Chapter 10

Technology, Production, and Costs

10.1 Learning Objective

10.1 Technology: An Economic Definition

Learning Objective 1 Define technology and give examples of technological change.

A firm’s technology is the processes it uses to turn inputs into outputs of goods and services. A firm’s technology depends on many factors, including the skills of its managers, the training of its workers, and the speed and efficiency of its machinery and equipment. Whenever a firm experiences positive technological change, it is able to produce more output using the same inputs, or the same output using fewer inputs. Positive technological change results from rearranging the layout of a store, faster or more reliable machinery, etc.

10.2 Learning Objective

10.2 The Short Run and the Long Run in Economics

Learning Objective 2 Distinguish between the economic short run and the economic long run.

A. The Short Run and the Long Run

The relationship between a firm’s production and cost can be divided into the short run and the long run. The short run is a period of time during which at least one of the firm’s inputs is fixed. The long run is a period of time long enough to allow a firm to vary all of its inputs, to adopt new technology, and to increase or decrease the size of its physical plant. The actual length of calendar time for the short run and the long will vary from firm to firm.

B. The Difference between Fixed Costs and Variable Costs

Total cost is the cost of all the inputs a firm uses in production. Fixed costs are costs that remain constant as output changes. Variable costs are costs that change as output changes. Since all of a firm’s short run costs are either fixed or variable costs we can write:

$$\text{Total cost } (TC) = \text{Fixed Cost } (FC) + \text{Variable Cost } (VC).$$
C. Implicit versus Explicit Costs

Economists always measure costs as opportunity costs. The opportunity cost of any activity is the highest-valued alternative that must be given up to engage in that activity. Costs may be explicit or implicit. An explicit cost is a cost that involves spending money. An implicit cost is a nonmonetary opportunity cost. Explicit costs are sometimes called accounting costs. Economic costs include both accounting costs and implicit costs.

D. The Production Function

The relationship between the inputs employed by the firm and the maximum output it can produce with those inputs is called the firm’s production function. The production function represents the firm’s technology.

E. A First Look at the Relationship between Production and Cost

Average total cost (ATC) is total cost divided by the quantity of output produced. In a graph, the ATC curve is U-shaped.

10.3 LEARNING OBJECTIVE

10.3 The Marginal Product of Labor and the Average Product of Labor

Learning Objective 3 Understand the relationship between the marginal product of labor and the average product of labor.

The marginal product of labor is the additional output a firm produces as a result of hiring one more worker. Labor is often considered a variable factor of production. Capital – buildings and equipment – is often considered a fixed factor in the short run. As a firm hires its first few workers, increases in marginal product result from the implementation of a division of labor and from specialization.

A. The Law of Diminishing Returns

The law of diminishing returns is the principle that, at some point, adding more of a variable input, such as labor, to the same amount of a fixed input, such as capital, will cause the marginal product of the variable input to decline. This occurs as the gains from specialization lessen as more of the variable unit is used. Although no firm would purposely do so, the marginal product of the variable factor could eventually become negative. This would result in a decline in total output.

B. Graphing Production

The graph in Figure 10-2 and Table 10-2 show a typical relationship short-run production function and diminishing returns to labor.

C. The Relationship Between Marginal and Average Product

The average product of labor is the total output produced by a firm divided by the quantity of workers.
The relationship between the marginal product of labor and the average products of labor is: The average product of labor is the average of the marginal products of labor. The marginal product of labor equals the average product of labor for the quantity of workers where the average product of labor is at a maximum.

D. An Example of Marginal and Average Values: College Grades

The relationship between the marginal product of labor and the average product of labor is the same as the relationship between the marginal and average values of any variable. For example: a student’s grade point average (GPA) in one semester—the marginal GPA—affects his cumulative GPA—or average GPA. If the marginal GPA is greater (less) than the average GPA, the average GPA rises (falls).

10.4 The Relationship Between Short-Run Production and Short-Run Cost

Learning Objective 4 Explain and illustrate the relationship between marginal cost and average total cost.

It is important to emphasize that the relationships described in this section are applicable to the short run, a time period too short for the firm to alter its technology or the size of its physical plant.

A. Marginal Cost

Marginal cost is the change in a firm’s total cost from producing one more unit of a good or service. Marginal cost ($MC$) can be expressed mathematically as:

$$MC = \frac{\Delta TC}{\Delta Q}$$

Where $\Delta$ represents “change in,” $TC$ is total cost and $Q$ is output.

B. Why Are the Marginal and Average Cost Curves U-Shaped?

There is an important relationship between the marginal cost and the marginal product of labor. When the marginal product of labor is rising, the marginal cost will be falling. When the marginal product of labor is falling, the marginal cost of production will be rising. The relationship between marginal cost and the average total cost is another example of the relationship between marginal and average values. As long as marginal cost is below average total cost, average total cost will fall. When marginal cost is above average total cost, average total cost will rise. Marginal cost will equal average total cost when average total cost is at its lowest point. The average total cost curve has a U-shape because the marginal cost curve has a U-shape.
10.5 Graphing Cost Curves

**Learning Objective 5**  Graph average total cost, average variable cost, average fixed cost, and marginal cost.

Several related average cost measures can be described mathematically.

\[
\text{Average total cost} = ATC = \frac{TC}{Q}
\]

**Average fixed cost** \((AFC)\) equals fixed cost divided by the quantity of output produced.

\[
AFC = \frac{FC}{Q}
\]

**Average variable cost** \((AVC)\) equals variable cost divided by the quantity of output produced.

\[
AVC = \frac{VC}{Q}
\]

The \(MC\), \(ATC\) and \(AVC\) curves are all U-shaped and the \(MC\) curve intersects the \(AVC\) and \(ATC\) curves at their minimum points. When \(MC\) is above \(AVC\) or \(ATC\), it causes them to increase. When \(MC\) equals \(AVC\) or \(ATC\), they must be at their minimum points. \(AFC\) gets smaller and smaller as output increases, and the difference between \(ATC\) and \(AVC\) (this is equal to \(AFC\)) gets smaller.

10.6 Costs in the Long Run

**Learning Objective 6**  Understand how firms use the long-run average cost curve in their planning.

In the long run, all costs are variable; therefore, there are no fixed costs in the long run. Total cost equals variable cost and average total cost equals average variable cost. Managers of firms decide simultaneously how they can run their current store or office in the short run, and whether in the long run it would be more profitable if firms became larger or smaller.
A. Economies of Scale

A long-run average cost curve shows the lowest cost at which the firm is able to produce a given quantity of output in the long run, when no inputs are fixed. Many firms experience economies of scale, which exist when a firm’s long-run average costs fall as it increases output. Managers can use long-run average cost curves for planning because they show the effect on cost of expanding output by building a larger or smaller factory or store.

B. Long-Run Average Total Cost Curves for Bookstores

Figure 10-6 shows an example of a long-run average cost curve for the retail bookstore industry. The industry experiences economies of scale at low rates of output. Firms may experience economies of scale for several reasons. For example, the firm’s technology may make it possible to increase production with a smaller proportional increase in at least one input. Another possibility is that workers and managers can become more specialized, enabling them to become more productive. Or, firms may be able to purchase inputs at lower costs than their competitors. Finally, as a firm expands, it may be able to borrow money more cheaply. But economies of scale do not continue indefinitely. The long-run average cost curve in most industries has a flat segment. Constant returns to scale exist when a firm’s long-run average cost remains unchanged as it increases output. The level at which all economies of scale have been achieved is known as minimum efficient scale. Diseconomies of scale exist when a firm’s long-run average cost rises as it increases output. Diseconomies of scale may result when managers have difficulty coordinating