

## Microeconomics

Topic 6: “Be able to explain and calculate average and marginal cost to make production decisions.”

Reference: Gregory Mankiw’s *Principles of Microeconomics*, 2<sup>nd</sup> edition, Chapter 13.

### **Long-Run versus Short-Run**

In order to understand average cost and marginal cost, it is first necessary to understand the distinction between the “long run” and the “short run.”

Short run: a period of time during which one or more of a firm’s inputs cannot be changed.

Long run: a period of time during which all inputs can be changed.

For example, consider the case of Bob’s Bakery. Bob’s uses two inputs to make loaves of bread: labor (bakers) and capital (ovens). (This is obviously a simplification, because the bakery uses other inputs such as flour and floor space. But we will pretend there are just two inputs to make the example easier to understand.) Bakers can be hired or fired on very short notice. But new ovens take 3 months to install. Thus, the short run for Bob’s Bakery is any period less than 3 months, while the long run is any period longer than 3 months.

The concepts of long run and short run are closely related to the concepts of fixed inputs and variable inputs.

Fixed input: an input whose quantity remains constant during the time period in question.

Variable input: an input whose quantity can be altered during the time period in question.

In the case of Bob’s Bakery, ovens are a fixed input during any period less than 3 months, whereas labor is a variable input.

### **Fixed Cost, Variable Cost, and Total Cost**

In the short run, a firm will have both fixed inputs and variable inputs. These correspond to two types of cost: fixed cost and variable cost.

Fixed cost (FC): the cost of all fixed inputs in a production process. Another way of saying this: production costs that do not change with the quantity of output produced.

Variable cost (VC): the cost of all variable inputs in a production process. Another way of saying this: production costs that change with the quantity of output produced.

In the case of Bob's Bakery, the cost of renting ovens is a fixed cost in the short run, while the cost of hiring labor is a variable cost.

Since fixed inputs cannot be changed in the short run, fixed cost cannot be changed either. That means fixed cost is constant, no matter what quantity the firm chooses to produce in the short run.

Variable cost, on the other hand, does depend on the quantity the firm produces. Variable cost rises when quantity rises, and it falls when quantity falls.

When you add fixed and variable costs together, you get total cost.

Total cost (TC): the total cost of producing a given amount of output.

$$TC = FC + VC$$

Note: the total cost curve has the same shape as the variable cost curve because total costs rise as output increases.

In the case of Bob's Bakery, suppose the firm's rental payments on ovens add up to \$40 a day; then  $FC = 40$ . And suppose that if the firm produces 100 loaves in a day, its labor cost (wages for bakers) is \$500; then  $VC = 500$ . The firm's total cost is  $TC = 40 + 500 = 540$ . Suppose that when the firm produces 150 loaves a day, its labor cost rises to \$700; then the new  $VC = 700$  and the new  $TC = 40 + 700 = 740$ . This information is summarized in the table below.

Bob's Bakery's Total, Fixed, and Variable Costs

Quantity (per day)	Total Cost	Fixed Cost	Variable Cost
100	540	40	500
150	740	40	700

### **Average Cost or Average Total Cost**

Average cost (AC), also known as average total cost (ATC), is the average cost per unit of output. To find it, divide the total cost (TC) by the quantity the firm is producing (Q).

Average cost (AC) or average total cost (ATC): the per-unit cost of output.

$$ATC = TC/Q$$

Since we already know that TC has two components, fixed cost and variable cost, that means ATC has two components as well: average fixed cost (AFC) and average variable cost (AVC). The AFC is the fixed cost per unit of output, and AVC is the variable cost per unit of output.

$$ATC = AFC + AVC$$

$$AFC = FC/Q$$

$$AVC = VC/Q$$

In the case of Bob's Bakery, we said earlier that the firm can produce 100 loaves with  $FC = 40$ ,  $VC = 500$ , and  $TC = 540$ . Therefore,  $ATC = TC/Q = 540/100 = 5.4$ . Also,  $AFC = 40/100 = 0.4$  and  $AVC = 500/100 = 5$ . Notice that we can use AFC and AVC to find ATC a different way:  $ATC = AFC + AVC = 0.4 + 5 = 5.4$ , which is the same answer we got before.

If Bob's Bakery produced 150 loaves instead of 100, the calculations would be the same, except we'd use  $Q = 150$ ,  $VC = 700$ , and  $TC = 740$  instead. FC would still be 40. This information is summarized in the table below.

Bob's Bakery's Total and Average Costs

Quantity (per day)	TC	FC	VC	ATC	AFC	AVC
100	540	40	500	5.40	0.40	5.00
150	740	40	700	4.93	0.27	4.67

It's easy to find ATC using TC and Q, like we just did. But you should also be able to find Q using TC and ATC, or find TC using Q and ATC. Since we know that  $ATC = TC/Q$ , we also know that  $TC = ATC \times Q$  and  $Q = TC/ATC$ .

For example, suppose you know that Bob's Bakery has  $TC = 740$  and  $ATC = 4.93$ . Since  $ATC = TC/Q$ , the following equation must hold:

$$4.93 = 740/Q$$

If you solve the equation, you'll find that  $Q = 150$  (approximately).

### Marginal Cost

Often, we are interested in knowing what happens to a firm's costs if output is increased by just a small amount. This is not the same as the average cost, because the next unit of output the firm produces might be more or less costly to produce than previous units.

Marginal cost (MC): the additional cost that results from increasing output by one unit. Another way of saying this: the additional cost per additional unit of output.

We use the symbol  $\Delta$  (the Greek letter delta) to designate the change in a variable. For instance, if total cost (TC) rose from 75 to 100, we would say  $\Delta TC = 100 - 75 = 25$ . Using this symbol, we can write the mathematical formula for marginal cost:

$$MC = \Delta TC / \Delta Q$$

Notice that we divide by the change in quantity ( $\Delta Q$ ). Often, we set  $\Delta Q = 1$ , because marginal cost is defined as the additional cost from one more unit of output. But sometimes we don't know how much the added cost from just one more unit is, so we calculate marginal cost for a larger change in quantity.

In the case of Bob's Bakery, we said that  $TC = 540$  when  $Q = 100$ , and  $TC = 740$  when  $Q = 150$ . So  $\Delta TC = 740 - 540 = 200$ ,  $\Delta Q = 150 - 100 = 50$ , and therefore  $MC = 200/50 = 4$ . We say that the marginal cost is 4 for units between 100 and 150. This is assuming we don't have information about how much it would cost to increase output by just one, from 100 to 101 loaves of bread.

Notice that the MC differs from ATC. At Bob's Bakery, the original ATC was 5.4, and the new ATC (after increasing quantity to 150) was 4.93. Neither of these is equal to the MC of 4 that we just calculated. The table is the same as the last one, but with a new column for MC.

Bob's Bakery's Total, Average, and Marginal Costs

Quantity (per day)	TC	FC	VC	ATC	AFC	AVC	MC
100	540	40	500	5.40	0.40	5.00	
							4
150	740	40	700	4.93	0.27	4.67	

Notice that MC is listed between lines. That's because MC shows the change that results from going from the first line to the second line. But sometimes, for simplicity, MC is just shown on the second line.

In calculating MC, notice that you use four different numbers: the old TC, the new TC, the old Q, and the new Q. You should also be able to find any one of these numbers if you know the other three plus the marginal cost.

For example, suppose you know that Bob's Bakery had a total cost of \$540 at its old quantity of 100, and you know that Bob's has a total cost of \$740 at its new quantity, but you don't know the firm's new quantity. But you do know its marginal cost per unit in making the change was 4. Since  $MC = \Delta TC / \Delta Q$ , the following equation must hold:

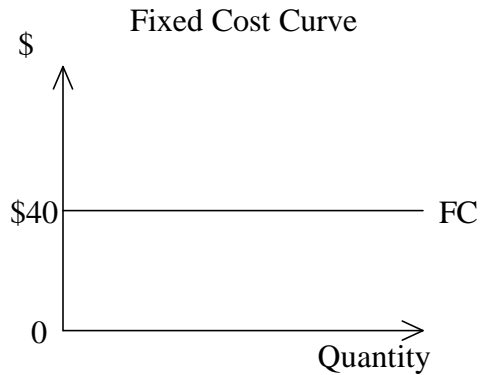
$$4 = (740 - 540) / (\text{new } Q - 100)$$

If you solve the equation for new Q, you'll find that it's 150.

### The Typical Shapes of Cost Curves

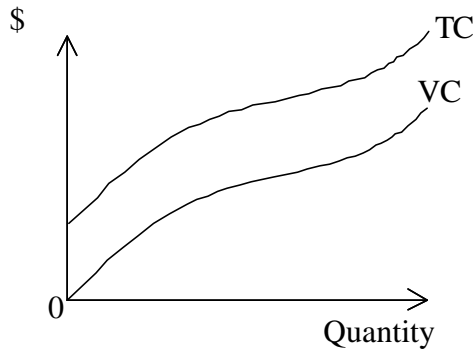
Sometimes you will need to use curves representing the different kinds of cost. Here are the typical curve shapes.

Since FC is constant, the FC curve is always horizontal like the one shown in the figure below. In our example, FC is always \$40 --whether the firm produces 10 or 100 units of output.



On the other hand, VC increases as quantity increases. As a result, any VC curve is upward sloping like the one shown in the figure below. The TC curve looks very much like the VC curve, except that it's higher because it includes the FC as well.

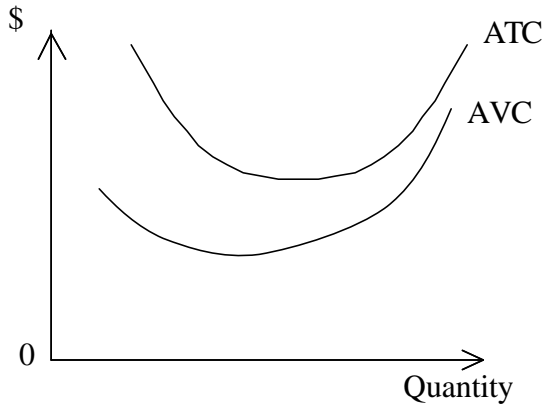
Total and Variable Cost Curves



Both AVC and ATC curve tend to have a U-shape, as shown in the figure below. That is, both AVC and ATC tends to fall at first and then rise as the output level increases. Of course, ATC is higher because it includes fixed costs.

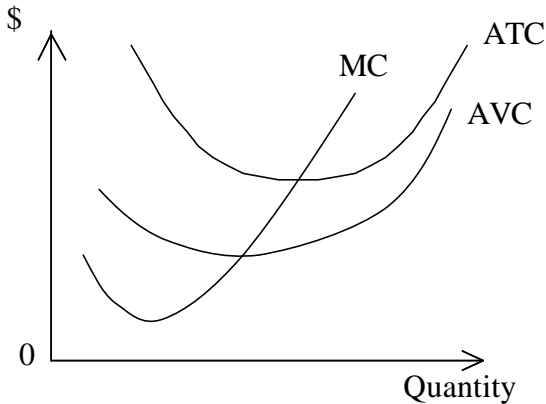
Although it is not shown in the figure above, we could also draw the AFC curve. Since  $AFC = FC/Q$  and FC is constant, AFC gets smaller and smaller as Q gets larger. That means the AFC curve is always downward sloping.

ATC and AVC Curves



MC also tends to have a U-shape. However, the bottom of the U occurs earlier, so the upward-sloping part of the MC is more important. The figure below shows a typical MC curve, along with ATC and AVC. Notice that MC crosses both ATC and AVC at their lowest points.

ATC and AVC Curves



The figure above is the most important one for you to remember, because ATC, AVC, and MC are useful in understanding how a firm maximizes profit. For more on this, see the notes on Micro Topic 7.