

6. MYRIAD COSTS

LEARNING OBJECTIVE

1. What are the different ways of measuring costs, and how are they related to the amount of time the firm has to change its behavior?

How much does it cost to produce a given quantity q ? We already have a detailed answer to this question, but now need to focus less on the details and more on the “big picture.” First, let’s focus on the short run, and suppose L is adjustable in the short run but K is not. Then the **short-run total cost** of producing q ,—that is, the total cost of output with only short-term factors varying—given the capital level, is

$$\text{SRTC}(q|K) = \min_L rK + wL, \text{ over all } L \text{ satisfying } F(K, L) \geq q.$$

In words, this equation says that the short-run total cost of the quantity q , given the existing level K , is the minimum cost, where L gets to vary (which is denoted by “min over L ”) and where the L considered is large enough to produce q . The vertical line $|$ is used to indicate a condition or conditional requirement; here $|K$ indicates that K is fixed. The minimum lets L vary but not K . Finally, there is a constraint $F(K, L) \geq q$, which indicates that one must be able to produce q with the mix of inputs because we are considering the short-run cost of q .

The short-run total cost of q , given K , has a simple form. First, since we are minimizing cost, the constraint $F(K, L) \geq q$ will be satisfied with equality, $F(K, L) = q$. This equation determines L , since K is fixed; that is, $F(K, L_S(q, K)) = q$ gives the short-run value of L , $L_S(q, K)$. Finally, the cost is then $rK + wL = rK + wL_S(q, K)$.

The **short-run marginal cost**, given K , is just the derivative of short-run total cost with respect to output, q . To establish the short-run marginal cost, note that the equation $F(K, L) = q$ implies

$$\frac{\partial F}{\partial L}(K, L_S(q, K)) dL = dq,$$

or

$$\frac{dL}{dq} \Big|_{F=q} = \frac{1}{\frac{\partial F}{\partial L}(K, L_S(q, K))}.$$

The tall vertical line, subscripted with $F = q$, is used to denote the constraint $F(K, L) = q$ that is being differentiated. Thus, the short-run marginal cost is

$$\text{SRMC}(q|K) = \text{SRTC}'(q) = \frac{d}{dq}(rK + wL) = w \frac{dL}{dq} \Big|_{F=q} = \frac{w}{\frac{\partial F}{\partial L}(K, L_S(q, K))}.$$

There are three other short-run costs we require to complete the analysis. First, there is the short-run average cost of production that we obtain by dividing the total cost by the quantity produced:

$$\text{SRAC}(q | K) = \frac{\text{SRTC}(q | K)}{q}.$$

Second, there is the **short-run variable cost** that is the total cost minus the cost of producing zero units, that is, minus the fixed cost, which in this case is rK . Finally, we need one more short-run cost: The short-run average variable cost. The short-run average variable cost is the short-run variable cost divided by quantity, which is given,

Short-run total cost

The total cost of output with only short-run factors varying.

Short-run marginal cost

The derivative of short-run total cost with respect to output.

Short-run variable cost

The total cost minus the cost of producing zero units.

$$SRAVC(q | K) = \frac{SRTC(q | K) - SRTC(0 | K)}{q} = \frac{wL_S(q | K)}{q}.$$

Short-run average variable cost

The average cost ignoring the investment in capital equipment.

Short-run average cost

The average of the total cost per unit of output.

Short-run fixed cost

The difference between variable cost and total cost.

Long-run total cost

The total cost of output with all factors varying.

Long-run average variable cost

The long-run total cost divided by output.

The **short-run average variable cost** is the average cost ignoring the investment in capital equipment.

The **short-run average cost** could also be called the short-run average total cost, since it is the average of the total cost per unit of output, but “average total” is a bit of an oxymoron.^[11] Consequently, when total, fixed, or variable is not specified, the convention is to mean total. Note that the marginal variable cost is the same as the marginal total costs, because the difference between variable cost and total cost is a constant—the cost of zero production, also known as the **short-run fixed cost** of production.

At this point, we have identified four distinct costs, all of which are relevant to the short run. These are the total cost, the marginal cost, the average cost, and the average variable cost. In addition, all of these costs may be considered in the long run as well. There are three differences in the long run. First, the long run lets all inputs vary, so the **long-run total cost** is the total cost of output with all factors varying. In this case,

$$LRTC(q) = \min_{L, K} rK + wL, \text{ over all } L \text{ and } K \text{ combinations satisfying } F(K, L) = q.$$

Second, since all inputs can vary, the long-run cost isn't conditioned on K . Finally, the **long-run average variable cost** is the long-run total cost divided by output; it is also known as the long-run average total cost. Since a firm could use no inputs in the long run and thus incur no costs, the cost of producing zero is zero. Therefore, in the long run, all costs are variable, and the long-run average variable cost is the long-run average total cost divided by quantity.

Note that the easiest way to find the long-run total cost is to minimize the short-run total cost over K . Since this is a function of one variable, it is straightforward to identify the K that minimizes cost, and then plug that K into the expression for total cost.

One might want to distinguish the very short run from the short run, from the medium run, from the long run, from the very long run. But a better approach is to view adjustment as a continuous process, with a gradual easing of the constraints. Faster adjustment costs more. Continuous adjustment is a more advanced topic, requiring an Euler equation approach.

KEY TAKEAWAYS

- The short-run total cost is the minimum cost of producing a given quantity minimized over the inputs variable in the short run. Sometimes the word total is omitted.
- The short-run fixed cost is the short-run total cost at a zero quantity.
- The short-run marginal cost, given K , is just the derivative of the short-run total cost with respect to quantity.
- The short-run average cost is the short-run total cost divided by quantity.
- The short-run average variable cost is the short-run total cost minus the short-run fixed cost, all divided by quantity.
- Marginal variable cost is the same as the marginal total costs, because the difference between total cost and variable cost is the fixed cost of production, a constant.
- The long-run total cost is the minimum cost of producing a given quantity minimized over all inputs. Sometimes the word total is omitted.
- The long-run fixed cost is zero.
- The long-run marginal cost is the derivative of the long-run total cost with respect to quantity.
- The long-run average cost is the long-run total cost divided by quantity.
- The long-run average variable cost equals the long-run average cost.