

Behind the Supply Curve: >> Inputs and Costs

Section 3: Short-Run Versus Long-Run Costs

Up to this point, we have treated fixed cost as completely outside the control of a firm because we have focused on the short run. But as we noted earlier, all inputs are variable in the long run: this means that in the long run fixed cost may also be varied. In the long run, in other words, a firm's fixed cost becomes a variable it can choose. For example, given time, Ben's Boots can acquire additional boot-making machinery or dispose of some of its existing machinery. In this section, we will examine how a firm's costs behave in the short run and in the long run. We will also see that the firm will choose its fixed cost in the long run based on the level of output it expects to produce.

Let's begin by supposing that Ben's Boots is considering whether to acquire additional boot-making machines. Acquiring additional machinery will affect its total cost in two ways. First, the firm will have to either rent or buy the additional machinery; either way, that will mean higher fixed cost in the short run. Second, if the workers have more equipment, they will be more productive: fewer workers will be needed to produce any given output, so variable cost for any given output level will be reduced.

The table in Figure 8-10 shows how acquiring an additional machine affects costs. In our original example, we assumed that Ben's Boots had a fixed cost of \$108. The left half

of the table shows variable cost as well as total cost and average total cost assuming a fixed cost of \$108. The average total cost curve for this level of fixed cost is given by ATC_1 in Figure 8-10. Let's compare that to a situation in which the firm buys an additional boot-making machine, doubling its fixed cost to \$216 but reducing its variable cost at any given level of output. The right half of the table shows the firm's variable cost, total cost, and average total cost with this higher level of fixed cost. The average total cost curve corresponding to \$216 in fixed cost is given by ATC_2 in Figure 8-10.

Figure 8-10

Choosing the Level of Fixed Cost for Ben's Boots

There is a trade-off between higher fixed cost and lower variable cost for any given output level, and vice versa. ATC_1 is the average total cost curve corresponding to a fixed cost of \$108; it leads to high variable cost. ATC_2 is the average total cost curve corresponding to a higher fixed cost of \$216 but lower variable cost. At low output levels, fewer than 4 pairs of boots per day, ATC_1 lies below ATC_2 : average total cost is lower with only \$108 in fixed cost. But as output goes up, average total cost is lower with the higher amount of fixed cost, \$216: at more than 4 pairs of boots per day, ATC_2 lies below ATC_1 .

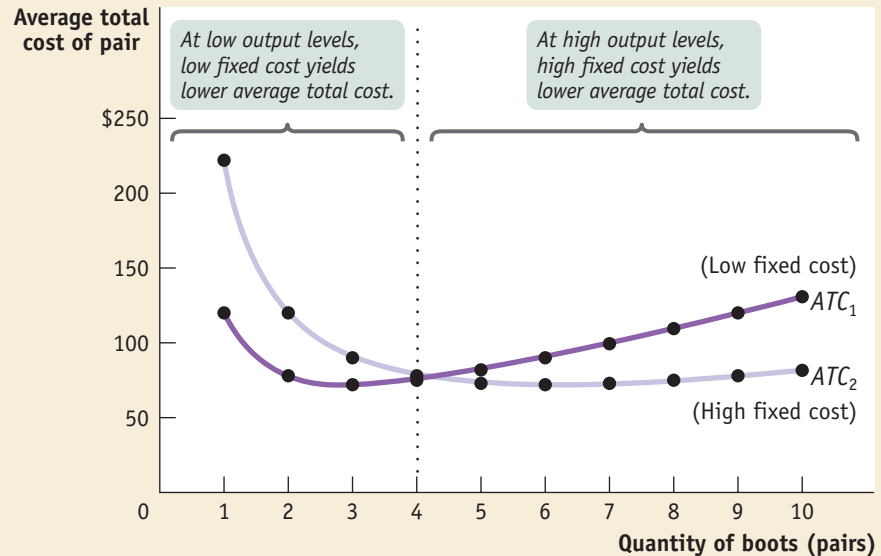


Figure 8-10 (continued)

Quantity of boots (pairs)	Low fixed cost (FC = \$108)			High fixed cost (FC = \$216)		
	High variable cost	Total cost	Average total cost of pair ATC_1	Low variable cost	Total cost	Average total cost of pair ATC_2
1	\$12	\$120	\$120	\$6	\$222	\$222
2	48	156	78	24	240	120
3	108	216	72	54	270	90
4	192	300	75	96	312	78
5	300	408	81.6	150	366	73.2
6	432	540	90	216	432	72
7	588	696	99.4	294	510	72.9
8	768	876	109.5	384	600	75
9	972	1,080	120	486	702	78
10	1,200	1,308	130.8	600	816	81.6

From the figure you can see that when output is small, 4 pairs of boots per day or fewer, average total cost is smaller when Ben's Boots forgoes the additional machinery and maintains the lower fixed cost of \$108: ATC_1 lies below ATC_2 . For example, at 3 pairs of boots per day, average total cost is \$72 without the additional machinery and \$90 with the additional machinery. But as output increases beyond 4 pairs per day, the firm's average total cost is lower if it acquires the additional machinery, raising its fixed cost to \$216. For example, at 9 pairs of boots per day, average total cost is \$120 when fixed cost is \$108, but only \$78 when fixed cost is \$216.

Why does average total cost change like this when fixed cost increases? When output is low, the increase in fixed cost from the additional machinery outweighs the reduction in variable cost from higher worker productivity—that is, there are too few units of output over which to spread the additional fixed cost. So if Ben’s Boots plans to produce fewer than 4 pairs of boots per day, it would be better off to choose the lower level of fixed cost, \$108, to achieve a lower average total cost of production. When planned output is high, however, it should acquire the additional machinery.

In general, for each output level there is some choice of fixed cost that minimizes the firm’s average total cost for that output level. So when the firm has a desired output level that it expects to maintain over time, it should choose the level of fixed cost appropriate to that level—that is, the level of fixed cost that minimizes its average total cost.

Now that we are studying a situation in which fixed cost can change, we need to take time into account when discussing average total cost. All of the average cost curves we have considered until now are defined for a given level of fixed cost—that is, they are defined for the short run, the period of time over which fixed cost doesn’t vary. To reinforce that distinction, for the rest of this chapter we will refer to these average total cost curves as “short-run average total cost curves.”

For most firms, it is realistic to assume that there are many possible choices of fixed cost, not just two. This implies that for such a firm, many possible short-run average total cost curves will exist, each corresponding to a different choice of fixed cost and so giving rise to what is called a firm’s “family” of short-run average total cost curves.

At any given time, a firm will find itself on one of its short-run cost curves, the one corresponding to its current level of fixed cost; a change in output will cause it to move along that curve. If the firm expects that change in output level to be long-standing, then it is likely that the firm’s current level of fixed cost is no longer appropriate. Given sufficient time, it will want to adjust its fixed cost to a new level that minimizes average total cost for its new output level. For example, if Ben’s Boots had

The **long-run average total cost curve** shows the relationship between output and average total cost when fixed cost has been chosen to minimize total costs for each level of output.

been producing 2 pairs of boots per day with a fixed cost of \$108 but found itself increasing its output to 8 pairs per day for the foreseeable future, then in the long run it should increase its fixed cost to a level that minimizes average total cost at the 8-pairs-per-day output level.

Suppose we do a thought experiment and calculate the lowest possible average total cost that can be achieved for each output level if the firm were to choose its fixed cost for each output level. Economists have given this thought experiment a name: the *long-run average total cost curve*. Specifically, the **long-run average total cost curve**, or *LRATC*, is the relationship between output and average total cost when fixed cost has been chosen to minimize average total cost *for each level of output*. If there are many possible choices of fixed cost, the long-run average total cost curve will have the familiar, smooth U shape, as shown by *LRATC* in Figure 8-11.

We can now draw the distinction between the short run and the long run more fully. In the long run, when a producer has had time to choose the fixed cost appropriate for its desired level of output, that producer will be on some point on the long-run average total cost curve. But if the output level is altered, the firm will no longer be on its long-run average total cost curve and will instead be moving along its current short-run average total cost curve. It will not be on its long-run average total cost curve again until it readjusts its fixed cost for its new output level.

Figure 8-11 illustrates this point. The curve ATC_3 shows short-run average total costs if a boot producer has chosen the level of fixed cost that minimizes average total cost at an output of 3 pairs of boots per day. This is confirmed by the fact that at 3 pairs per day, ATC_3 touches *LRATC*, the long-run average total cost curve. Similarly, ATC_6 shows short-run average total costs if a boot producer has chosen the level of fixed cost that would minimize average total cost if its output is 6 pairs of boots per day. It touches *LRATC* at 6 pairs per day. And ATC_9 shows short-run average total costs if a boot producer has chosen the level of fixed cost that would minimize average total cost if its output is 9 pairs of boots per day. It touches *LRATC* at 9 pairs per day.

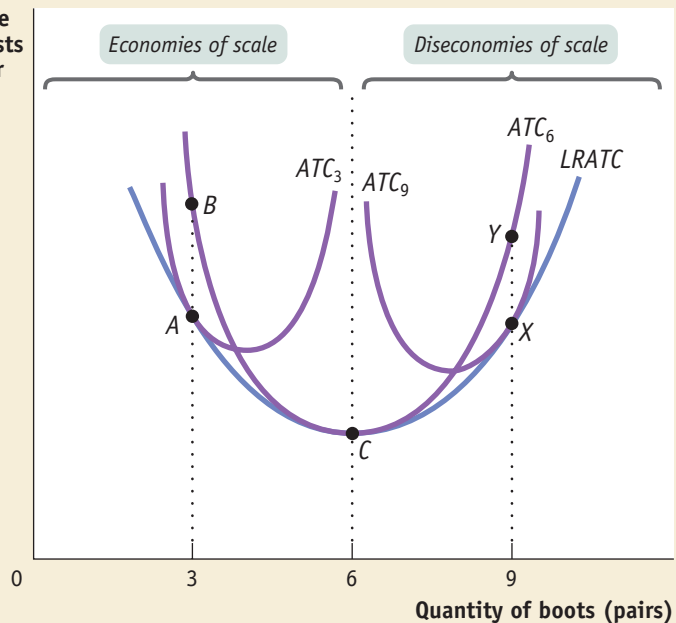
Suppose that the firm has initially chosen to be on ATC_6 . If the firm actually produces 6 pairs of boots per day, it will be at point C on both its short-run and long-run average total cost curves. Suppose, however, that the firm ends up producing only 3 pairs of boots per day. In the short run, its average total cost is indicated by point B on ATC_6 ; it is no longer on $LRATC$. If the firm had known that it would be pro-

Figure 8-11

Short-Run and Long-Run Average Total Cost Curves

If Ben's Boots has chosen the level of fixed cost that minimizes short-run average total cost at an output of six pairs of boots per day and actually ends up producing six pairs per day, it will be on $LRATC$ at point C. But if it produces more or less, in the short run it will be on the short-run average total cost curve ATC_6 and not on $LRATC$. So if it produces only three pairs per day, its average total cost is shown by point B, not point A. If it produces nine pairs per day, its average total cost is shown by point Y, not point X. There are economies of scale when long-run average total cost declines as output increases, and there are diseconomies of scale when long-run average total cost increases as output increases.

Average total costs of pair



ducing only 3 pairs per day, it would have been better off to reduce its fixed cost and achieve lower average total cost. That is, it would have been better off to choose the level of fixed cost corresponding to ATC_3 . Then it would have found itself at point A on the long-run average total cost curve, which lies below point B .

Suppose, on the other hand, that the firm ends up producing 9 pairs of boots per day. In the short run its average total cost is indicated by point Y on ATC_6 . But it would be better off to incur a higher fixed cost in order to reduce its variable cost and move to ATC_9 . This would allow it to reach point X on the long-run average total cost curve, which lies below Y .

The distinction between short-run and long-run average total costs is extremely important in making sense of how real firms operate over time. A company that has to increase output suddenly to meet a surge in demand will typically find that in the short run its average total cost rises sharply because it is hard to get extra production out of the existing facilities. But given time to build new factories or add machinery, short-run average total cost falls.

Economies and Diseconomies of Scale

Finally, what determines the shape of the long-run average total cost curve? The answer is that *scale*, the size of a firm's operations, is often an important determinant of its long-run average total cost of production. Firms that experience scale effects in production find that their long-run average total cost changes substantially depending on the quantity of output they produce. There are **economies of scale** when long-run average total cost declines as output increases. As you can see in Figure 8-11, Ben's Boots experiences economies of scale over output levels ranging from 0 to 6 pairs of boots—the output levels over which the long-run average total cost curve is declining. There are **diseconomies of scale** when long-run average total cost increases as output increases. For Ben's Boots, diseconomies of scale occur at output levels of 6 pairs of boots or more, the output levels over which its long-run average total cost curve is rising.

There are **economies of scale** when long-run average total cost declines as output increases.

There are **diseconomies of scale** when long-run average total cost increases as output increases.

There are **constant returns to scale** when long-run average total cost is constant as output increases.

Although it is not shown in Figure 8-11, there is a third possible relationship between long-run average total cost and scale: firms experience **constant returns to scale** when long-run average total cost is constant as output increases. In this case, the firm's long-run average total cost curve is horizontal over the output levels for which there are constant returns to scale.

What explains these scale effects in production? The answer ultimately lies in the firm's technology of production. Economies of scale often arise from the increased *specialization* that larger output levels allow—a larger scale of operation means that individual workers can limit themselves to more specialized tasks, becoming more skilled and efficient at doing them. Another source of economies of scale is very large set-up cost; in some industries—such as auto manufacturing, electricity generating, or petroleum refining—a very large set-up cost in the form of plant and equipment is necessary to produce any output. As we'll see in Chapter 14, where we study monopoly, economies of scale have very important implications for how firms and industries interact and behave.

Diseconomies of scale, on the other hand, typically arise in large firms due to problems of coordination and communication: as the firm grows in size, it becomes ever more difficult and therefore costly to communicate and organize its activities. While economies of scale induce firms to get larger, diseconomies of scale tend to limit their size. And when constant returns to scale exist, scale has no effect on a firm's long-run average total cost: it is the same regardless of whether the firm produces 1 unit or 100,000 units.

Summing Up Costs: The Short and Long of It

If a firm is to make the best decisions about how much to produce, it has to understand how its costs relate to the quantity of output it chooses to produce. Table 8-3 provides a quick summary of the concepts and measures of cost you have learned about.

TABLE 8-3

Concepts and Measures of Cost

	Measurement	Definition	Mathematical term
Short run	Fixed cost	Cost that does not depend on the quantity of output produced	FC
	Average fixed cost	Fixed cost per unit of output	$AFC = FC/Q$
Short run and long run	Variable cost	Cost that depends on the quantity of output produced	VC
	Average variable cost	Variable cost per unit of output	$AVC = VC/Q$
	Total cost	The sum of fixed cost (short-run) and variable cost	$TC = FC$ (short-run) + VC
	Average total cost (average cost)	Total cost per unit of output	$ATC = TC/Q$
	Marginal cost	The change in total cost generated by producing one more unit of output	$MC = \Delta TC/\Delta Q$
Long run	Long-run average total cost	Average cost when fixed cost has been chosen to minimize total cost for each level of output	$LRATC$