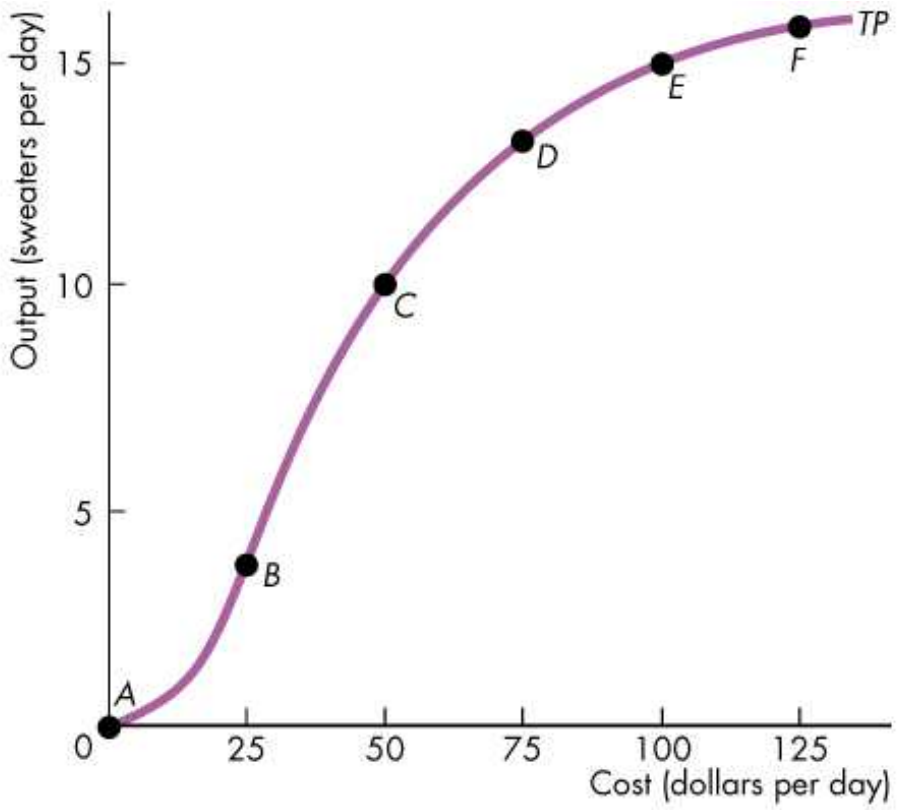


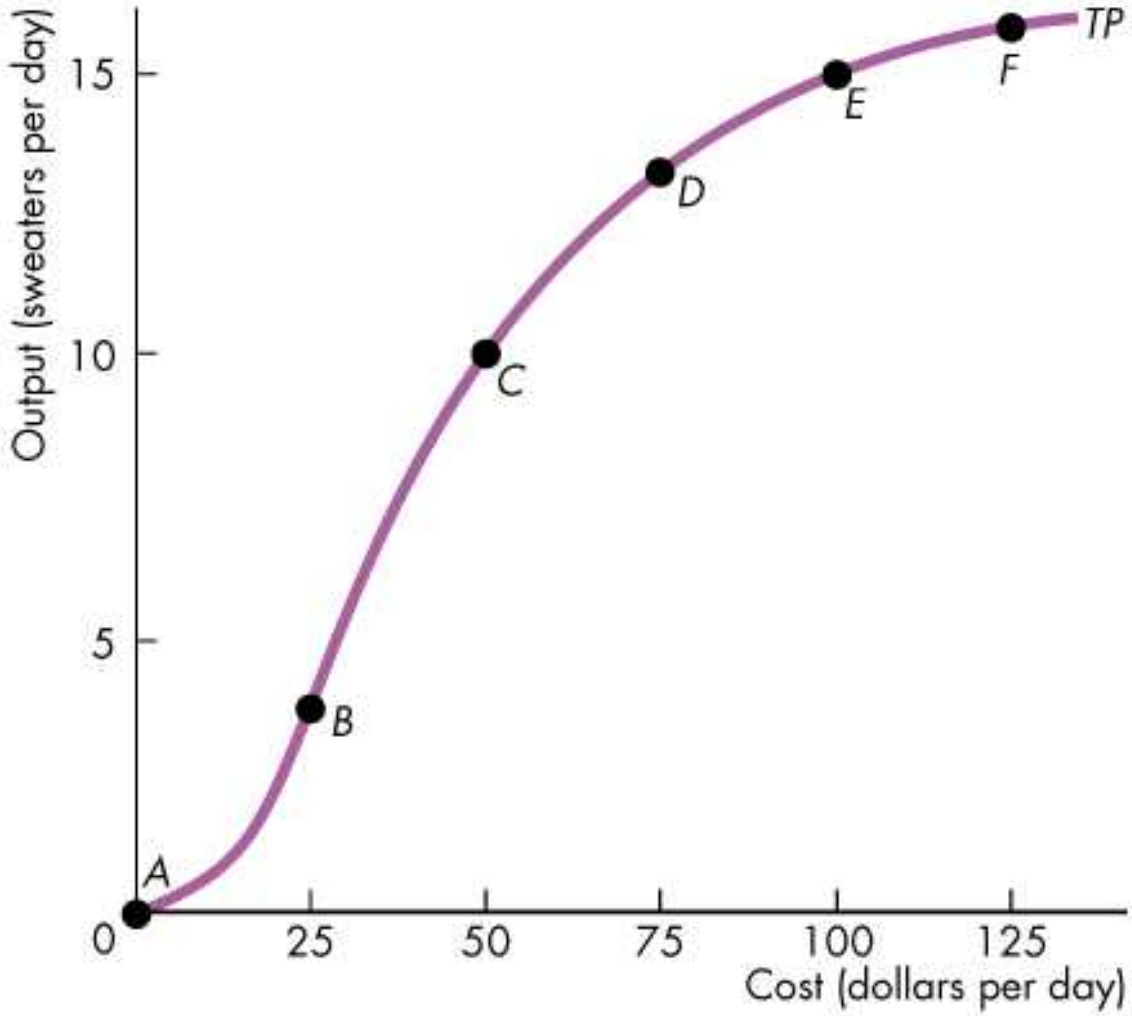
Short-Run Cost

Redraw the graph with cost on the *y*-axis and output on the *x*-axis, and you've got the *TVC* curve drawn the usual way.

Put the *TFC* curve back in the figure,

and add *TFC* to *TVC*, and you've got the *TC* curve.





Short-Run Cost

Marginal Cost

Marginal cost *(MC)* is the increase in total cost that results from a one-unit increase in total product.

Over the output range with *increasing marginal returns,* marginal cost falls as output increases.

Over the output range with *diminishing marginal returns,* marginal cost rises as output increases.

Short-Run Cost

Average Cost

Average cost measures can be derived from each of the total cost measures:

Average fixed cost *(AFC)* is total fixed cost per unit of output.

Average variable cost *(AVC)* is total variable cost per unit of output.

Average total cost *(ATC)* is total cost per unit of output.

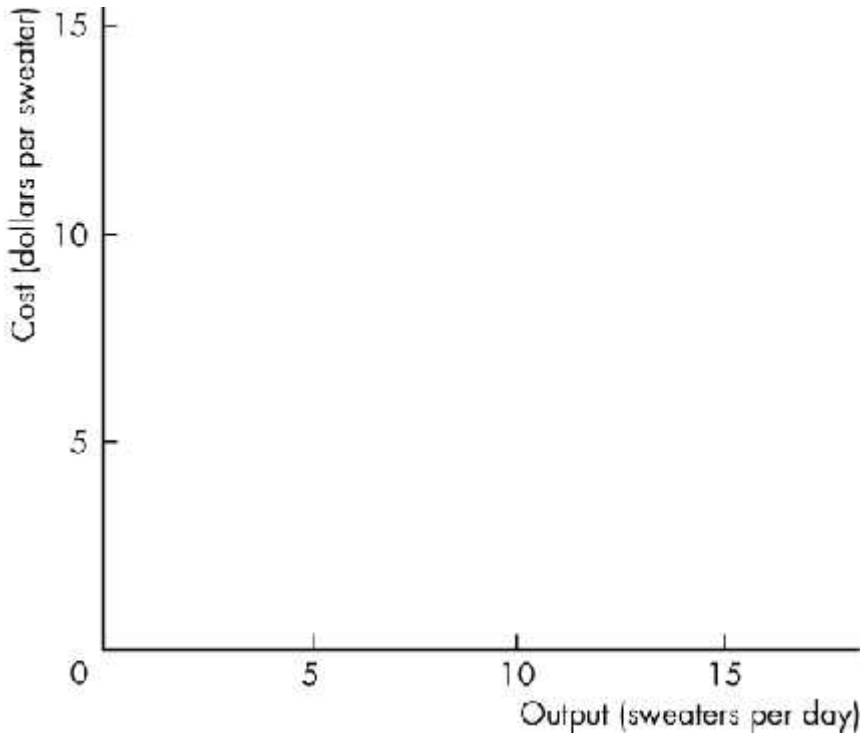
$$ATC = AFC + AVC.$$

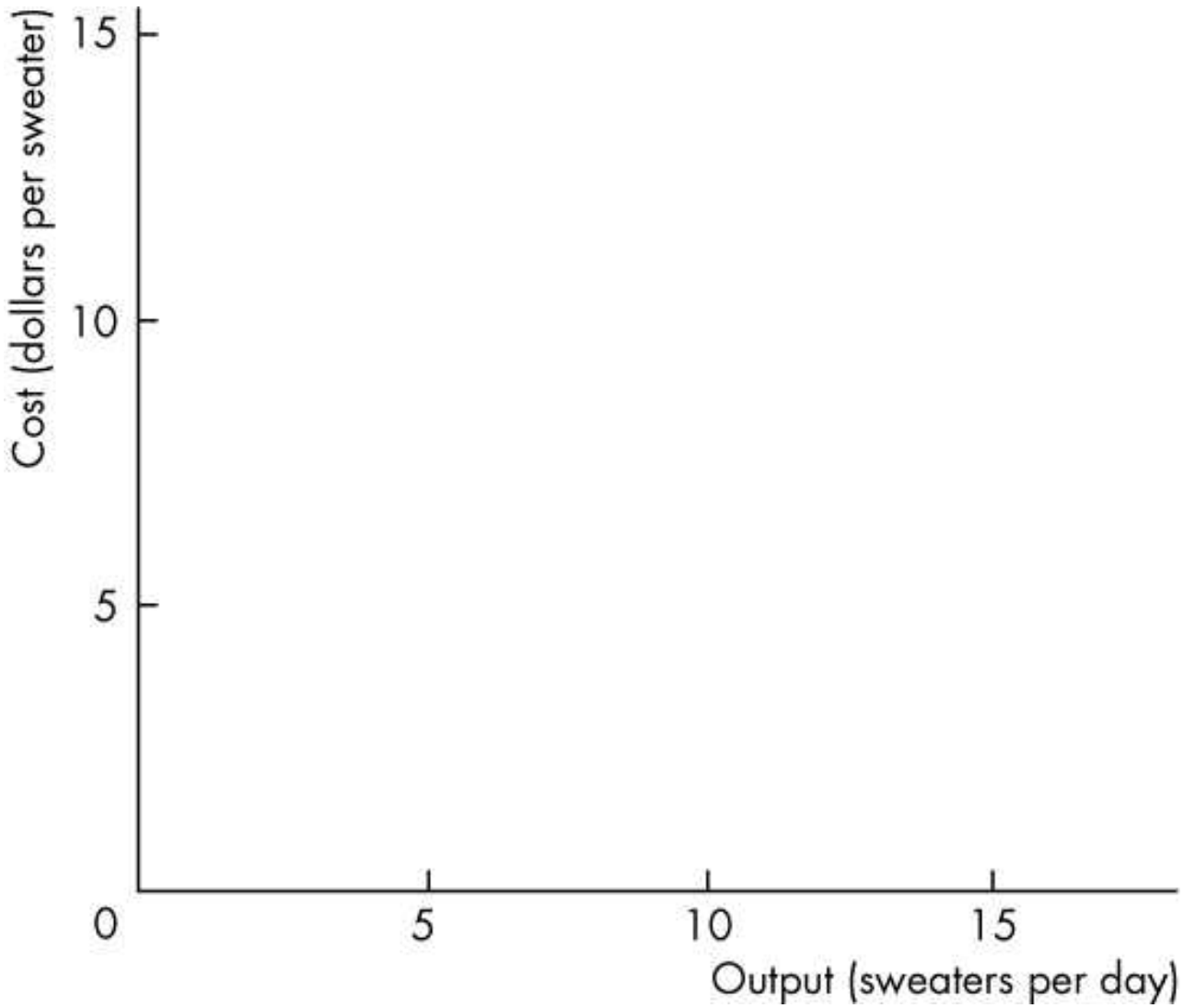
Short-Run Cost

Figure 11.5 shows the *MC*, *AFC*, *AVC*, and *ATC* curves.

The *AFC* curve shows that average fixed cost falls as output increases.

The *AVC* curve is U-shaped. As output increases, average variable cost falls to a minimum and then increases.





Short-Run Cost

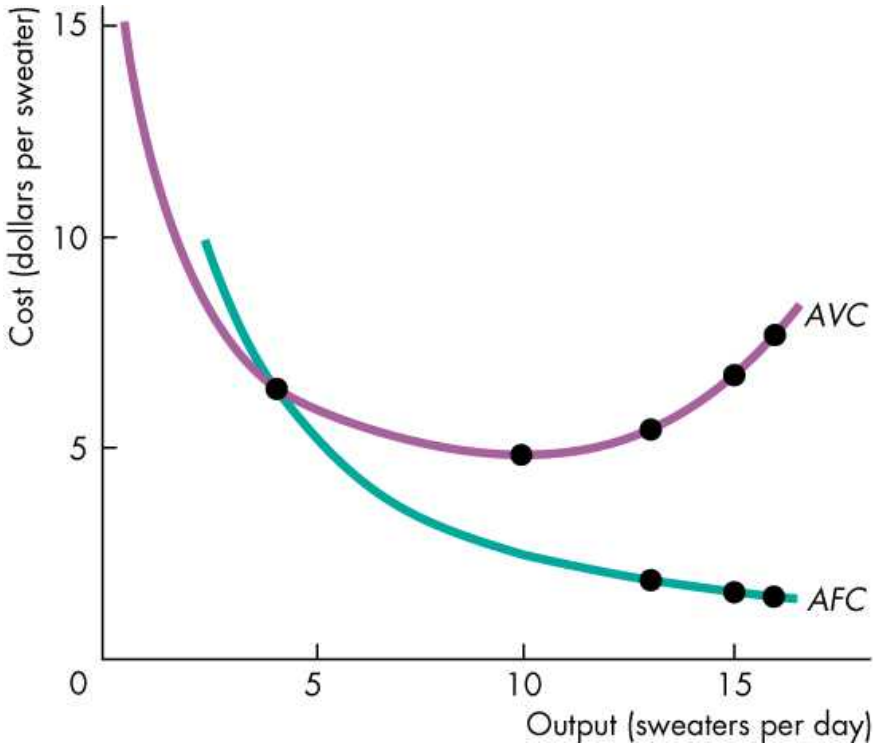
The *ATC* curve is also U-shaped.

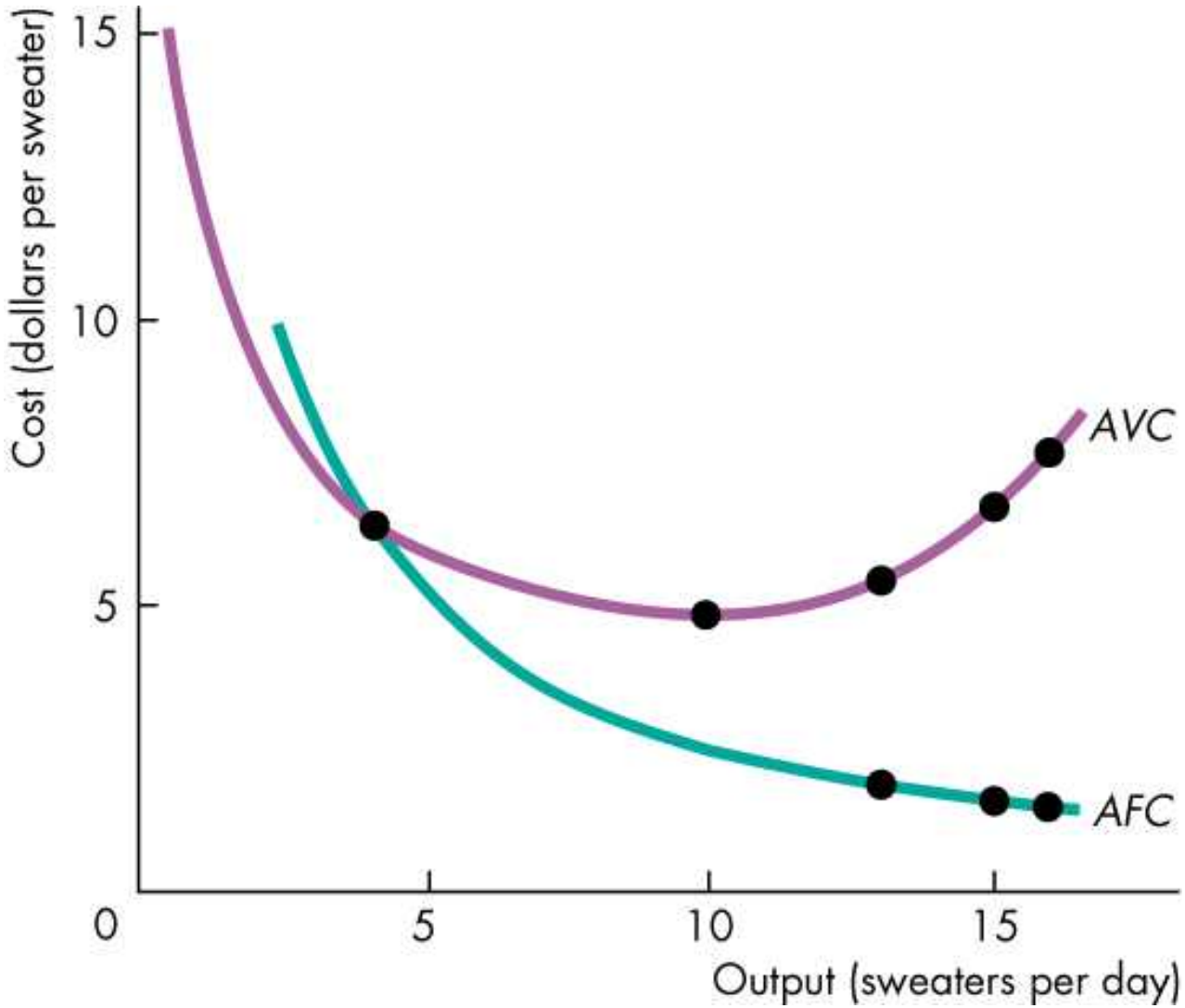
The *MC* curve is very special.

The outputs over which *AVC* is falling, *MC* is *below AVC*.

The outputs over which *AVC* is rising, *MC* is *above AVC*.

The output at which *AVC is at* the minimum, *MC equals AVC*.



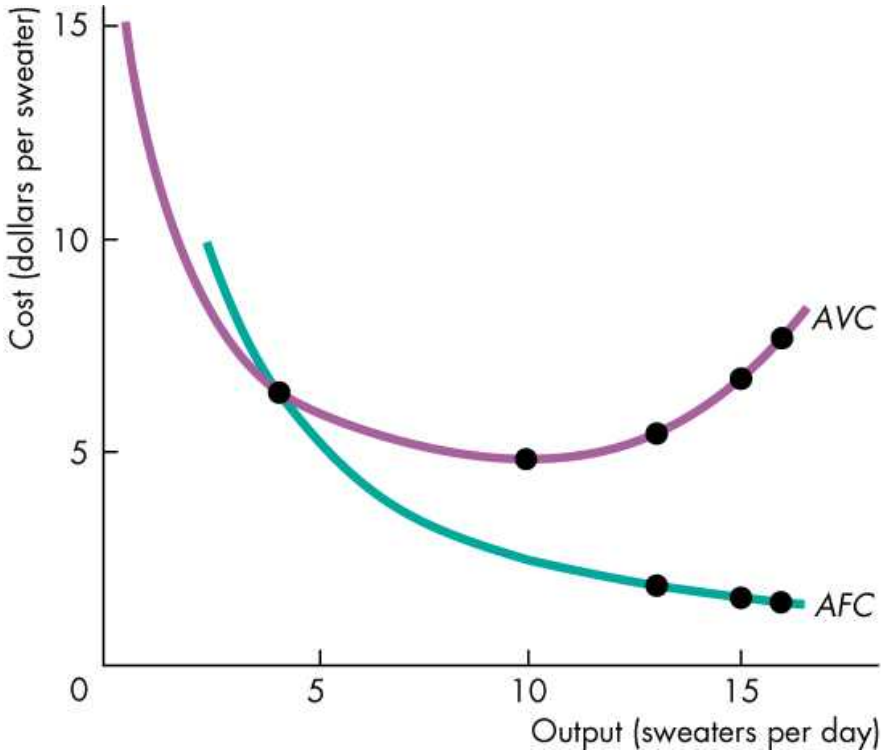


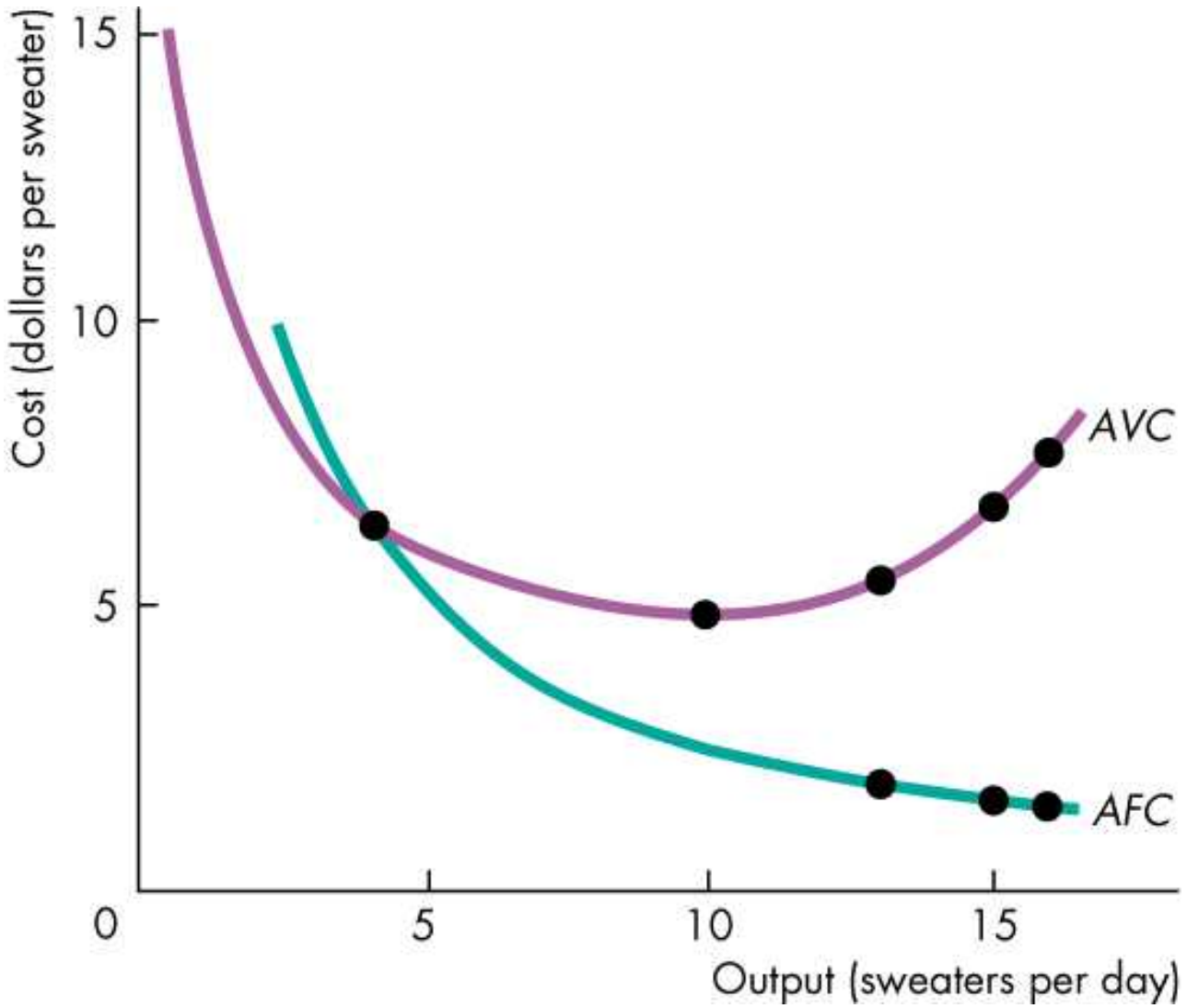
Short-Run Cost

Similarly, the outputs over which *ATC* is falling, *MC* is *below ATC*.

The outputs over which *ATC* is rising, *MC* is *above ATC*.

At the minimum *ATC*, *MC equals ATC*.





Short-Run Cost

The *AVC* curve is U-shaped because:

Initially, *MP* exceeds *AP*, which brings rising *AP* and falling *AVC.*

Eventually, *MP* falls below *AP*, which brings falling *AP* and rising *AVC*.

The *ATC* curve is U-shaped for the same reasons.

In addition, *ATC* falls at low output levels because *AFC* is falling quickly.

Short-Run Cost

Why the Average Total Cost Curve Is U-Shaped

The *ATC* curve is the vertical sum of the *AFC* curve and the *AVC* curve.

The U-shape of the *ATC* curve arises from the influence of two opposing forces:

1. Spreading total fixed cost over a larger output—*AFC* curve slopes downward as output increases.
2. Eventually diminishing returns—the *AVC* curve slopes upward and *AVC* increases more quickly than *AFC* is decreasing.

Short-Run Cost

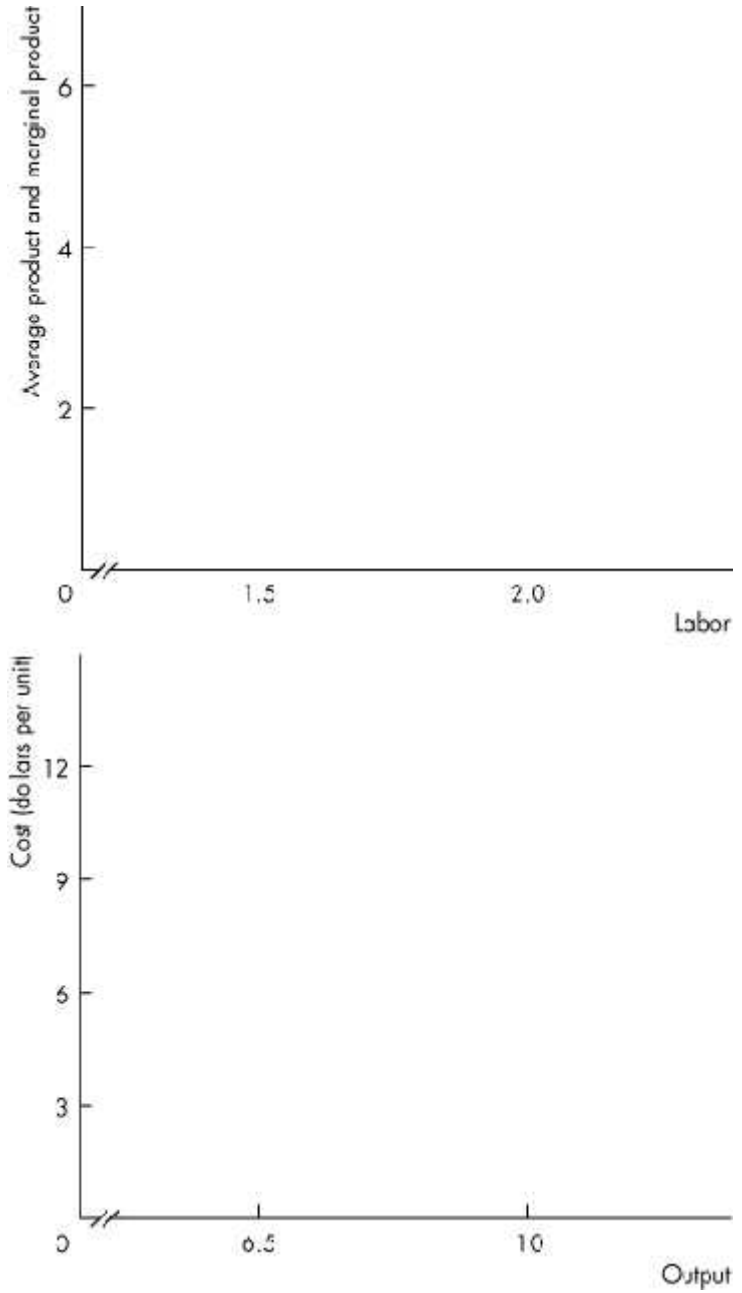
Cost Curves and Product Curves

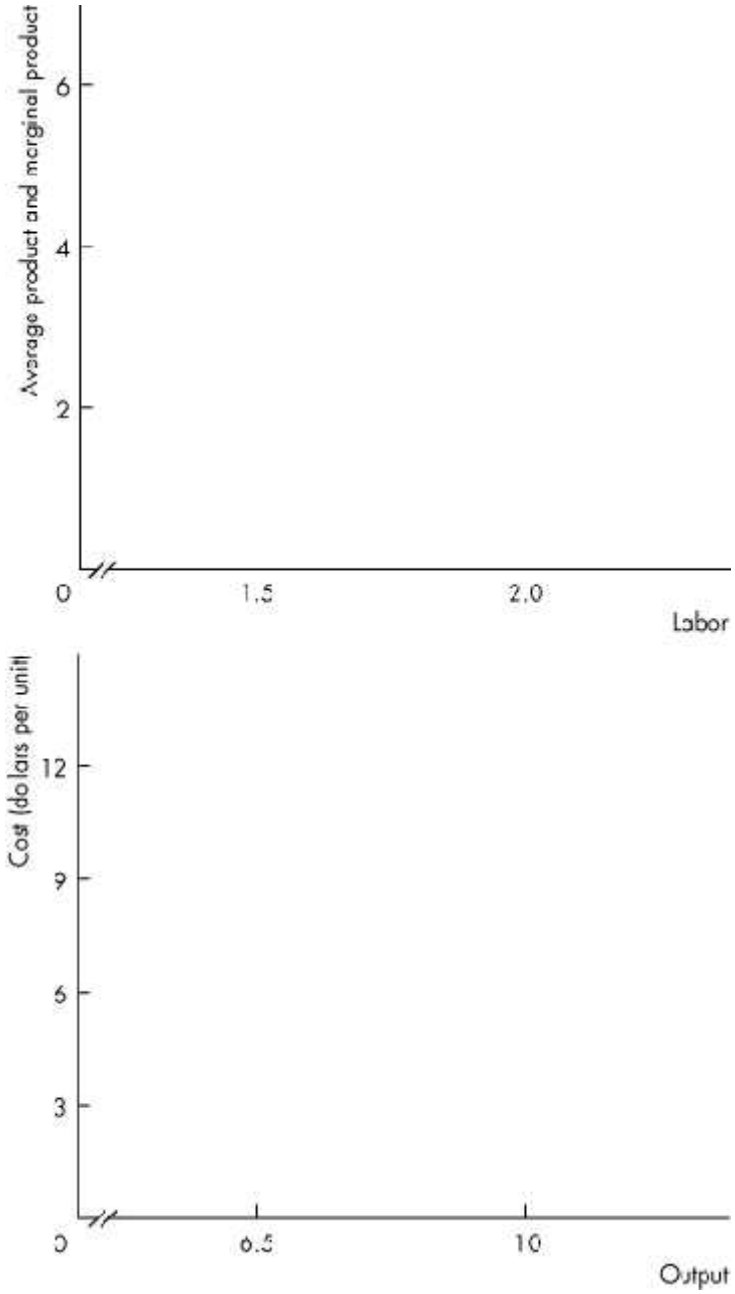
The shapes of a firm's cost curves are determined by the technology it uses:

- *MC* is at its minimum at the same output level at which *MP* is at its maximum.
- When *MP* is rising, *MC* is falling.
- *AVC* is at its minimum at the same output level at which *AP* is at its maximum.
- When *AP* is rising, *AVC* is falling.

Short-Run Cost

Figure 11.6 shows these relationships.





Short-Run Cost

Shifts in the Cost Curves

The position of a firm's cost curves depend on two factors:

- Technology
- Prices of factors of production

Short-Run Cost

Technology

Technological change influences both the product curves and the cost curves.

An increase in productivity shifts the product curves upward and the cost curves downward.

If a technological advance results in the firm using more capital and less labor, fixed costs increase and variable costs decrease.

In this case, average total cost increases at low output levels and decreases at high output levels.

Short-Run Cost

Prices of Factors of Production

An increase in the price of a factor of production increases costs and shifts the cost curves.

An increase in a *fixed* cost shifts the total cost (*TC*) and average total cost (*ATC*) curves upward but does *not* shift the marginal cost (*MC*) curve.

An increase in a *variable* cost shifts the total cost (*TC*), average total cost (*ATC*), and marginal cost (*MC*) curves upward.

Long-Run Cost

In the long run, *all* inputs are variable and *all* costs are variable.

The Production Function

The behavior of long-run cost depends upon the firm's production function.

The firm's *production function* is the relationship between the maximum output attainable and the quantities of both capital and labor.

Long-Run Cost

Table 11.3 shows a firm's production function.

As the size of the plant increases, the output that a given quantity of labor can produce increases.

But for each plant, as the quantity of labor increases, diminishing returns occur.

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	1	2	3	4

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	1	2	3	4

Long-Run Cost

Diminishing Marginal Product of Capital

The *marginal product of capital* is the increase in output resulting from a one-unit increase in the amount of capital employed, holding constant the amount of labor employed.

A firm's production function exhibits diminishing marginal returns to labor (for a given plant) as well as diminishing marginal returns to capital (for a quantity of labor).

For *each* plant, diminishing marginal product of labor creates a set of short run, U-shaped costs curves for *MC*, *AVC,* and *ATC*.

Long-Run Cost

Short-Run Cost and Long-Run Cost

The average cost of producing a given output varies and depends on the firm's plant.

The larger the plant, the greater is the output at which *ATC* is at a minimum.

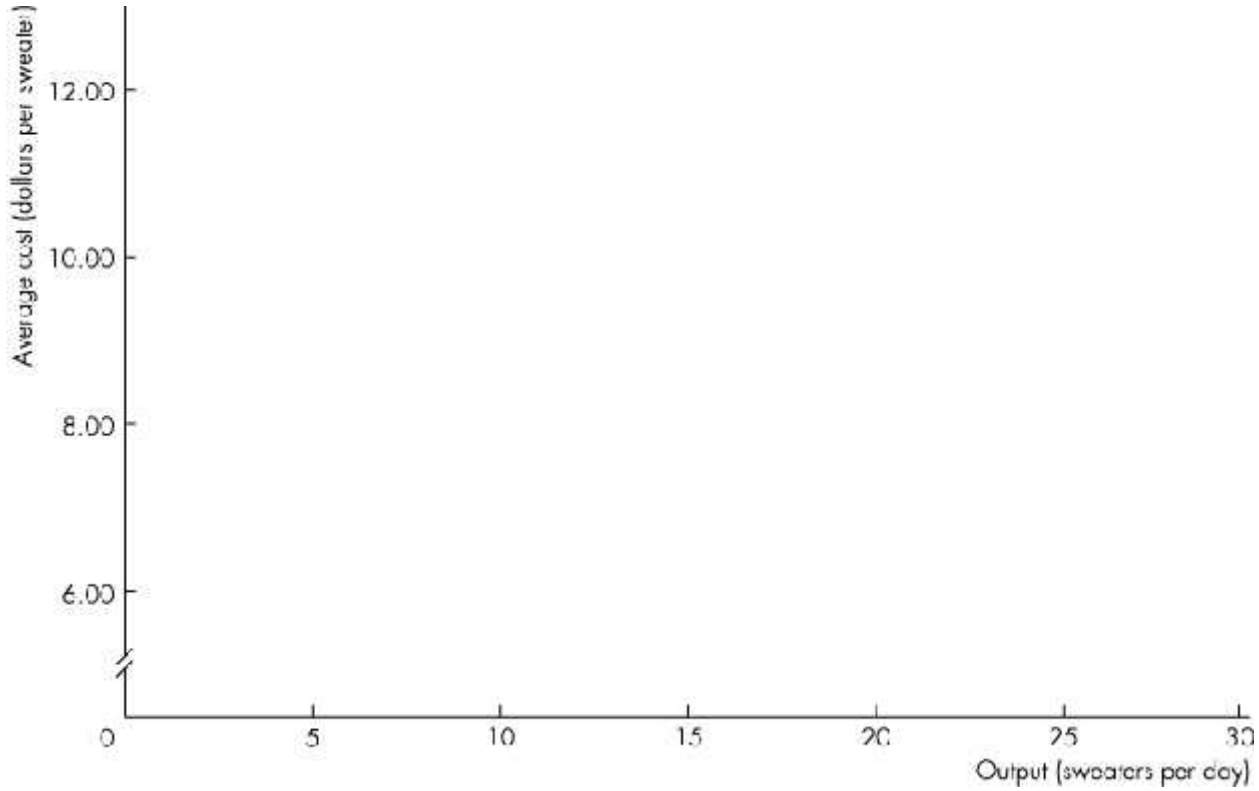
The firm has 4 different plants: 1, 2, 3, or 4 knitting machines.

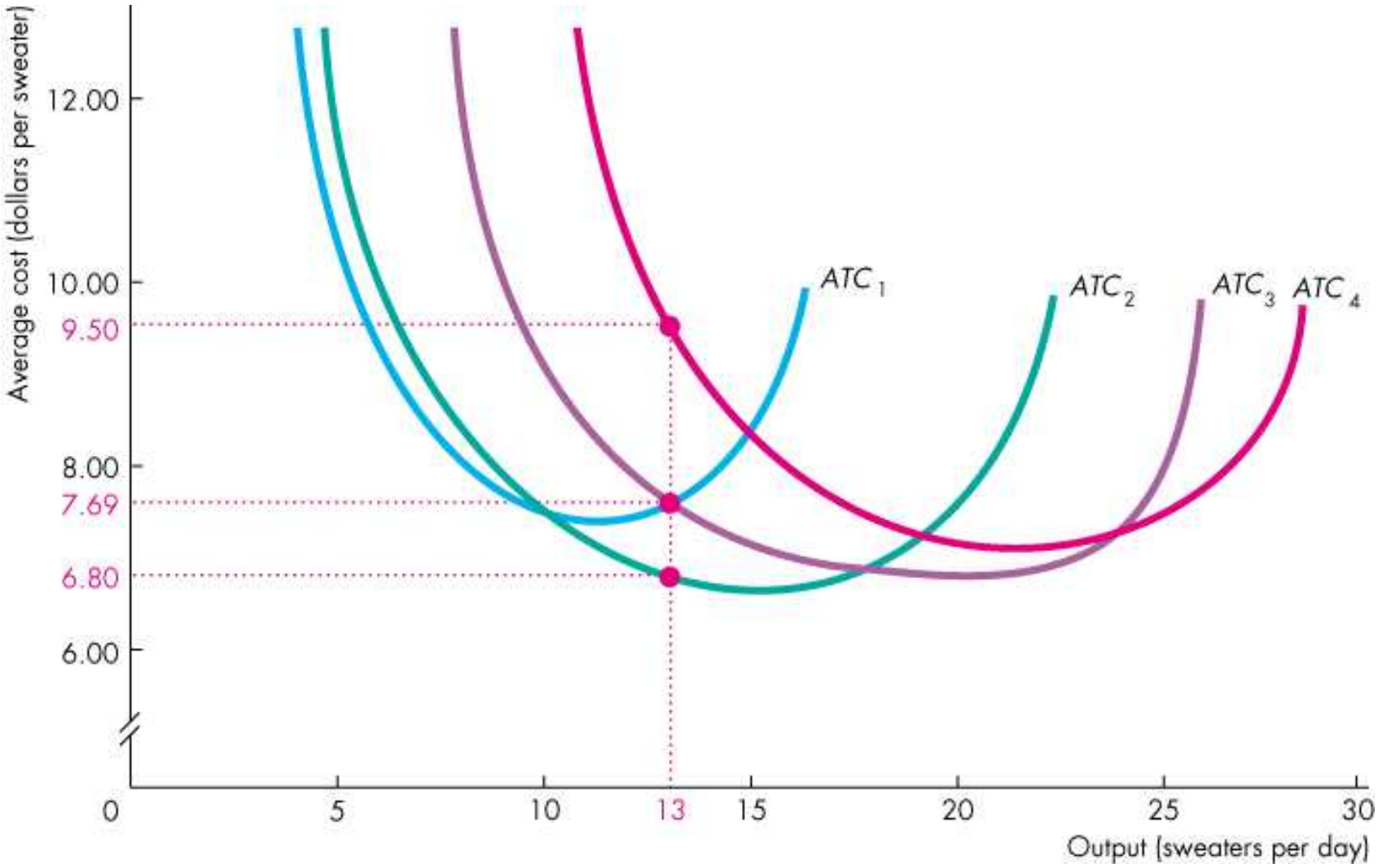
Each plant has a short-run *ATC* curve.

The firm can compare the *ATC* for each output at different plants.

Long-Run Cost

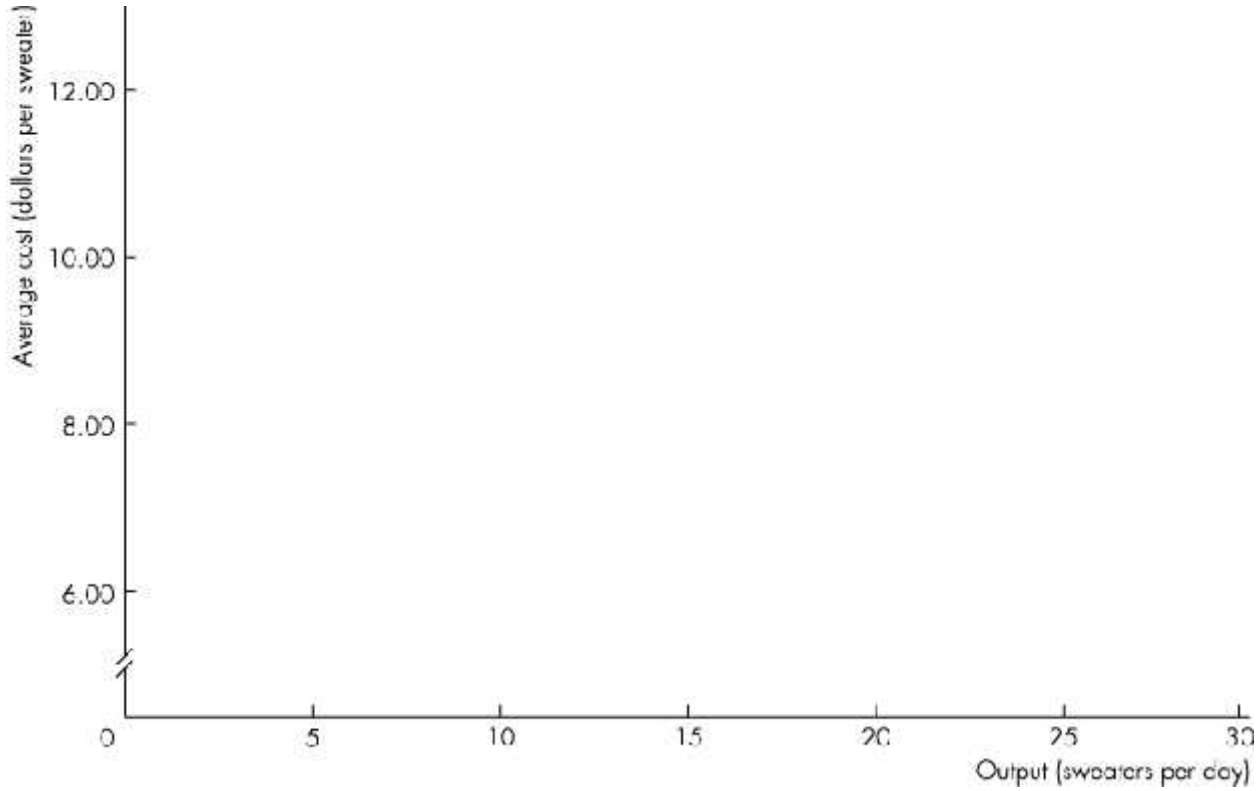
ATC_1 is the *ATC* curve for a plant with 1 knitting machine.





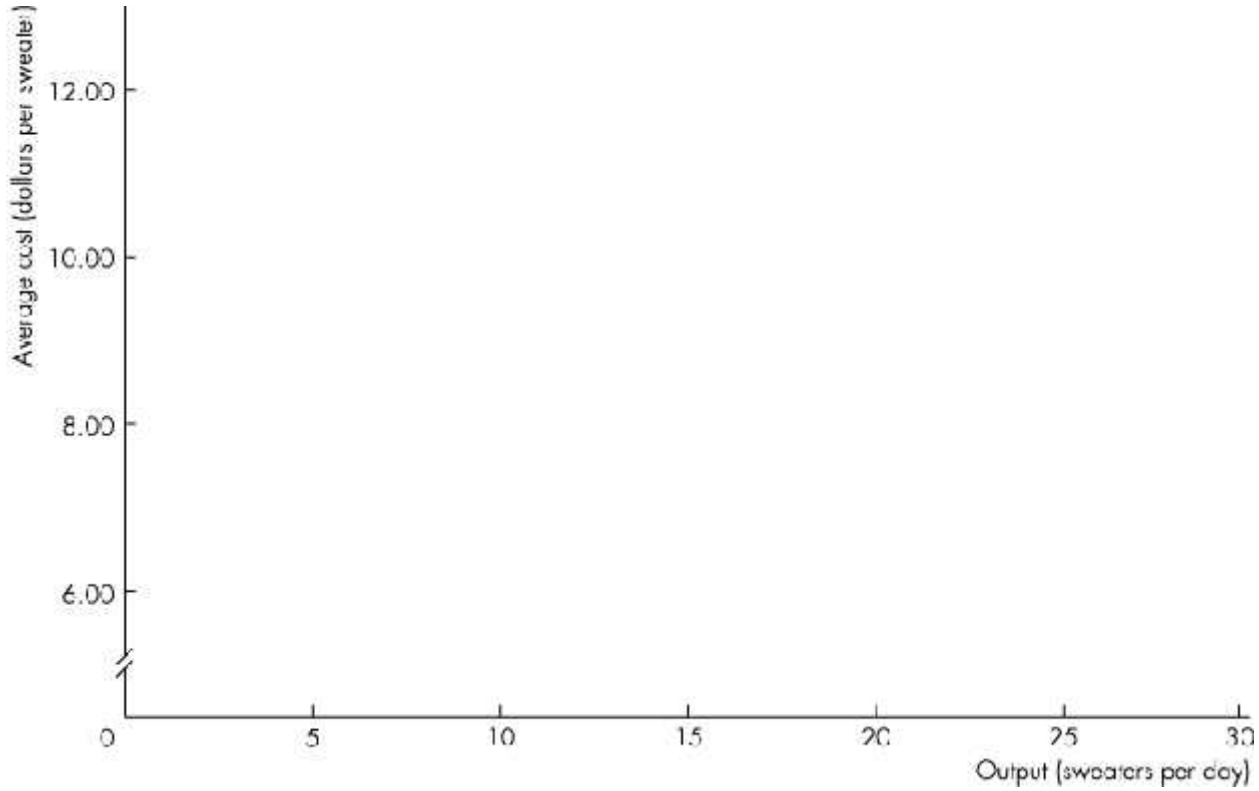
Long-Run Cost

ATC_2 is the *ATC* curve for a plant with 2 knitting machines.



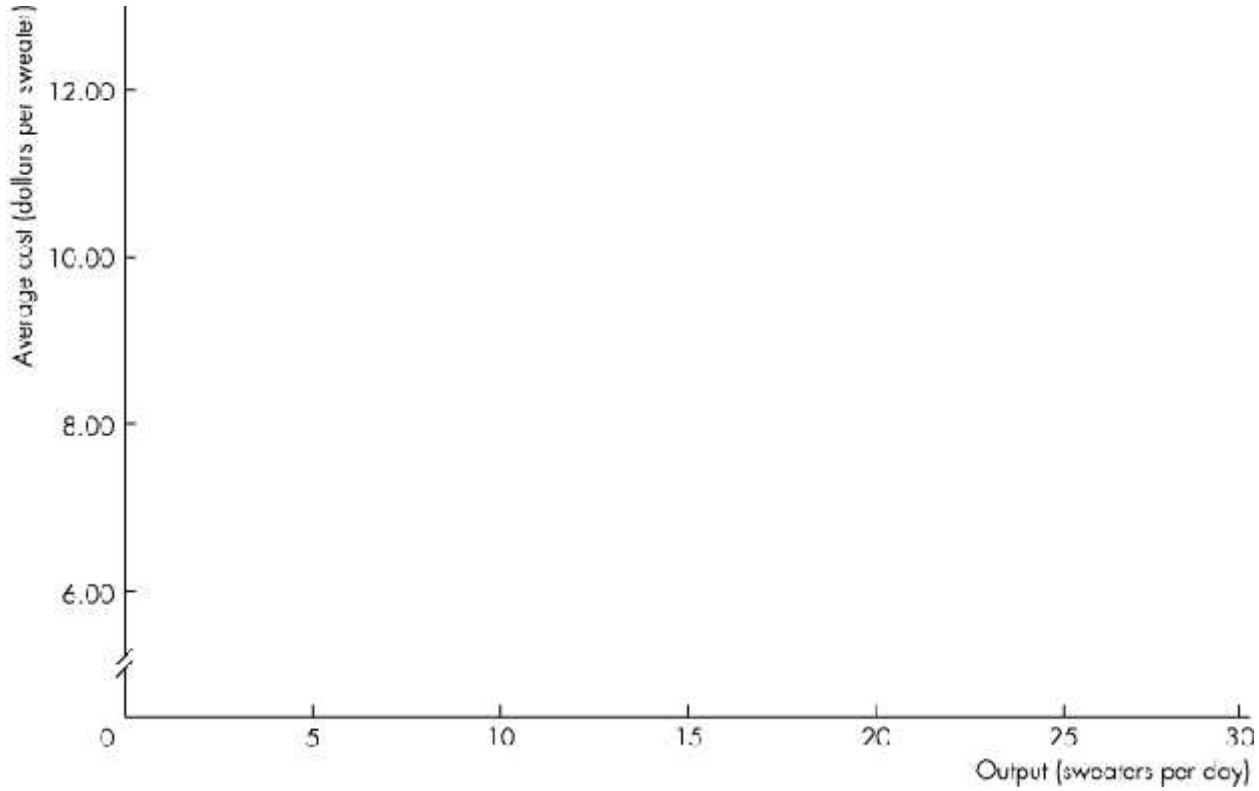
Long-Run Cost

ATC_3 is the *ATC* curve for a plant with 3 knitting machines.



Long-Run Cost

ATC_4 is the *ATC* curve for a plant with 4 knitting machines.



Long-Run Cost

The long-run average cost curve is made up from the lowest *ATC* for each output level.

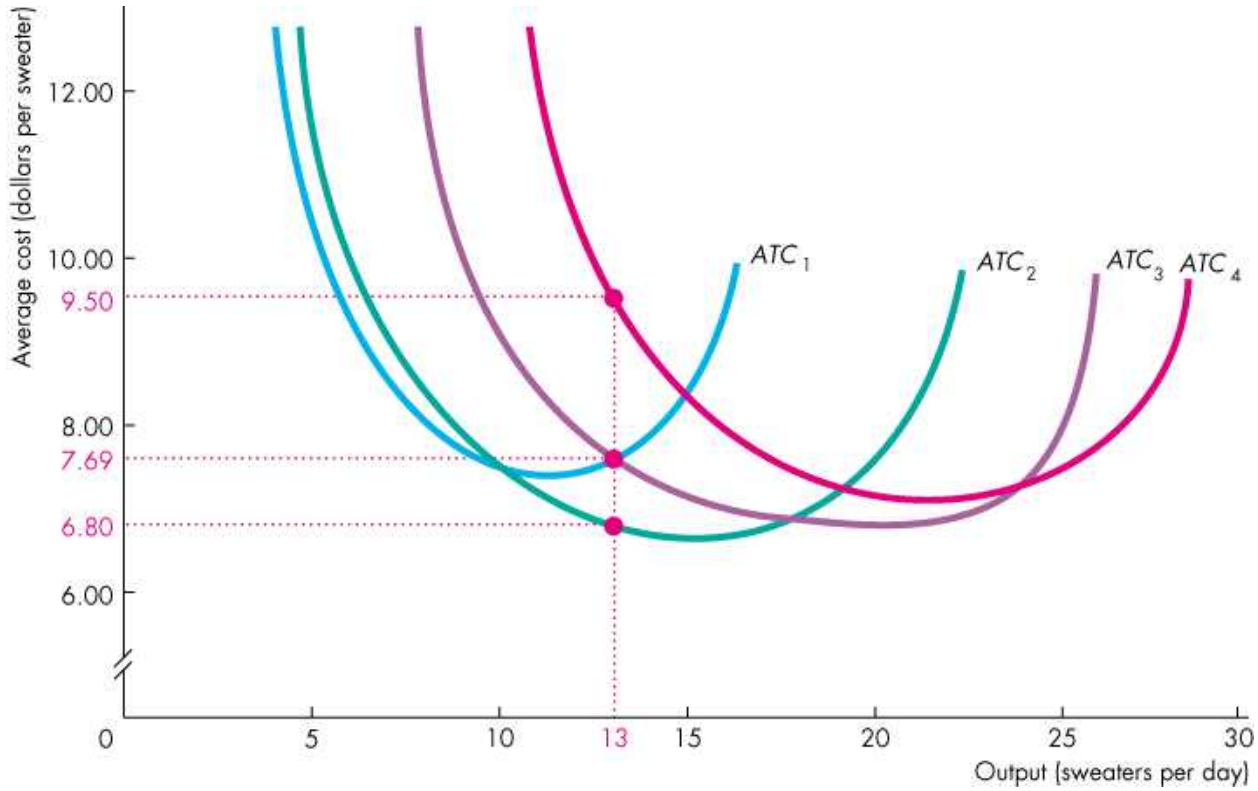
So, we want to decide which plant has the lowest cost for producing each output level.

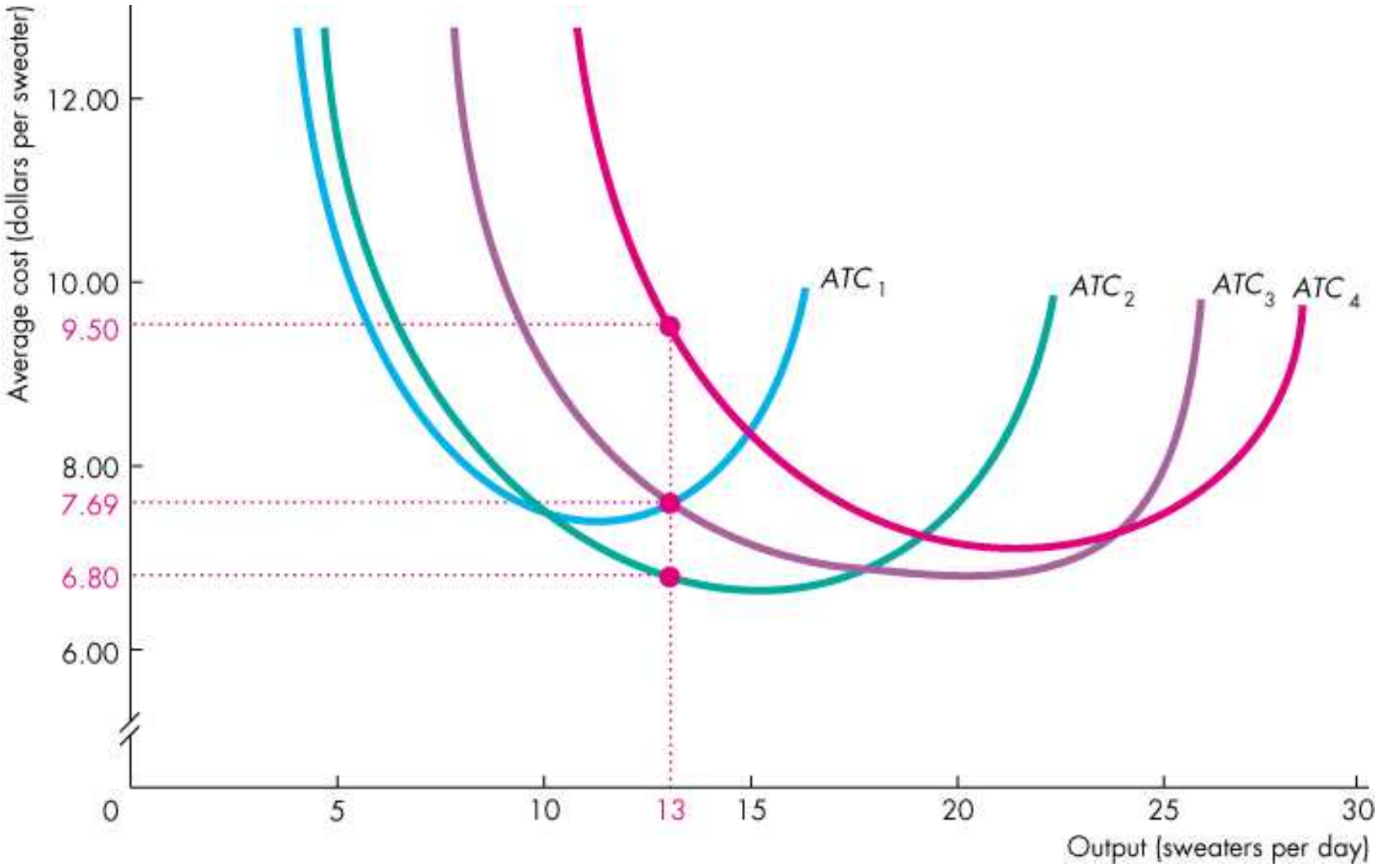
Let's find the least-cost way of producing a given output level.

Suppose that the firm wants to produce 13 sweaters a day.

Long-Run Cost

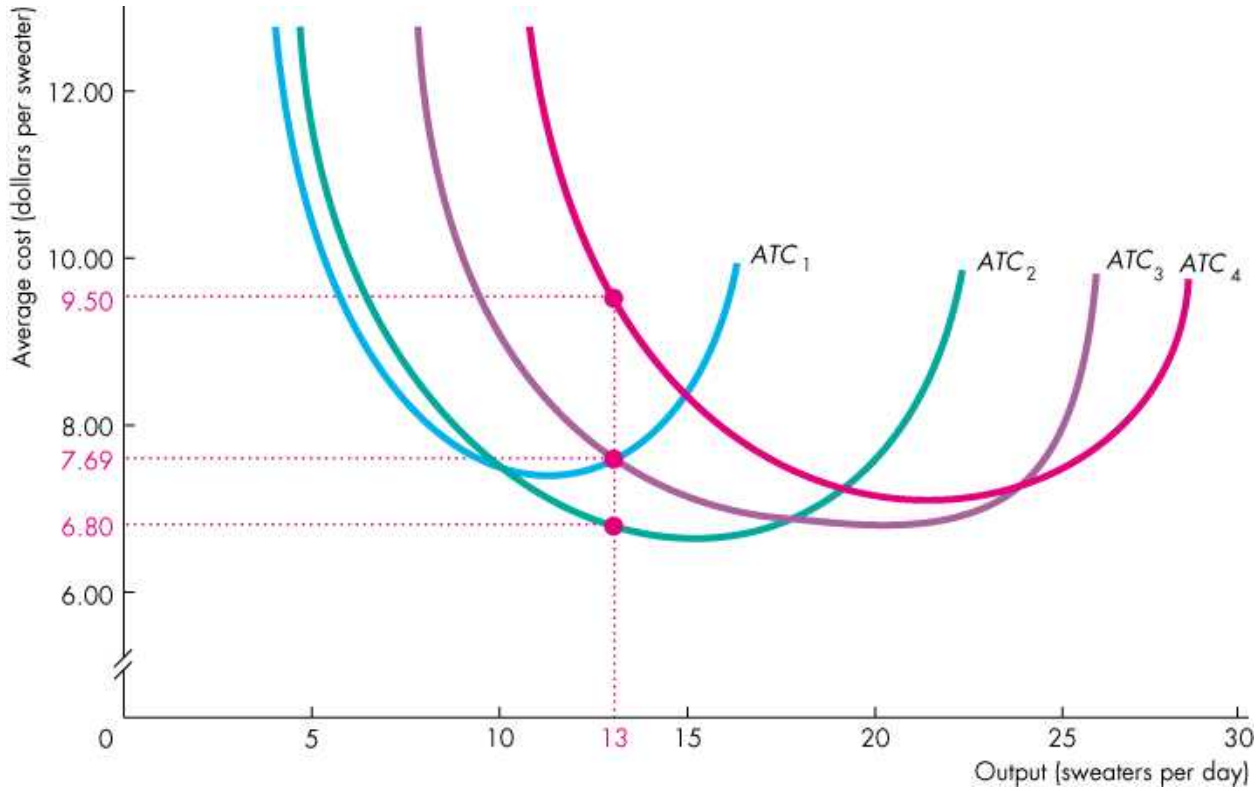
13 sweaters a day cost $7.69 each on ATC_1.





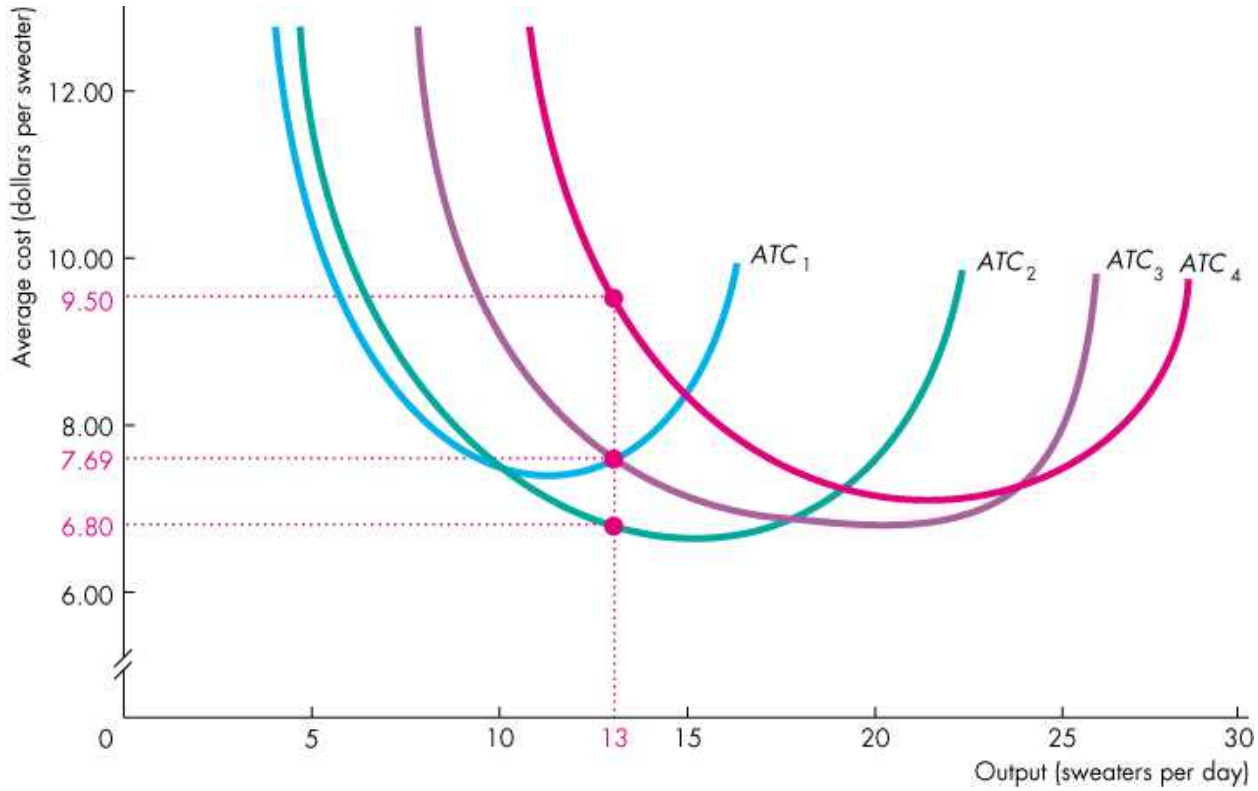
Long-Run Cost

13 sweaters a day cost $6.80 each on ATC_2.



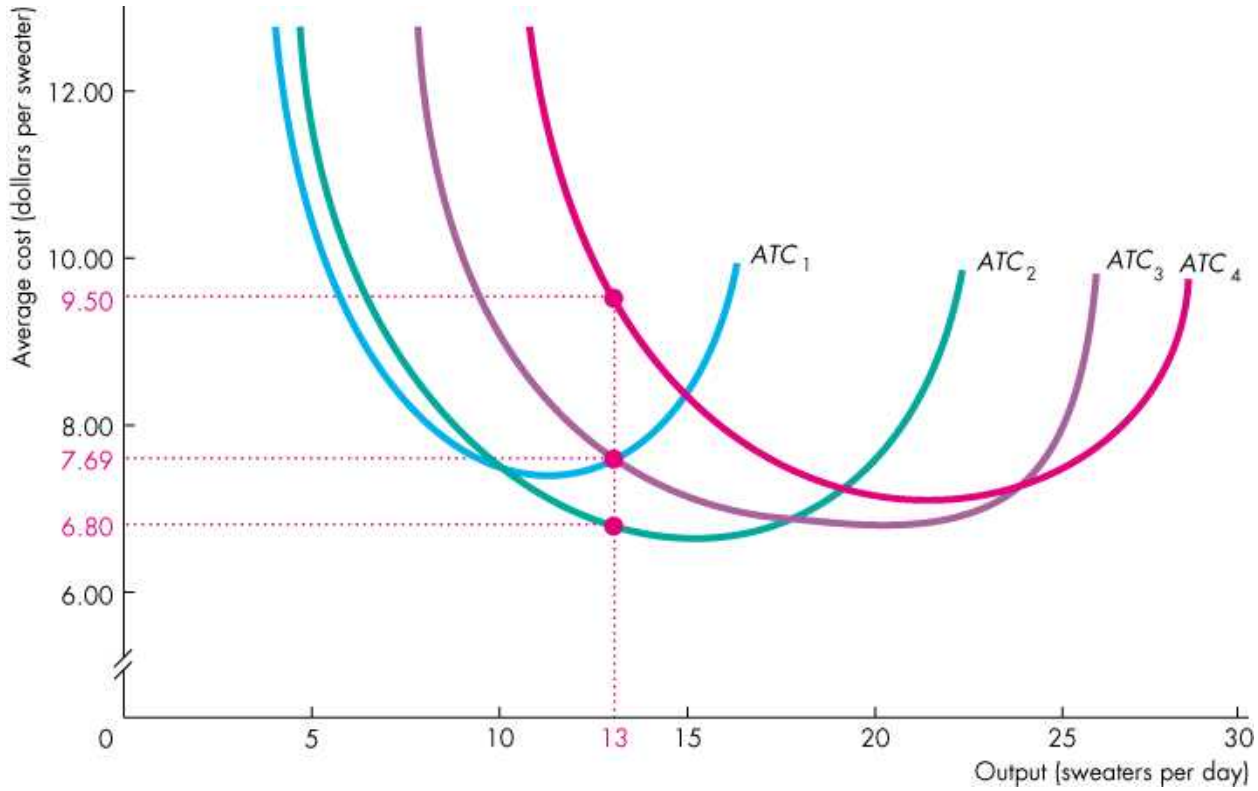
Long-Run Cost

13 sweaters a day cost \$7.69 each on ATC_3.



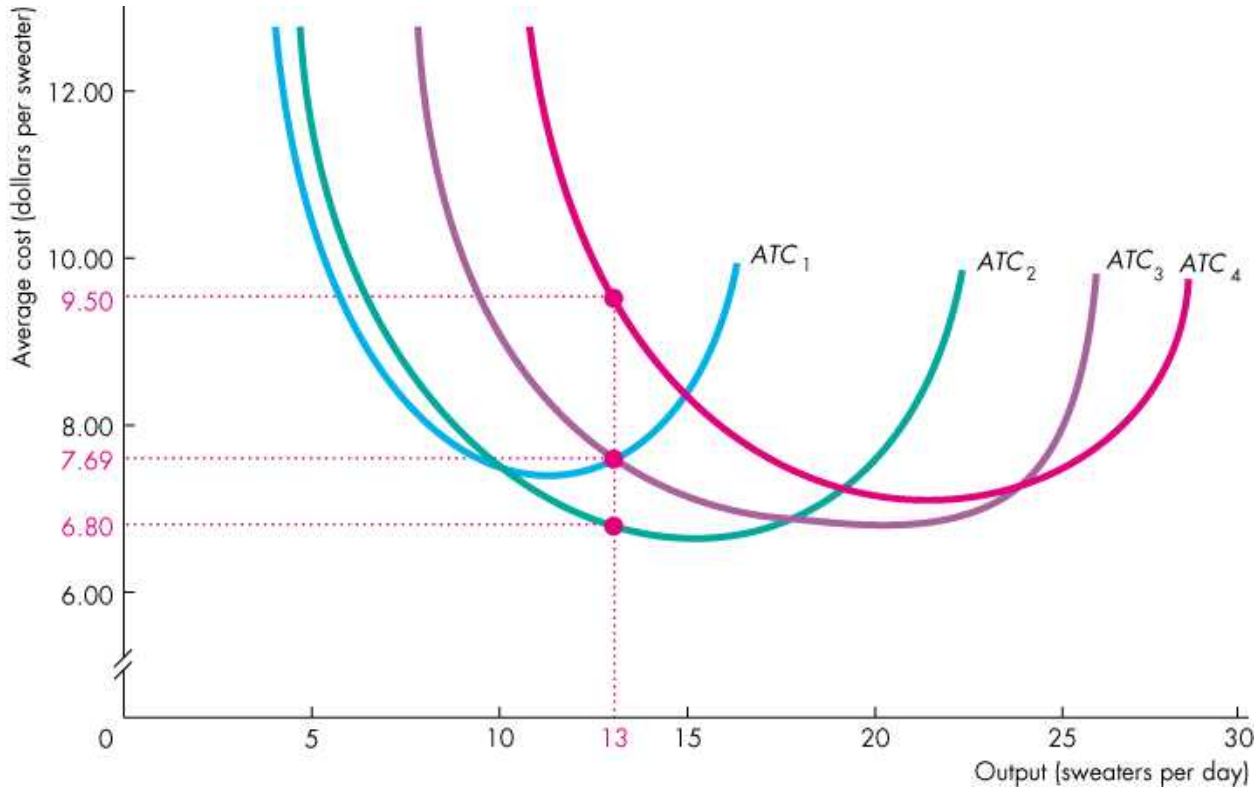
Long-Run Cost

13 sweaters a day cost $9.50 each on ATC_4.



Long-Run Cost

The least-cost way of producing 13 sweaters a day is to use 2 knitting machines.



Long-Run Cost

Long-Run Average Cost Curve

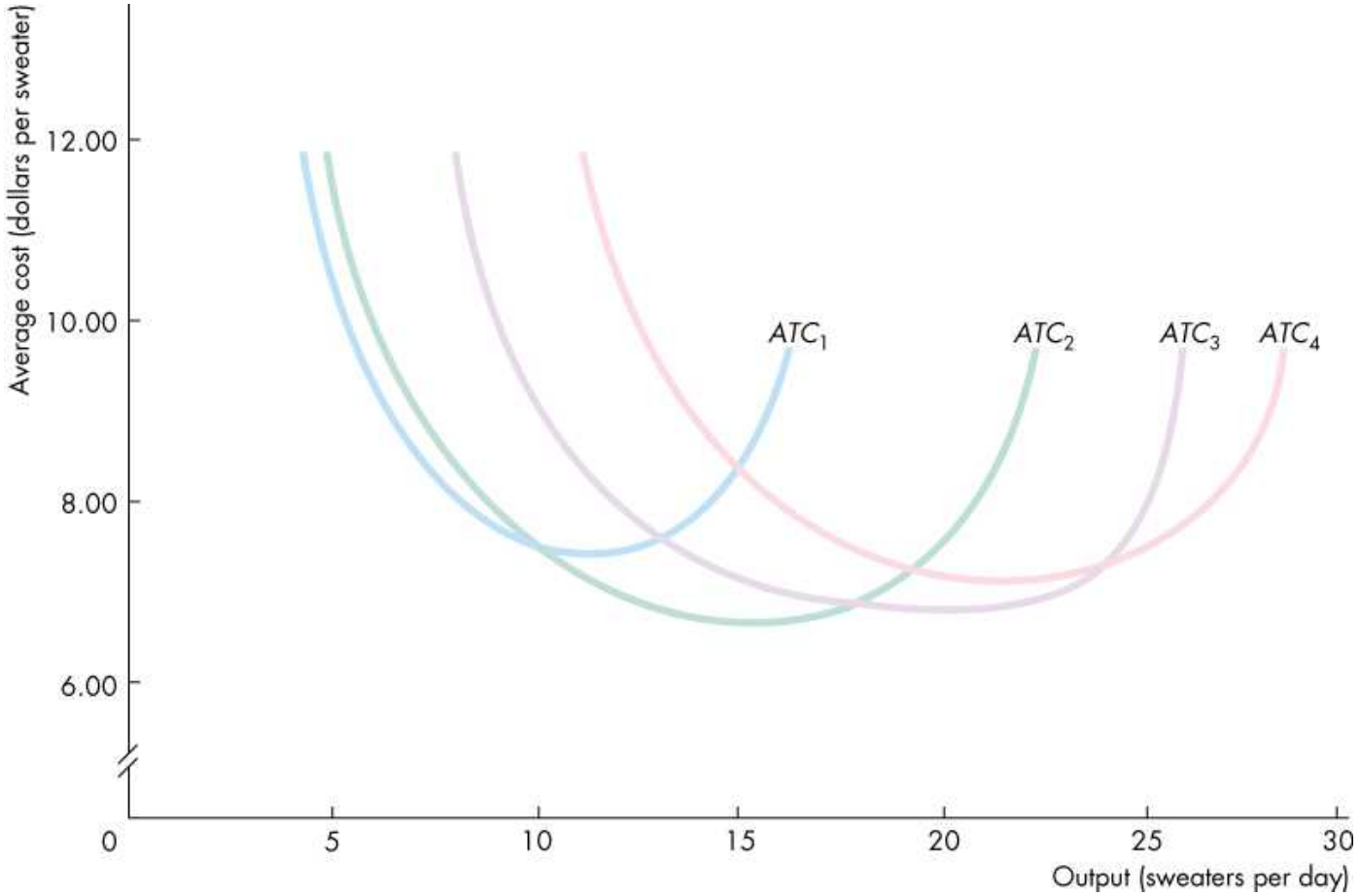
The **long-run average cost curve** is the relationship between the lowest attainable average total cost and output when both the plant and labor are varied.

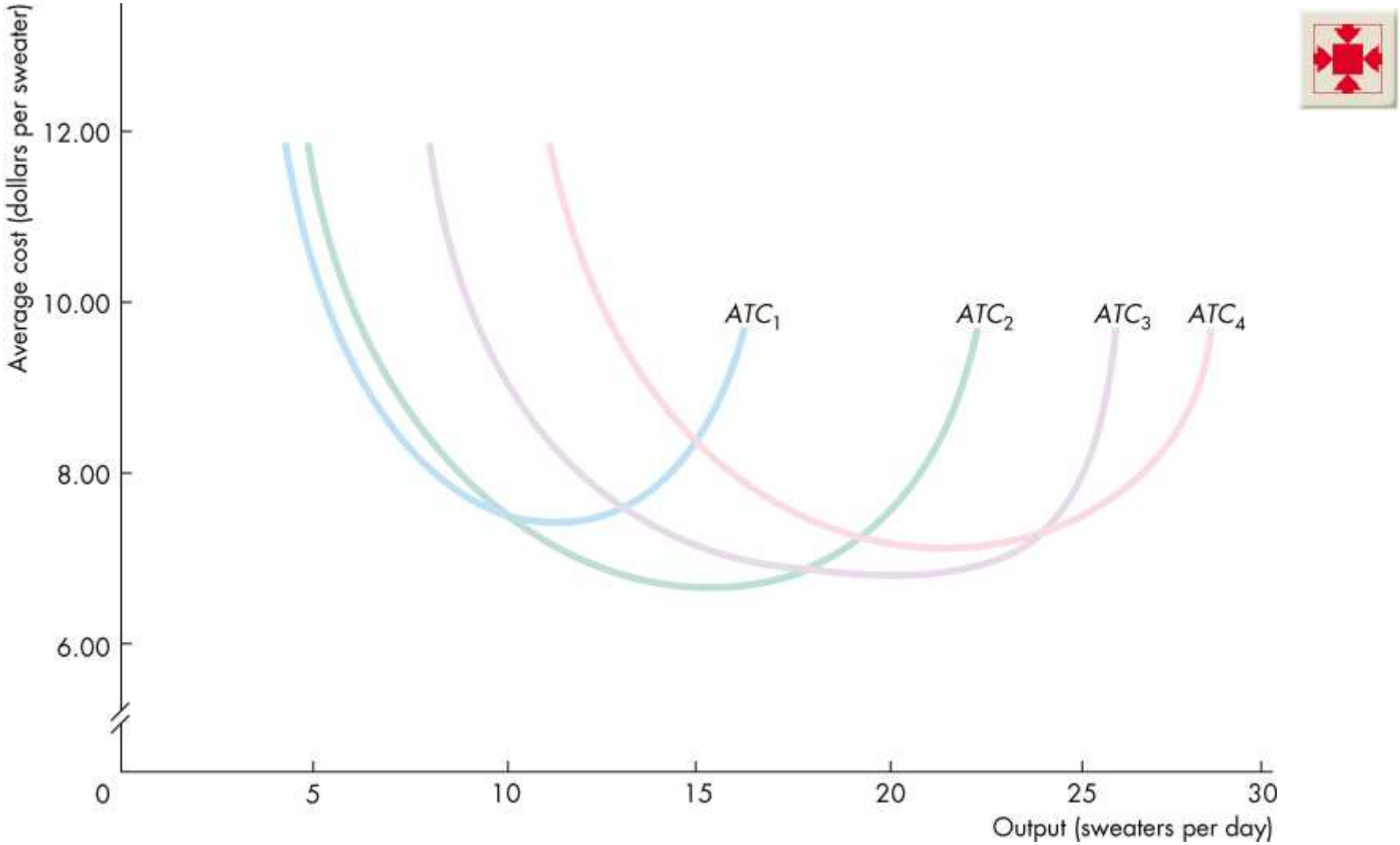
The long-run average cost curve is a planning curve that tells the firm the plant that minimizes the cost of producing a given output range.

Once the firm has chosen its plant, the firm incurs the costs that correspond to the *ATC* curve for that plant.

Long-Run Cost

Figure 11.8 illustrates the long-run average cost (*LRAC*) curve.





Long-Run Cost

Economies and Diseconomies of Scale

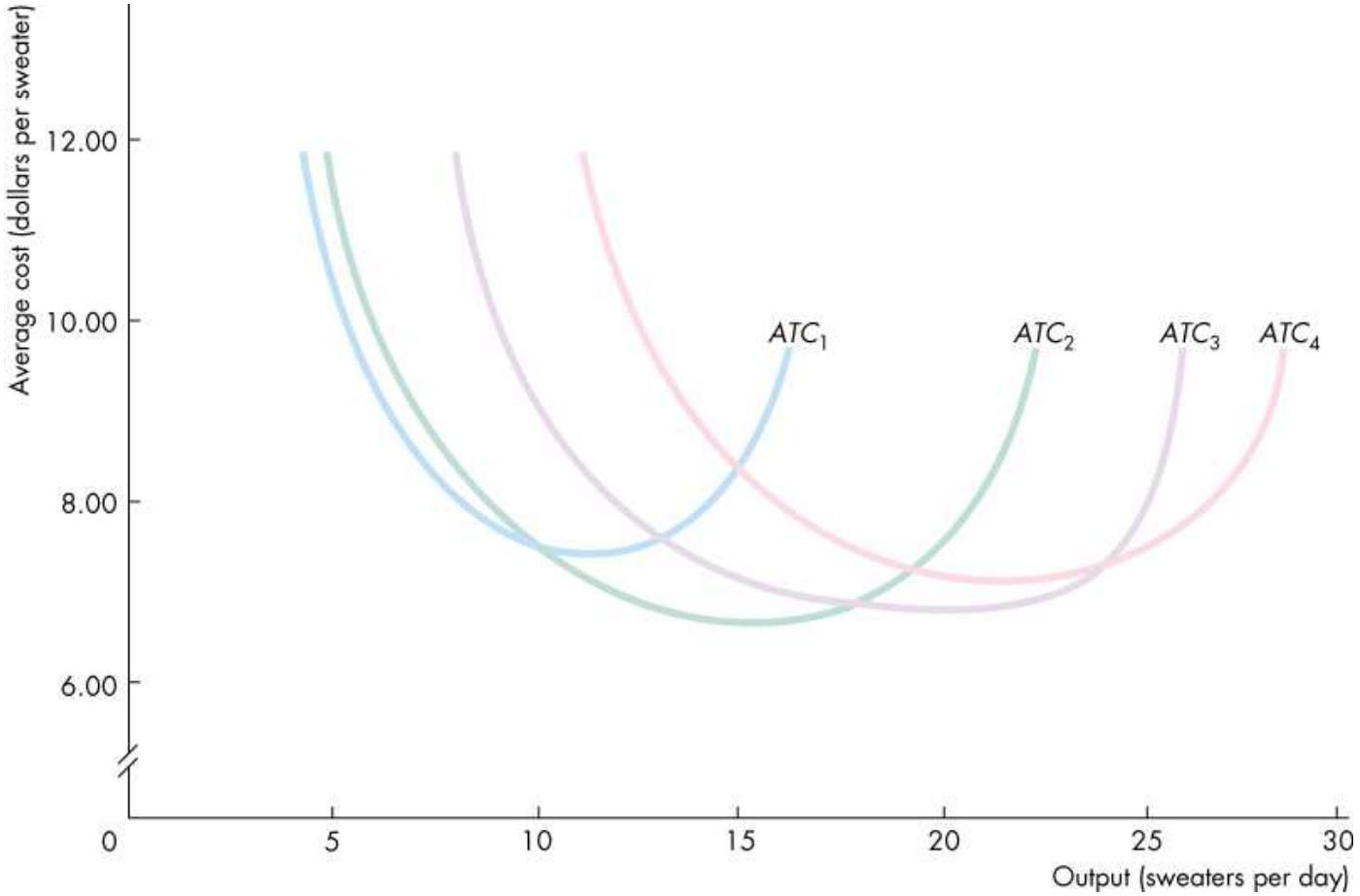
Economies of scale are features of a firm's technology that lead to falling long-run average cost as output increases.

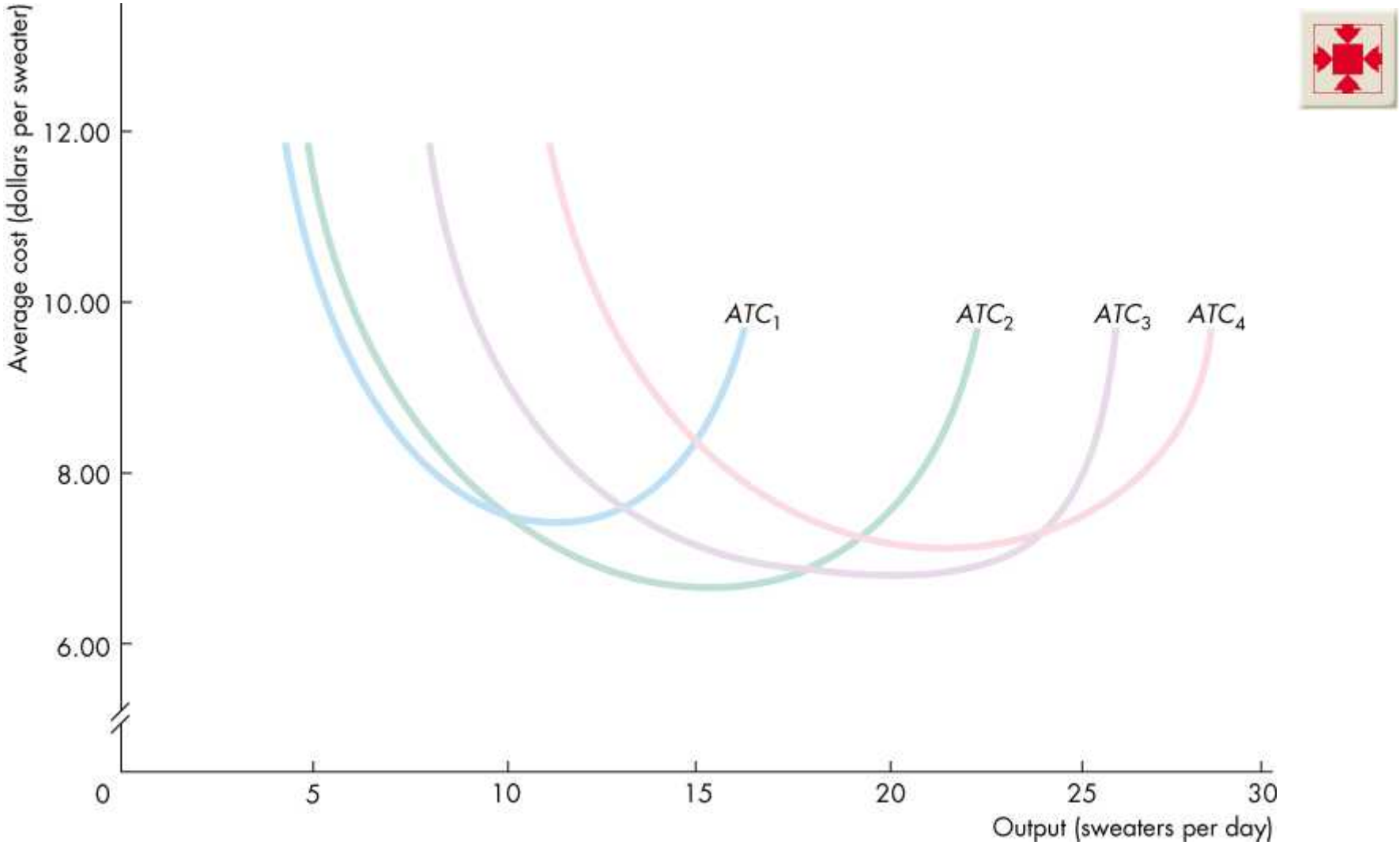
Diseconomies of scale are features of a firm's technology that lead to rising long-run average cost as output increases.

Constant returns to scale are features of a firm's technology that lead to constant long-run average cost as output increases.

Long-Run Cost

Figure 11.8 illustrates economies and diseconomies of scale.





Long-Run Cost

Minimum Efficient Scale

A firm experiences economies of scale up to some output level.

Beyond that output level, it moves into constant returns to scale or diseconomies of scale.

Minimum efficient scale is the smallest quantity of output at which the long-run average cost reaches its lowest level.

If the long-run average cost curve is U-shaped, the minimum point identifies the minimum efficient scale output level.