Short-Run Cost

To produce more output in the short run, a firm must employ more labor, which means that it must increase its costs. We describe the relationship between output and cost by using three cost concepts:

- Total cost
- Marginal cost
- Average cost

Total Cost

A firm's **total cost** (TC) is the cost of *all* the factors of production it uses. We separate total cost into total *fixed* cost and total *variable* cost.

Total fixed cost (TFC) is the cost of the firm's fixed factors. For Campus Sweaters, total fixed cost includes the cost of renting knitting machines and *normal profit*, which is the opportunity cost of Cindy's entrepreneurship (see Chapter 10, p. 229). The quantities of fixed factors don't change as output changes, so total fixed cost is the same at all outputs.

Total variable cost (TVC) is the cost of the firm's variable factors. For Campus Sweaters, labor is the variable factor, so this component of cost is its wage bill. Total variable cost changes as output changes.

Total cost is the sum of total fixed cost and total variable cost. That is,

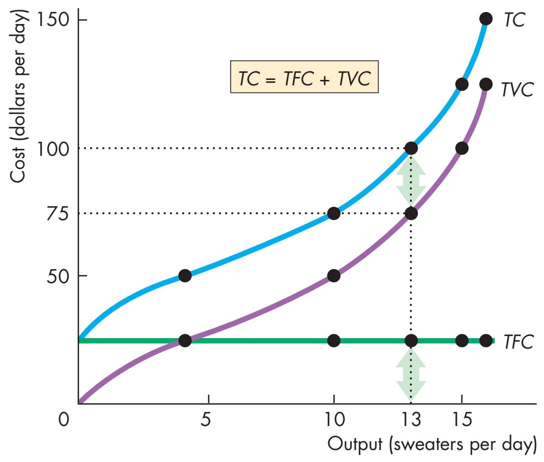
$$TC = TFC + TVC.$$

The table in Fig. 11.4 shows total costs. Campus Sweaters rents one knitting machine for \$25 a day, so its TFC is \$25. To produce sweaters, the firm hires labor, which costs \$25 a day. TVC is the number of workers multiplied by \$25. For example, to produce 13 sweaters a day, in row D, the firm hires 3 workers and TVC is \$75. TC is the sum of TFC and TVC, so to produce 13 sweaters a day, TC is \$100. Check the calculations in the other rows of the table.

Figure 11.4 shows Campus Sweaters' total cost curves, which graph total cost against output. The green TFC curve is horizontal because total fixed cost (\$25 a day) does not change when output changes. The purple TVC curve and the blue TC curve both slope upward because to increase output, more labor must be employed, which increases total variable cost. Total fixed cost equals the vertical distance between the TVC and TC curves.

Let's now look at a firm's marginal cost.

FIGURE 11.4 Total Cost Curves



	Labor (workers per day)	Output (sweaters per day)	Total fixed cost (TFC)	Total variable cost (TVC)	Total cost (TC)
			(dollars per day)		
A	0	0	25	0	25
B	1	4	25	25	50
C	2	10	25	50	75
D	**3**	**13**	**25**	**75**	**100**
E	4	15	25	100	125
F	5	16	25	125	150

Campus Sweaters rents a knitting machine for \$25 a day, so this cost is the firm's total fixed cost. The firm hires workers at a wage rate of \$25 a day, and this cost is its total variable cost. For example, in row D, Campus Sweaters employs 3 workers and its total variable cost is $3 \times \$25$, which equals \$75. Total cost is the sum of total fixed cost and total variable cost. For example, when Campus Sweaters employs 3 workers, total cost is \$100—total fixed cost of \$25 plus total variable cost of \$75.

The graph shows Campus Sweaters' total cost curves. Total fixed cost is constant—the TFC curve is a horizontal line. Total variable cost increases as output increases, so the TVC curve and the TC curve increase as output increases. The vertical distance between the TC curve and the TVC curve equals total fixed cost, as illustrated by the two arrows.

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Marginal Cost

Figure 11.4 shows that total variable cost and total cost increase at a decreasing rate at small outputs but eventually, as output increases, total variable cost and total cost increase at an increasing rate. To understand this pattern in the change in total cost as output increases, we need to use the concept of *marginal cost*.

A firm's **marginal cost** is the increase in total cost that results from a one-unit increase in output. We calculate marginal cost as the increase in total cost divided by the increase in output. The table in Fig. 11.5 shows this calculation. When, for example, output increases from 10 sweaters to 13 sweaters, total cost increases from \$75 to \$100. The change in output is 3 sweaters, and the change in total cost is \$25. The marginal cost of one of those 3 sweaters is (\$25 ÷ 3), which equals \$8.33.

Figure 11.5 graphs the marginal cost data in the table as the red marginal cost curve, *MC*. This curve is U-shaped because when Campus Sweaters hires a second worker, marginal cost decreases, but when it hires a third, a fourth, and a fifth worker, marginal cost successively increases.

At small outputs, marginal cost decreases as output increases because of greater specialization and the division of labor. But as output increases further, marginal cost eventually increases because of the *law of diminishing returns*. The law of diminishing returns means that the output produced by each additional worker is successively smaller. To produce an additional unit of output, ever more workers are required, and the cost of producing the additional unit of output—marginal cost—must eventually increase.

Marginal cost tells us how total cost changes as output increases. The final cost concept tells us what it costs, on average, to produce a unit of output. Let's now look at Campus Sweaters' average costs.

Average Cost

Three average costs of production are

1. Average fixed cost
2. Average variable cost
3. Average total cost

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. The average cost concepts are calculated from the total cost concepts as follows:

$$TC = TFV + TVC.$$

Divide each total cost term by the quantity produced, Q, to get

$$\frac{TC}{Q} = \frac{TFC}{Q} + \frac{TVC}{Q},$$

or

$$ATC = AFC + AVC.$$

The table in Fig. 11.5 shows the calculation of average total cost. For example, in row *C*, output is 10 sweaters. Average fixed cost is (\$25 ÷ 10), which equals \$2.50, average variable cost is (\$50 ÷ 10), which equals \$5.00, and average total cost is (\$75 ÷ 10), which equals \$7.50. Note that average total cost is equal to average fixed cost (\$2.50) plus average variable cost (\$5.00).

Figure 11.5 shows the average cost curves. The green average fixed cost curve (*AFC*) slopes downward. As output increases, the same constant total fixed cost is spread over a larger output. The blue average total cost curve (*ATC*) and the purple average variable cost curve (*AVC*) are U-shaped. The vertical distance between the average total cost and average variable cost curves is equal to average fixed cost—as indicated by the two arrows. That distance shrinks as output increases because average fixed cost declines with increasing output.

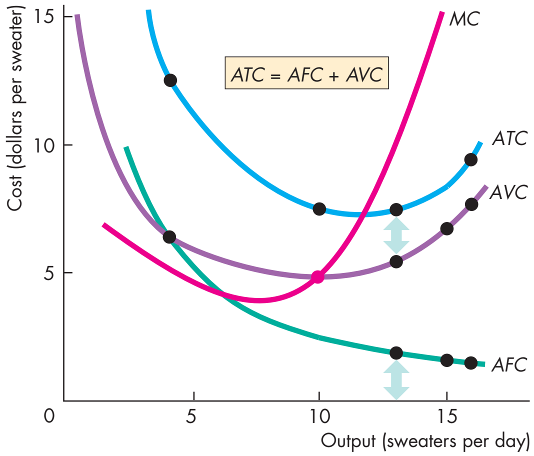
Marginal Cost and Average Cost

The marginal cost curve (*MC*) intersects the average variable cost curve and the average total cost curve *at their minimum points*. When marginal cost is less than average cost, average cost is decreasing, and when marginal cost exceeds average cost, average cost is increasing. This relationship holds for both the *ATC* curve and the *AVC* curve. It is another example of the relationship you saw in Fig. 11.3 for average product and marginal product and in your average and marginal grades.

Why the Average Total Cost Curve Is U-Shaped

Average total cost is the sum of average fixed cost and average variable cost, so the shape of the *ATC* curve

FIGURE 11.5 Marginal Cost and Average Costs



Marginal cost is calculated as the change in total cost divided by the change in output. When output increases from 4 to 10 sweaters, an increase of 6 sweaters, total cost increases by \$25. Marginal cost is \$25 ÷ 6, which is \$4.17.

Each average cost concept is calculated by dividing the related total cost by output. When 10 sweaters are produced, *AFC* is \$2.50 (\$25 ÷ 10), *AVC* is \$5 (\$50 ÷ 10), and *ATC* is \$7.50 (\$75 ÷ 10).

The graph shows that the *MC* curve is U-shaped and intersects the *AVC* curve and the *ATC* curve at their minimum points. The average fixed cost curve (*AFC*) is downward sloping. The *ATC* curve and *AVC* curve are U-shaped. The vertical distance between the *ATC* curve and the *AVC* curve is equal to average fixed cost, as illustrated by the two arrows.

	Labor (workers per day)	Output (sweaters per day)	Total fixed cost (*TFC*) (dollars per day)	Total variable cost (*TVC*) (dollars per day)	Total cost (*TC*) (dollars per day)	Marginal cost (*MC*) (dollars per additional sweater)	Average fixed cost (*AFC*) (dollars per sweater)	Average variable cost (*AVC*) (dollars per sweater)	Average total cost (*ATC*) (dollars per sweater)
A	0	0	25	0	25		—	—	—
						6.25			
B	1	4	25	25	50		6.25	6.25	12.50
						4.17			
C	2	10	25	50	75		2.50	5.00	7.50
						8.33			
D	3	13	25	75	100		1.92	5.77	7.69
						12.50			
E	4	15	25	100	125		1.67	6.67	8.33
						25.00			
F	5	16	25	125	150		1.56	7.81	9.38

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combines the shapes of the *AFC* and *AVC* curves. The U shape of the *ATC* curve arises from the influence of two opposing forces:

1. Spreading total fixed cost over a larger output
2. Eventually diminishing returns

When output increases, the firm spreads its total fixed cost over a larger output and so its average fixed cost decreases—its *AFC* curve slopes downward.

Diminishing returns means that as output increases, ever-larger amounts of labor are needed to produce an additional unit of output. So as output increases, average variable cost decreases initially but eventually increases, and the *AVC* curve slopes upward. The *AVC* curve is U shaped.

The shape of the *ATC* curve combines these two effects. Initially, as output increases, both average fixed cost and average variable cost decrease, so average total cost decreases. The *ATC* curve slopes downward.

But as output increases further and diminishing returns set in, average variable cost starts to increase. With average fixed cost decreasing more quickly than average variable cost is increasing, the *ATC* curve continues to slope downward. Eventually, average variable cost starts to increase more quickly than average fixed cost decreases, so average total cost starts to increase. The *ATC* curve slopes upward.

Cost Curves and Product Curves

The technology that a firm uses determines its costs. Figure 11.6 shows the links between the firm's product curves and its cost curves. The upper graph shows the average product curve, *AP*, and the marginal product curve, *MP*—like those in Fig. 11.3. The lower graph shows the average variable cost curve, *AVC*, and the marginal cost curve, *MC*—like those in Fig. 11.5.

As labor increases up to 1.5 workers a day (upper graph), output increases to 6.5 sweaters a day (lower graph). Marginal product and average product rise and marginal cost and average variable cost fall. At the point of maximum marginal product, marginal cost is at a minimum.

As labor increases from 1.5 workers to 2 workers a day, (upper graph) output increases from 6.5 sweaters to 10 sweaters a day (lower graph). Marginal product falls and marginal cost rises, but average product continues to rise and average variable cost continues to fall. At the point of maximum average product, average variable cost is at a minimum. As labor increases further, output increases. Average product diminishes and average variable cost increases.

Shifts in the Cost Curves

The position of a firm's short-run cost curves depends on two factors:

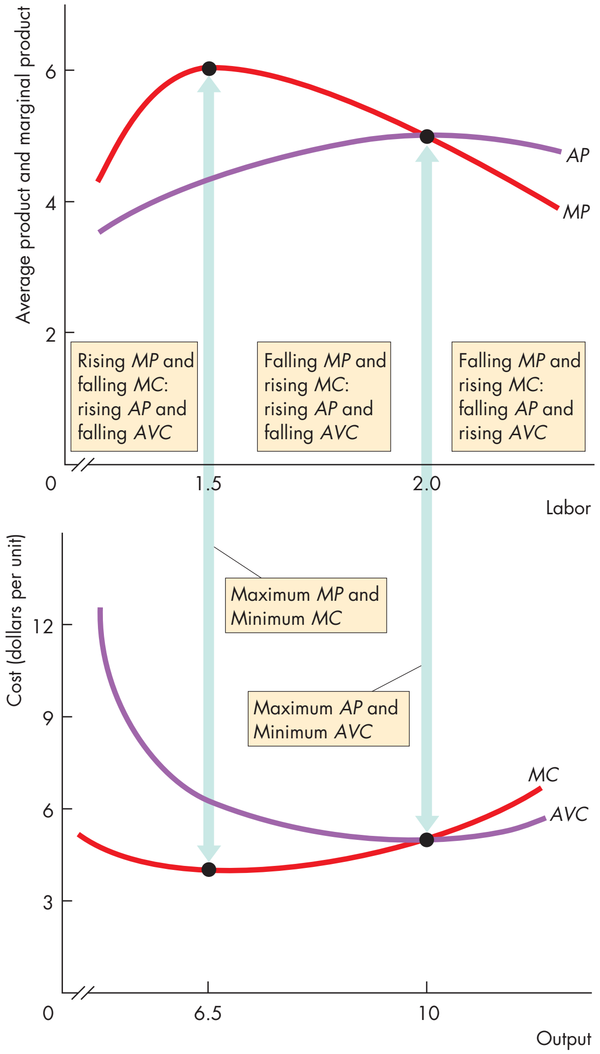
- Technology
- Prices of factors of production

Technology A technological change that increases productivity increases the marginal product and average product of labor. With a better technology, the same factors of production can produce more output, so the technological advance lowers the costs of production and shifts the cost curves downward.

For example, advances in robot production techniques have increased productivity in the automobile industry. As a result, the product curves of Chrysler, Ford, and GM have shifted upward and their cost curves have shifted downward. But the relationships between their product curves and cost curves have not changed. The curves are still linked in the way shown in Fig. 11.6.

Often, as in the case of robots producing cars, a technological advance results in a firm using more capital, a fixed factor, and less labor, a variable factor.

FIGURE 11.6 Product Curves and Cost Curves



A firm's *MP* curve is linked to its *MC* curve. If, as the firm increases its labor from 0 to 1.5 workers a day, the firm's marginal product rises, its marginal cost falls. If marginal product is at a maximum, marginal cost is at a minimum. If, as the firm hires more labor, its marginal product diminishes, its marginal cost rises.

A firm's *AP* curve is linked to its *AVC* curve. If, as the firm increases its labor to 2 workers a day, its average product rises, its average variable cost falls. If average product is at a maximum, average variable cost is at a minimum. If, as the firm hires more labor, its average product diminishes, its average variable cost rises.

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TABLE 11.2 A Compact Glossary of Costs

Term	Symbol	Definition	Equation
Fixed cost		Cost that is independent of the output level; cost of a fixed factor of production	
Variable cost		Cost that varies with the output level; cost of a variable factor of production	
Total fixed cost	*TFC*	Cost of the fixed factors of production	
Total variable cost	*TVC*	Cost of the variable factors of production	
Total cost	*TC*	Cost of all factors of production	$TC = TFC + TVC$
Output (total product)	*TP*	Total quantity produced (output *Q*)	
Marginal cost	*MC*	Change in total cost resulting from a one-unit increase in total product	$MC = \Delta TC \div \Delta Q$
Average fixed cost	*AFC*	Total fixed cost per unit of output	$AFC = TFC \div Q$
Average variable cost	*AVC*	Total variable cost per unit of output	$AVC = TVC \div Q$
Average total cost	*ATC*	Total cost per unit of output	$ATC = AFC + AVC$

Another example is the use of ATMs by banks to dispense cash. ATMs, which are fixed capital, have replaced tellers, which are variable labor. Such a technological change decreases total cost but increases fixed costs and decreases variable cost. This change in the mix of fixed cost and variable cost means that at small outputs, average total cost might increase, while at large outputs, average total cost decreases.

Prices of Factors of Production An increase in the price of a factor of production increases the firm's costs and shifts its cost curves. How the curves shift depends on which factor price changes.

An increase in rent or some other component of *fixed* cost shifts the *TFC* and *AFC* curves upward and shifts the *TC* curve upward but leaves the *AVC* and *TVC* curves and the *MC* curve unchanged. For example, if the interest expense paid by a trucking company increases, the fixed cost of transportation services increases.

An increase in wages, gasoline, or another component of *variable* cost shifts the *TVC* and *AVC* curves upward and shifts the *MC* curve upward but leaves the *AFC* and *TFC* curves unchanged. For example, if truck drivers' wages or the price of gasoline increases, the variable cost and marginal cost of transportation services increase.

You've now completed your study of short-run costs. All the concepts that you've met are summarized in a compact glossary in Table 11.2.

REVIEW QUIZ

1. What relationships do a firm's short-run cost curves show?
2. How does marginal cost change as output increases (a) initially and (b) eventually?
3. What does the law of diminishing returns imply for the shape of the marginal cost curve?
4. What is the shape of the *AFC* curve and why does it have this shape?
5. What are the shapes of the *AVC* curve and the *ATC* curve and why do they have these shapes?

You can work these questions in Study Plan 11.3 and get instant feedback.