

## Costs of Production

What decisions lie behind the supply curve, and why is the supply curve upward sloping?

Obviously, costs are crucial. We will begin by discussing opportunity cost in more detail, and distinguishing between economic costs and accounting costs.

Next we will consider a firm's technology for transforming inputs into outputs. This technology is quantified by a production function.

Then we will derive a firm's total cost function, based on the prices of inputs and the production function.

In the next chapter, we will see how a firm's cost function, and the price of its output, determine its profit maximizing quantity supplied.

What is the main objective of Helen's Cookies?  
To make cookie lovers happy, to enjoy the  
cookie business, or *to make profit?*

Economists usually assume that firms seek to maximize profits, and this assumption works well for most firms.

In a competitive industry, maximum profits are very low, so any sacrifice of profits for other objectives might force the firm out of business.

Profit = Total Revenue - Total Cost. Total revenue is price  $\times$  quantity.

Measuring total cost can be tricky. There is a difference between "economic profits" and "accounting profits."

Costs of production include all opportunity costs, everything that a firm gives up in order to produce.

- Explicit “out of pocket” expenses are opportunity costs, because the money could have been used to buy something else. (For example, \$1000 for flour or \$2000 in wages)
- Some opportunity costs are implicit. For example, if Helen could have earned \$100 per hour as a computer programmer or cookie consultant.
- If the wage Helen would receive as a programmer increases from \$100 to \$500 per hour, her accounting costs are unchanged, but to an economist the cost of running her cookie business has gone up. Maybe she should shut down the business and become a programmer.

## The Cost of Capital

- Suppose Helen used \$300,000 of her savings to buy her cookie factory. If the interest rate is 5%, she is giving up the opportunity to earn \$15,000 per year in interest. Even though she owns the factory free and clear, she incurs the cost, because she could instead sell the factory and earn \$15,000 per year.
- Helen's capital costs are the interest rate multiplied by the value of the capital, whether the capital is owned or not. If instead Helen used \$100,000 of her money and \$200,000 of borrowed money to buy the factory, *explicit* costs per year are \$10,000 and *implicit* costs are \$5,000 per year.

- The *price* of capital is the interest rate. The quantity of capital is very hard to measure and aggregate, so we use the current market value. If the factory's market value falls to \$200,000 and the interest rate is still 5%, Helen's capital costs fall to \$10,000.
- Because accountants just use explicit costs and economists use explicit and implicit costs, accounting profits are usually higher than economic profits.
- For example, if a firm's stock sells for \$100 and it pays dividends of \$8 per share per year, an accountant might measure these dividends as corporate profits, but an economist would subtract the implicit capital costs. Economic profits might well be close to zero.

## The Production Function

The production function specifies how much output can be produced from each possible quantity of inputs. It is based on our current state of knowhow or *technology*.

We will assume that all inputs other than labor are fixed. In the short run, Helen cannot change the size of her factory.

The production function can be represented by a table, or a graph with labor input on the x axis and output on the y axis.

The *marginal product* of labor is the extra output that results from using one more unit of labor (the units are usually *labor hours*).

*Diminishing marginal product* or “diminishing returns” means that each additional labor hour results in less and less extra output.

## Deriving the Total Cost Function from the Production Function

The production function tells us how much output we get from hiring different amounts of labor to work the factory. Suppose that the wage is \$10 per hour and capital costs are \$30 per hour.

- If 1 worker can produce 50 cookies per hour, then the cost of producing 50 cookies is \$40.  $TC(50) = \$40$
- If 2 workers can produce 90 cookies per hour,  $TC(90) = \$50$ .
- The total cost curve gets steeper as quantity increases. This is due to diminishing marginal product.

## Various Measures of Cost

- *Fixed costs* (rent, professional licence, night watchman—if one is hired no matter how much output is produced) do not vary with the quantity of output. *Variable costs* (cost of ingredients, most workers' salaries) depend on the quantity of output.
- “How much does it cost to produce a typical glass of lemonade?” and “How much would it cost to produce one more glass of lemonade?” have different answers.
- *Average cost* is the total cost divided by the total quantity of output. *Marginal cost* is the extra cost of producing 1 more unit of output.
- $TC = VC + FC$
- $ATC = TC/Q = AVC + AFC$
- $MC = \Delta TC / \Delta Q$



## Shapes of the Cost Curves

*Marginal cost eventually increases as output increases, because of diminishing marginal product of labor.*

With few workers, there is plenty of equipment for each worker to use, and marginal product of labor is high. As the output target increases, workers need to wait to use the equipment, and marginal product of labor falls.

For example, if the marginal product of labor is 5, then one labor hour produces 5 glasses of lemonade, so one glass is produced with  $1/5$  of a labor hour. If the wage is \$10/hr, then the marginal cost of a glass is  $(1/5)10 = \$2$ .

In general, we have  $MC = w / MP_L$ .

Because marginal product of labor falls with output, marginal cost rises with output.

*Average total cost is U-shaped.* It is high at low outputs, because of the presence of fixed costs. It is high at high outputs, because of diminishing marginal product of labor.

Mankiw calls the bottom of the average total cost curve the “efficient scale” for the firm. Keep in mind, though, that other inputs like capital are fixed. It is more common to think of efficient scale as being a long run concept, where all inputs are variable.

*The marginal cost curve intersects the average total cost curve and the average variable cost curve at their minimum points.* The reason is that ATC and AVC are averages of the cost of the first unit of output, the second unit, and so on. If the average is falling, the last unit must have a cost below the average, in order to be bringing down the average. If the average is rising, the last unit must have a cost above the average, in order to be bringing up the average.

Beyond the important features described in previous slides, “typical” cost curves have U-shaped AVC and MC curves, as shown in Figure 5.

Note: If a firm has a capacity constraint, which is a maximum possible output no matter how much labor is added, this is an extreme version of diminishing marginal product of labor. The ATC, AVC, and MC curves become vertical at the capacity.

## Long Run Cost Curves

In the long run, a firm can change the size of its factories, or the number of its factories. A restaurant can move to a larger location, etc. Labor, capital, and all other inputs are variable.

In the long run, the production function depends on the choice of all inputs.

Figure 6 shows the relationship between the long run average total cost curve and several short run ATC curves, corresponding to a small factory, a medium sized factory, and a large factory.

As the firm's output target increases, it gradually increases the size of the factory it decides to build. Due to this flexibility in the long run, all the short run ATC curves lie on or above the long run ATC curve. To produce more output in the short run, the only choice is to hire enough additional labor to do the job. In the long run, we can expand our labor and capital inputs, which might be less costly.

At what quantity does a short run ATC curve touch the long run ATC curve?

When in the short run your factory size is fixed at exactly the optimal size for producing that quantity of output.

## Returns to Scale

Economies of scale (also called increasing returns to scale) occur when long run average total cost declines as output rises.

This is a property of the production function. Doubling all inputs results in more than double the output.

Diseconomies of scale (also called decreasing returns to scale) occur when long run average cost rises as output rises. Doubling all inputs leads to less than double the output.

Constant returns to scale occur when long run average total cost does not vary with output.

Reasons for economies of scale:

- higher production allows for the employment of more workers, who can specialize in tasks they excel at. (assembly line)
- larger batches allow for lower setup costs.
- some inputs only need to be used once, no matter how much output is produced, like programmers of computer software.

Reasons for diseconomies of scale:

- coordination costs rise exponentially as the organization gets bigger.

For intermediate levels of output, there is often constant returns to scale: duplicate what you are doing. Just build another factory, hire more workers and managers. If it is not a big deal to coordinate the two factories, then total costs and output should double.

How is constant returns to scale consistent with diminishing marginal product of labor? Can we have both at the same time?

Yes!

Diminishing marginal product of labor refers to what happens when we add more and more workers to the same factory. Eventually the additional output from hiring one more worker will fall.

On the other hand, constant returns to scale is about what happens if we increase all of the inputs, including capital. If we double all inputs, we would have double the workers and a second factory.