CHAPTER 8: THE COSTS OF PRODUCTION

Introduction
Now that we have examined consumer behavior in more detail, it is time to look at the decision making of the firm. Costs of production are important to determine points where efficiency and profit are maximized. Chapter 8 introduces the short-run and long-run costs of production, explains their calculation, and graphically illustrates relationships among cost curves. Material from Chapter 8 consistently appears in several multiple-choice questions on the AP microeconomics exam. Concepts from this chapter, along with information in later chapters, form the basis for free-response questions about output and pricing decisions that appear on nearly every AP microeconomics exam.

Economic Costs
Resources are scarce and have alternative uses, so costs are incurred when a resource is used for one product rather than another. Economic costs represent the opportunity cost of using a resource to make a product. Explicit (accounting) costs are money payments for resources we recognize as costs of production labor, materials, utilities, mortgage, equipment, and such. Implicit costs are opportunity costs of resources within the firm that could have gone to other uses. If you are an entrepreneur who used your own savings to start the business and you give up another job to work at your firm, your opportunity cost is the wage you gave up, as well as the interest and dividends you could have earned on the savings you instead invested in this firm. These implicit costs are not captured in accounting costs but nonetheless are still an important cost of business. Normal profit is the payment to the entrepreneur required to keep him or her working for that firm. It equals the cost of the entrepreneur's best alternative choice of career. If the entrepreneur receives no payment, he or she will leave the firm for other opportunities.

Accounting profit is the firm's total revenue minus explicit (accounting) costs. This is the kind of profit we typically hear about in the news. Economists, however, understand the importance of recognizing all of the costs of production, including normal profit and the other implicit costs necessary for production. Economic profit is the total revenue of the firm minus the economic (explicit and implicit) costs. Because accountants don't consider the implicit costs, accounting profit is generally higher than economic profit.

Taking the EEK! Out of Economics
Distinguishing accounting and economic profit will become very important in later chapters, when we consider how economic profits and losses draw firms into and out of industry. We will find that when a firm is making zero economic profit, the industry is in long-run equilibrium, and there is no incentive for firms to enter or leave the industry. At this point, students often ask why a firm would remain in business if it is making no profit. It is important to remember that a firm making zero economic profit is still covering all of its explicit costs, as well as paying the entrepreneur a normal profit and paying all other implicit costs. So a firm may show zero economic profit while still showing a substantial accounting profit in the traditional way we've understood profit.

The Short Run and the Long Run
A firm's ability to respond to a change in demand depends on how much time it has to respond. In the short run, the firm's plant capacity (factory size and large equipment) is fixed, but the firm can somewhat increase production by hiring more workers, increasing work hours, and bringing in new resources to increase production. In the long run, the firm can change the size of its
factory and equipment, and other firms can enter the industry. The difference between the short run and the long run is not a calendar time difference as much as it is a difference in the firm's ability to change the plant and equipment.

**Diminishing Returns**
In the short run, with fixed plant size and equipment, production can be measured in three ways. Total product is the total output from all of the workers together. Average product (productivity) is total product divided by the number of workers, measuring output per worker. Marginal product is the extra output produced when one more worker is hired.

To measure the effect on output as the number of workers increases, we assume that all workers are equal in terms of education, experience, and motivation. One worker is just the same as the next. Of course that isn't realistic. Remember the smiley (😊)? But it will help you understand the effect that occurs with the hiring of additional workers. These models generally focus on labor, but the concepts hold true for any variable resource.

<table>
<thead>
<tr>
<th>Number of Workers</th>
<th>Total Product</th>
<th>Marginal Product</th>
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<tbody>
<tr>
<td>0</td>
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<td>1</td>
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<td>8</td>
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Given total product, you can calculate marginal product by measuring the change in total product from hiring the next worker. The first three workers bring increasing returns, because the next worker adds even more to production than the worker before him due to specialization. Because each worker is more efficient at the one part of production that he's specializing in, and workers save time by not having to switch from task to task, all of the workers become more efficient by virtue of that next worker being there.

Workers 4–7 bring diminishing returns. Each worker adds to total product but less than the worker before him. Specialization wears off until the seventh worker adds no output. After that, each worker actually reduces production. In negative returns, each worker's marginal product is negative as workers overwhelm the fixed capital, so production falls.

**Taking the EEK! Out of Economics**
It is important to understand that marginal product doesn't change because of the quality of workers. Students commonly make the mistake of thinking the firm hires the highest quality workers first, resulting in high marginal product, but then marginal product starts to drop because the firm begins to hire less and less qualified workers. Remember, we assume all workers are equal. The marginal product falls because more workers are used with a fixed amount of capital, and increases in production will become more limited.
The Law of Diminishing Returns explains that as more units of a variable resource (like labor) are added to a fixed resource (like capital), marginal product falls. This concept recognizes the limit on production when the plant and equipment are fixed in the short run. Note on the graph that during increasing returns, total product rises quickly. During diminishing returns, total product increases but at a slower rate. In negative returns, total product falls. The relationship between marginal and average product is also important. Whenever the marginal product is higher than the average product, the marginal product pulls up the average, so average product rises. Conversely, if marginal product is lower than average product, average product falls. It is very similar to your grade point average (GPA). If your economics grade is higher than your GPA, that marginal grade will help pull up your GPA; if your econ grade is lower than your GPA, it will pull your GPA down.

Bear in Mind
The Law of Diminishing Returns may sound vaguely familiar. In some ways, it is similar to the Law of Diminishing Marginal Utility. In both cases, the more you have of something, the less you get out of each additional one. It is important to keep these terms straight, as they frequently appear together as options on multiple-choice questions. Diminishing utility measures the utility one gains from consuming one more product. Diminishing returns measures the production a firm gains from hiring one more worker. You must be able to calculate marginal product; identify the ranges of increasing, diminishing, and negative returns; and interpret those portions of the graphs for the exam.
Short-Run Production Costs

<table>
<thead>
<tr>
<th>Total Cost Data</th>
<th>Average Cost Data</th>
<th>Marginal Cost</th>
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<tbody>
<tr>
<td>(1) Total Cost</td>
<td>(2) Total Cost</td>
<td>(3) Average</td>
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<td>(4) Total Cost</td>
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<td>(7) Total Cost</td>
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<td>(10) Total Cost</td>
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<td>(12) Marginal</td>
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<td>(13) Total Cost</td>
<td>(14) Average</td>
<td>(15) Marginal</td>
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Total,- average-, and marginal-cost schedules for an individual firm in the short run

In the short run, fixed costs are those that do not change with the amount of output, such as the mortgage and equipment bought on contract with monthly payments.

\[
\text{Fixed Cost} = \text{Total Cost at Zero Output}
\]

Variable costs change with the amount of output, including labor, materials, and utilities. Variable costs increase with output. For the first units of output, the rate of increase in variable cost is small; after some point, variable cost begins to increase at an increasing rate because of diminishing returns. The specialization that occurs with the first few products reduces the amount by which variable cost increases; as specialization wears off and workers begin to overwhelm fixed capital, variable cost increases more quickly.

\[
\text{Variable Cost} = \text{Total Cost} - \text{Fixed Cost}
\]

Total cost is the sum of all production costs. At zero output, total cost is the fixed cost. As production increases, total cost increases by the variable cost at each output.

\[
\text{Total Cost} = \text{Fixed Cost} + \text{Variable Cost}
\]

Average (Per-Unit) Costs

The relationship of the marginal-cost curve to the average-total-cost and average-variable-cost curves

Average costs are calculated by simply dividing the cost by the amount of output.

\[
\text{Average Fixed Cost} = \frac{\text{Fixed Cost}}{\text{Output}}
\]
Remember, the fixed cost did not change with output. Therefore, as that fixed cost is spread over more and more output, the average fixed cost (AFC) continuously falls.

Average variable cost (AVC) is a U-shaped curve because of diminishing returns. As the first workers specialize, the firm increases production using few workers, so variable cost per product falls. But during diminishing returns, more workers and other resources are required to produce each product, so the average variable cost begins to rise again.

\[
\text{Average Variable Cost} = \frac{\text{Variable Cost}}{\text{Output}}
\]

The average total cost (ATC) is found by vertically adding the average fixed cost and average variable cost curves. It is also U-shaped and above both the AFC and AVC. The distance between the ATC and AVC is the AFC, and as more and more units of output are produced, ATC and AVC get closer and closer together as the AFC continues to fall.

\[
\text{Average Total Cost} = \frac{\text{Total Cost}}{\text{Output}}
\]

**Marginal Cost**
The marginal cost is the extra cost of producing one more unit of output.

\[
\text{Marginal Cost} = \frac{\text{Change in Total Cost}}{\text{Change in Output}}
\]

Marginal cost is the increase in total cost (or variable cost) for producing one more product. Because fixed cost doesn’t change, the amounts by which both the total and variable costs change will be identical. The marginal cost curve looks like a checkmark. Marginal cost falls with the first few workers hired because of the Law of Diminishing Returns; as marginal product per worker increases, the marginal cost of producing each additional product actually falls. But as specialization wears off and diminishing returns set in on production, the marginal cost of producing the next unit begins to rise quickly.

**Bear in Mind**
Given specific data, you must be able to calculate total, fixed, variable, marginal, and average costs in a variety of ways. You may be given total costs and then asked to calculate the marginal cost at a specific output. Or you may be given the fixed and marginal costs and then asked to calculate the total cost at a particular output. Be familiar with different ways to calculate each cost, because such questions have appeared on both the multiple-choice and free-response portions of the AP microeconomics exam.

**Relationship of Marginal Cost to Average Variable Cost and Average Total Cost**
The marginal cost curve crosses both AVC and ATC at their lowest points. Just as with marginal product and average product, whenever the marginal cost is lower than the AVC or ATC, it will pull down the average; whenever the marginal cost is higher than the AVC or ATC, it will pull up the average. Again, a similar example would be how your marginal grade in economics affects your entire grade point average. Because the fixed cost does not change with the amount of output, the AFC continues to fall as output rises.

**Bear in Mind**
It is essential that you understand the relationships between the marginal and average cost curves and be able to draw them from memory. Questions about these relationships consistently appear on the multiple-choice portion of the AP microeconomics exam, and almost every AP microeconomics exam contains at least one free-response question that requires you to draw a
Shifts in Cost Curves

Changes in the cost of production shift the cost curves directly up and down (because you are examining the cost at that same level of output). Improvements in technology reduce the cost of production. When a fixed cost such as a property tax increases, the AFC and ATC both increase, but AVC and MC do not change because those costs reflect changes in cost per individual unit produced. If, instead, a variable cost such as the wage for labor increases, the ATC increases along with the MC and AVC, but the AFC does not change.

Bear in Mind

It is vital that you be able to illustrate the shifts in the appropriate curves. Free-response questions frequently ask you to draw the graph for a market, and then present you with a particular scenario and ask you to shift the curves based on that situation. It is very important to know whether that situation shifts the marginal cost curve (if it is a variable cost) or not (if it is a fixed cost), because that decision will determine whether the firm changes the quantity of products it produces to maximize profit.

Long-Run Production Costs

The long-run average-total-cost curve

In the short run, firms are constrained by limitations in plant and equipment, and the fixed costs result from those constraints. But in the long run, all costs are variable. The firm can change its plant size or make significant changes in equipment, and other firms have time to enter or leave the industry. Therefore, the firm's long-run decisions focus on plant size. The long-run average-total-cost curve is U-shaped, made up of the minimum points of the short-run ATC curves for all of the potential quantities of output.
Economies and Diseconomies of Scale

Various possible long-run average-total-cost curves

For the first units of production, long-run ATC falls. With economies of scale, the larger the firm, the lower its ATC. Economies of scale result from factors such as labor and management specialization and the use of more efficient capital. If resource inputs are doubled, the firm’s output more than doubles; therefore, the average cost per unit falls.

At some point, long-run ATC rises. With diseconomies of scale, the larger the firm, the higher its ATC. Diseconomies of scale result from significantly larger management, communication issues, and worker alienation reducing productivity. If resource inputs are doubled, the firm’s output less than doubles; therefore, average cost per unit rises.

Between economies and diseconomies of scale is a range of production called constant returns to scale. In this range, ATC does not change with the size of the firm. When resource inputs are doubled, the firm’s output doubles. The minimum efficient scale is the lowest output at which a firm can minimize its long-run average cost. Because long-run average-total-cost curves vary so much in shape, firms in particular industries can be of very different sizes. Firms with large fixed costs and smaller variable costs, such as automakers and utility companies, tend to become large operations because of the economies of scale. Other kinds of firms with low fixed costs and higher variable costs, such as hot dog vendors, tend to remain smaller operations. Other industries with a wide range of constant returns to scale will tend to develop firms of a variety of sizes.

Multiple-Choice Questions
1. The payment to an entrepreneur to keep him engaged in an enterprise is
   (A) economic profit.
   (B) an explicit cost.
   (C) accounting profit.
   (D) an accounting cost.
normal profit.

2. In the short run, output of the firm is limited by
(A) quotas set by government.
(B) the inability to change the plant and equipment.
(C) a significant increase in demand for the product.
(D) the number of workers at the plant.
(E) the increase in fixed costs.

3. When the marginal product of the next worker is lower than the average product,
(A) average product must be falling.
(B) marginal product must be rising.
(C) the marginal cost must be falling.
(D) wages must be too high.
(E) the worker should not be hired.

4. During diminishing returns, as more workers are hired with fixed capital,
(A) production increases at a constant rate.
(B) production increases at an increasing rate.
(C) production increases at a decreasing rate.
(D) production decreases at a constant rate.
(E) production remains constant.

5. Which of the following is an example of a fixed cost?
(A) wages paid for labor
(B) the rent for the plant
(C) the electricity bill
(D) the raw materials for production
(E) the cost of shipping products

6. The distance between the average-total-cost and average-variable-cost curves is
(A) the average fixed cost.
(B) the marginal cost.
(C) the average marginal cost.
(D) the marginal product.
(E) the economic profit.

7. The cost of producing one more unit of output is
(A) the fixed cost.
(B) the variable cost.
(C) the total cost.
(D) the marginal cost.
(E) the difference between the total cost and the fixed cost.

8. An increase in the cost of electricity to produce a product would cause a firm s
(A) marginal cost to decrease.
(B) average variable cost to increase.
(C) economic profit to increase.
(D) average fixed cost to increase.
(E) average total cost to decrease.
9. If a firm makes improvements in production technology, average variable cost
   (A) shifts upward.
   (B) shifts downward.
   (C) shifts to the right.
   (D) shifts to the left.
   (E) becomes more elastic.

10. Long-run average total cost falls over the range when a firm experiences
    (A) economic profit.
    (B) normal profit.
    (C) economies of scale.
    (D) constant returns to scale.
    (E) negative returns.

11. Economies of scale are achieved when a firm doubles its inputs, and as a result
    (A) output falls to zero.
    (B) output decreases.
    (C) output increases, but less than doubles.
    (D) output exactly doubles.
    (E) output more than doubles.

Free-Response Questions

The graph above illustrates the short-run costs of a firm in a competitive industry.
(a) Explain how the marginal cost is calculated.
(b) Describe the shape of the marginal cost curve by explaining the following:
   (i) Explain why marginal cost falls over the first units of output.
   (ii) Explain why marginal cost eventually increases as output rises.
(c) Explain why the average-fixed-cost curve continues to fall as output increases.
(d) Explain the relationship between marginal cost and average total cost below.
   (i) Describe where the marginal cost crosses the average total cost curve.
   (ii) Explain why the average total cost curve is downward sloping over the range of
        output when average total cost is higher than marginal cost.

Multiple-Choice Explanations
1. (E) Normal profit is an implicit cost included in the economic cost.
2. (B) In the short run, the firm cannot make changes in the size of the plant or the
   equipment; in the long run, the firm can make those changes.
3. (A) The lower marginal product causes the average product of all workers together to fall.

4. (C) During diminishing returns, specialization wears off and workers begin to overwhelm capital; production increases but at a slowing rate of growth.

5. (B) Rent is a fixed cost that does not change with the amount of output; all of the other answers are variable costs that increase as production increases.

6. (A) The average total cost equals the average fixed cost plus the average variable cost, so the difference between ATC and AVC must be AFC.

7. (E) Marginal cost is the increase in total product for producing one more unit.

8. (B) Electricity is a variable cost of production; an increase in variable cost also increases the marginal cost and the average total cost.

9. (B) Improved technology lowers the cost of production, so the average variable cost curve shifts downward.

10. (C) Economies of scale occur when the long-run total cost of production falls as plant size increases.

11. (E) With economies of scale, labor specialization and the more efficient use of capital allow firms to increase output at a greater rate than input increases.

Free-Response Explanations

6 points (1 + 2 + 1 + 2)

(a) 1 point:
• 1 point is earned for stating that marginal cost is calculated by the increase in total cost for one more unit of output (or change in total cost / change in output).

(b) 2 points:
• 1 point is earned for stating that marginal cost falls due to increasing returns or increasing marginal product or specialization among employees.
• 1 point is earned for stating that marginal cost rises due to diminishing returns or diminishing marginal product or limitations on productivity with fixed capital.

(c) 1 point:
• 1 point is earned for stating that average fixed cost falls because the fixed cost is divided over larger and larger amounts of output.

(d) 2 points:
• 1 point is earned for stating that the marginal cost curve crosses average total cost at the lowest point on the average total cost curve.
• 1 point is earned for stating that when the marginal cost of producing the next unit of output is lower than the average total cost of producing that output, the marginal cost lowers the average total cost.