8 Profit Maximization and Competitive Supply

CHAPTER OUTLINE

LIST OF EXAMPLES

A cost curve describes the minimum cost at which a firm can produce various amounts of output. Once we know its cost curve, we can turn to a fundamental problem faced by every firm: *How much should be produced?* In this chapter, we will see how a firm chooses the level of output that maximizes its profit. We will also see how the output choices of individual firms lead to a supply curve for an entire industry.

Because our discussion of production and cost in Chapters 6 and 7 applies to firms in all kinds of markets, we will begin by explaining the profit-maximizing output decision in a general setting. However, we will then turn to the focus of this chapter—*perfectly competitive markets,* in which all firms produce an identical product and each is so small in relation to the industry that its production decisions have no effect on market price. New firms can easily enter the industry if they perceive a potential for profit, and existing firms can exit if they start losing money.

We begin by explaining exactly what is meant by a *competitive market*. We then explain why it makes sense to assume that firms (in any market) have the objective of maximizing profit. We provide a rule for choosing the profit-maximizing output for firms in all markets, competitive or otherwise. Following this we show how a competitive firm chooses its output in the short and long run.

We next examine how the firm's output choice changes as the cost of production or the prices of inputs change. In this way, we show how to derive the *firm's supply curve*. We then aggregate the supply curves of individual firms to obtain the *industry supply curve*. In the short run, firms in an industry choose which level of output to produce in order to maximize profit. In the long run, they not only make output choices, but also decide whether to be in a market at all. We will see that while the prospect of high profits encourages firms to enter an industry, losses encourage them to leave.

8.1 PERFECTLY COMPETITIVE MARKETS

In Chapter 2, we used supply–demand analysis to explain how changing market conditions affect the market price of such products as wheat and gasoline. We saw that the equilibrium price and quantity of each product was determined by the intersection of the market demand and market supply curves. Underlying this analysis is the model of a *perfectly competitive market*. The model of perfect competition is very useful for studying a variety of markets, including agriculture, fuels and other commodities, housing, services, and financial markets. Because this model is so important, we will spend some time laying out the basic assumptions that underlie it.

The model of perfect competition rests on three basic assumptions: (1) price taking, (2) product homogeneity, and (3) free entry and exit. You have encountered these assumptions earlier in the book; here we summarize and elaborate on them.

Price Taking Because many firms compete in the market, each firm faces a significant number of direct competitors for its products. Because *each individual firm sells a sufficiently small proportion of total market output, its decisions have no impact on market price*. Thus, each firm *takes the market price as given*. In short, firms in perfectly competitive markets are **price takers**.

• **price taker** Firm that has no influence over market price and thus takes the price as given.

Suppose, for example, that you are the owner of a small electric lightbulb distribution business. You buy your lightbulbs from the manufacturer and resell them at wholesale to small businesses and retail outlets. Unfortunately, you are only one of many competing distributors. As a result, you find that there is little room to negotiate with your customers. If you do not offer a competitive price—one that is determined in the marketplace—your customers will take their business elsewhere. In addition, you know that the number of lightbulbs that you sell will have little or no effect on the wholesale price of bulbs. You are a price taker.

The assumption of price taking applies to *consumers* as well as firms. In a perfectly competitive market, each consumer buys such a small proportion of total industry output that he or she has no impact on the market price, and therefore takes the price as given.

Another way of stating the price-taking assumption is that there are many independent firms and independent consumers in the market, all of whom believe—correctly—that their decisions will not affect prices.

Product Homogeneity Price-taking behavior typically occurs in markets where firms produce identical, or nearly identical, products. When *the products of all of the firms in a market are perfectly substitutable with one another*—that is, when they are *homogeneous*—no firm can raise the price of its product above the price of other firms without losing most or all of its business. Most agricultural products are homogeneous: Because product quality is relatively similar among farms in a given region, for example, buyers of corn do not ask which individual farm grew the product. Oil, gasoline, and raw materials such as copper, iron, lumber, cotton, and sheet steel are also fairly homogeneous. Economists refer to such homogeneous products as *commodities*.

In contrast, when products are heterogeneous, each firm has the opportunity to raise its price above that of its competitors without losing all of its sales. Premium ice creams such as Häagen-Dazs, for example, can be sold at higher prices because Häagen-Dazs has different ingredients and is perceived by many consumers to be a higher-quality product.

The assumption of product homogeneity is important because it ensures that there is a *single market price*, consistent with supply-demand analysis.

• **free entry (or exit)** Condition under which there are no special costs that make it difficult for a firm to enter (or exit) an industry.

Free Entry and Exit This third assumption, **free entry (or exit)**, means that there are no special costs that make it difficult for a new firm either to enter an industry and produce, or to exit if it cannot make a profit. *As a result,* *buyers can easily switch from one supplier to another, and suppliers can easily enter or exit a market.*

The special costs that could restrict entry are costs which an entrant to a market would have to bear, but which a firm that is already producing would not. The pharmaceutical industry, for example, is not perfectly competitive because Merck, Pfizer, and other firms hold patents that give them unique rights to produce drugs. Any new entrant would either have to invest in research and development to obtain its own competing drugs or pay substantial license fees to one or more firms already in the market. R&D expenditures or license fees could limit a firm's ability to enter the market. Likewise, the aircraft industry is not perfectly competitive because entry requires an immense investment in plant and equipment that has little or no resale value.

The assumption of free entry and exit is important for competition to be effective. It means that consumers can easily switch to a rival firm if a current supplier raises its price. For businesses, it means that a firm can freely enter an industry if it sees a profit opportunity and exit if it is losing money. Thus a firm can hire labor and purchase capital and raw materials as needed, and it can release or move these factors of production if it wants to shut down or relocate.

If these three assumptions of perfect competition hold, market demand and supply curves can be used to analyze the behavior of market prices. In most markets, of course, these assumptions are unlikely to hold exactly. This does not mean, however, that the model of perfect competition is not useful. Some markets do indeed come close to satisfying our assumptions. But even when one or more of these three assumptions fails to hold, so that a market is not perfectly competitive, much can be learned by making comparisons with the perfectly competitive ideal.

When Is a Market Highly Competitive?

Apart from agriculture, few real-world markets are *perfectly* competitive in the sense that each firm faces a perfectly horizontal demand curve for a homogeneous product in an industry that it can freely enter or exit. Nevertheless, many markets are *highly* competitive in the sense that firms face highly elastic demand curves and relatively easy entry and exit.

In §2.4, we explain that demand is price elastic when the percentage decline in quantity demanded is greater than the percentage increase in price.

A simple rule of thumb to describe whether a market is close to being perfectly competitive would be appealing. Unfortunately, we have no such rule, and it is important to understand why. Consider the most obvious candidate: an industry with many firms (say, at least 10 to 20). Because firms can implicitly or explicitly collude in setting prices, the presence of many firms is not sufficient for an industry to approximate perfect competition. Conversely, the presence of only a few firms in a market does not rule out competitive behavior. Suppose that only three firms are in the market but that market demand for the product is very elastic. In this case, the demand curve facing each firm is likely to be nearly horizontal and the firms will behave *as if* they were operating in a perfectly competitive market. Even if market demand is not very elastic, these three firms might compete very aggressively (as we will see in Chapter 13). The important point to remember is that although firms may behave competitively in many situations, there is no simple indicator to tell us when a market is highly competitive. Often it is necessary to analyze both the firms themselves and their strategic interactions, as we do in Chapters 12 and 13.

8.2 PROFIT MAXIMIZATION

We now turn to the analysis of profit maximization. In this section, we ask whether firms do indeed seek to maximize profit. Then in Section 8.3, we will describe a rule that any firm—whether in a competitive market or not—can use to find its profit-maximizing output level. Finally, we will consider the special case of a firm in a competitive market. We distinguish the demand curve facing a competitive firm from the market demand curve, and use this information to describe the competitive firm's profit-maximization rule.

Do Firms Maximize Profit?

The assumption of *profit maximization* is frequently used in microeconomics because it predicts business behavior reasonably accurately and avoids unnecessary analytical complications. But the question of whether firms actually do seek to maximize profit has been controversial.

For smaller firms managed by their owners, profit is likely to dominate almost all decisions. In larger firms, however, managers who make day-to-day decisions usually have little contact with the owners (i.e., the stockholders). As a result, owners cannot monitor the managers' behavior on a regular basis. Managers then have some leeway in how they run the firm and can deviate from profit-maximizing behavior.

Managers may be more concerned with such goals as revenue maximization, revenue growth, or the payment of dividends to satisfy shareholders. They might also be overly concerned with the firm's short-run profit (perhaps to earn a promotion or a large bonus) at the expense of its longer-run profit, even though long-run profit maximization better serves the interests of the stockholders.[1] Because technical and marketing information is costly to obtain, managers may sometimes operate using rules of thumb that require less-than-ideal information. On some occasions they may engage in acquisition and/or growth strategies that are substantially more risky than the owners of the firm might wish.

The recent rise in the number of corporate bankruptcies, especially those in the dot-com, telecom, and energy areas, along with the rapid increase in CEO salaries, has raised questions about the motivations of managers of large corporations. These are important questions, which we will address in Chapter 17, when we discuss the incentives of managers and owners in detail. For now, it is important to realize that a manager's freedom to pursue goals other than long-run profit maximization is limited. If they do pursue such goals, shareholders or boards of directors can replace them, or the firm can be taken over by new management. In any case, firms that do not come close to maximizing profit are not likely to survive. Firms that do survive in competitive industries make long-run profit maximization one of their highest priorities.

Thus our working assumption of profit maximization is reasonable. Firms that have been in business for a long time are likely to care a lot about profit, whatever else their managers may appear to be doing. For example, a firm that subsidizes public television may seem public-spirited and altruistic. Yet this beneficence is likely to be in the long-run financial interest of the firm because it generates goodwill.

[1]To be more exact, *maximizing the market value of the firm* is a more appropriate goal than profit maximization because market value includes the stream of profits that the firm earns over time. It is the stream of current and future profits that is of direct interest to the stockholders.

Alternative Forms of Organization

Now that we've underscored the fact that profit maximization is a fundamental assumption in most economic analyses of firm behavior, let's pause to consider an important qualifier to this assumption: Some forms of organizations have objectives that are quite different from profit maximization. An important such organization is the **cooperative**—an association of businesses or people jointly owned and operated by members for mutual benefit. For example, several farms might decide to enter into a cooperative agreement by which they pool their resources in order to distribute and market milk to consumers. Because each participating member of the milk cooperative is an autonomous economic unit, each farm will act to maximize its own profits (rather than the profits of the cooperative as a whole), taking the common marketing and distribution agreement as given. Such cooperative agreements are common in agricultural markets.

• **cooperative** Association of businesses or people jointly owned and operated by members for mutual benefit.

In many towns or cities, one can join a food cooperative, the objective of which is to provide its members with food and other groceries at the lowest possible cost. Usually, a food cooperative looks like a store or small supermarket. Shopping is either restricted to members or else unrestricted with members receiving discounts. Prices are set so that the cooperative avoids losing money, but any profits are incidental and are returned to the members (usually in proportion to their purchases).

Housing cooperatives, or *co-ops*, are another example of this form of organization. A co-op might be an apartment building for which the title to the land and the building is owned by a corporation. The member residents of the co-op own shares in the corporation, accompanied by a right to occupy a unit—an arrangement much like a long-term lease. The members of the co-op can participate in the management of their building in a variety of ways: organizing social events, handling finances, or even deciding who their neighbors will be. As with other types of cooperatives, the objective is not to maximize profits, but rather to provide members with high-quality housing at the lowest possible cost.

A related type of housing organization is the *condominium*. A condominium is not a cooperative because housing units (or "condos") are individually owned. This has the important advantage of simplifying governance, as discussed in Example 8.1.

EXAMPLE 8.1 Condominiums versus Cooperatives in New York City

While owners of condominiums must join with fellow condo owners to manage common spaces (e.g., entry areas), they can make their own decisions as to how to manage their individual units so as to achieve the greatest value possible. In contrast, co-ops share joint liability on any outstanding mortgage on the co-op building and are subject to more complex governance rules. Although much of the governance is usually delegated to a board that represents all co-op members, members must often spend substantial time in the governance of the association. In addition, condo members can sell their units whenever and to whomever they choose, whereas co-op members must get permission from the co-op board before a sale can be made.

Nationwide, condos are a far more common than co-ops, outnumbering them by a factor of nearly 10 to 1. In this regard, New York City is very different from the rest of the nation—co-ops are more popular, and outnumber condos by a factor of about 4 to 1. What accounts for the relative popularity of housing cooperatives in New York City? Part of the answer is historical. Housing cooperatives are a much older form of organization in the U.S., dating back to the mid-nineteenth century, whereas the development of condominiums began only in the 1960s, at which point a large number of buildings in New York were already co-ops. In addition, while condominiums were becoming increasingly popular in other parts of the country, building regulations in New York made the co-op the required governance structure.

But that's history. The building restrictions in New York have long disappeared, and yet the conversion of apartments from co-ops to condos has been relatively slow. Why? A recent study provides some interesting answers.[2] The authors find that the typical condominium apartment is worth about 15.5 percent more than an equivalent apartment held in the form of a co-op. Clearly, holding an apartment in the form of a co-op is not the best way to maximize the apartment's value. On the other hand, co-op owners can be more selective in choosing their neighbors when sales are made—something that New Yorkers seem to care a great deal about. It appears that in New York, many owners have been willing to forgo substantial amounts of money in order to achieve non-monetary benefits.

8.3 MARGINAL REVENUE, MARGINAL COST, AND PROFIT MAXIMIZATION

We now return to our working assumption of profit maximization and examine the implications of this objective for the operation of a firm. We will begin by looking at the profit-maximizing output decision for *any* firm, whether it operates in a perfectly competitive market or is one that can influence price. Because **profit** is the difference between (total) revenue and (total) cost, finding the firm's profit-maximizing output level means analyzing its revenue. Suppose that the firm's output is q, and that it obtains revenue R. This revenue is equal to the price of the product P times the number of units sold: $R = Pq$. The cost of production C also depends on the level of output. The firm's profit, π, is the difference between revenue and cost:

• **profit** Difference between total revenue and total cost.

$$\pi(q) = R(q) - C(q)$$

(Here we show explicitly that π, R, and C depend on output. Usually we will omit this reminder.)

To maximize profit, the firm selects the output for which the difference between revenue and cost is the greatest. This principle is illustrated in Figure 8.1. Revenue $R(q)$ is a curved line, which reflects the fact that the firm can sell a greater level of output only by lowering its price. The slope of this revenue curve is **marginal revenue**: the change in revenue resulting from a one-unit increase in output.

• **marginal revenue** Change in revenue resulting from a one-unit increase in output.

Also shown is the total cost curve $C(q)$. The slope of this curve, which measures the additional cost of producing one additional unit of output, is the firm's *marginal cost*. Note that total cost $C(q)$ is positive when output is zero because there is a fixed cost in the short run.

[2]Michael H. Schill, Ioan Voicu, and Jonathan Miller, "The Condominium v. Cooperative Puzzle: An Empirical Analysis of Housing in New York City," NYU, Law & Economics Research Paper No. 04-003, Feb. 10, 2004.

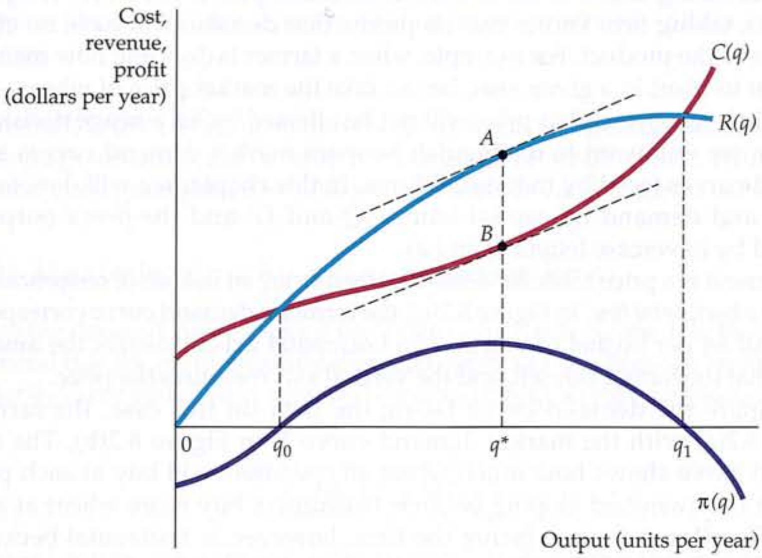

FIGURE 8.1 Profit Maximization in the Short Run

A firm chooses output q^*, so that profit, the difference AB between revenue R and cost C, is maximized. At that output, marginal revenue (the slope of the revenue curve) is equal to marginal cost (the slope of the cost curve).

For the firm illustrated in Figure 8.1, profit is negative at low levels of output because revenue is insufficient to cover fixed and variable costs. As output increases, revenue rises more rapidly than cost, so that profit eventually becomes positive. Profit continues to increase until output reaches the level q^*. At this point, marginal revenue and marginal cost are equal, and the vertical distance between revenue and cost, AB, is greatest. q^* is the profit-maximizing output level. Note that at output levels above q^*, cost rises more rapidly than revenue—i.e., marginal revenue is less than marginal cost. Thus, profit declines from its maximum when output increases above q^*.

The rule that profit is maximized when marginal revenue is equal to marginal cost holds for all firms, whether competitive or not. This important rule can also be derived algebraically. Profit, $\pi = R - C$, is maximized at the point at which an additional increment to output leaves profit unchanged (i.e., $\Delta\pi/\Delta q = 0$):

$$\Delta\pi/\Delta q = \Delta R/\Delta q - \Delta C/\Delta q = 0$$

$\Delta R/\Delta q$ is marginal revenue MR and $\Delta C/\Delta q$ is marginal cost MC. Thus we conclude that profit is maximized when MR − MC = 0, so that

$$\boxed{\mathrm{MR}(q) = \mathrm{MC}(q)}$$

Demand and Marginal Revenue for a Competitive Firm

Because each firm in a competitive industry sells only a small fraction of the entire industry output, *how much output the firm decides to sell will have no effect on the market price of the product*. The market price is determined by the industry demand and supply curves. Therefore, the competitive firm is a *price taker*. Recall that price taking is one of the fundamental assumptions of perfect competition. The price-taking firm knows that its production decision will have no effect on the price of the product. For example, when a farmer is deciding how many acres of wheat to plant in a given year, he can take the market price of wheat—say, $4 per bushel—as given. That price will not be affected by his acreage decision.

Often we will want to distinguish between market demand curves and the demand curves faced by individual firms. In this chapter we will denote *market* output and demand by capital letters (Q and D) and the *firm's* output and demand by lowercase letters (q and d).

In §4.1, we explain how the demand curve relates the quantity of a good that a consumer will buy to the price of that good.

Because it is a price taker, *the demand curve d facing an individual competitive firm is given by a horizontal line.* In Figure 8.2(a), the farmer's demand curve corresponds to a price of $4 per bushel of wheat. The horizontal axis measures the amount of wheat that the farmer can sell, and the vertical axis measures the price.

Compare the demand curve facing the firm (in this case, the farmer) in Figure 8.2(a) with the market demand curve D in Figure 8.2(b). The market demand curve shows how much wheat *all consumers* will buy at each possible price. It is downward sloping because consumers buy more wheat at a lower price. The demand curve facing the firm, however, is horizontal because the firm's sales will have no effect on price. Suppose the firm increased its sales from 100 to 200 bushels of wheat. This would have almost no effect on the market because industry output is 100 million bushels. Price is determined by the interaction of all firms and consumers in the market, not by the output decision of a single firm.

By the same token, when an individual firm faces a horizontal demand curve, it can sell an additional unit of output without lowering price. As a result, when it sells an additional unit, the firm's *total revenue* increases by an amount equal to the price: one bushel of wheat sold for $4 yields additional revenue of $4. Thus,

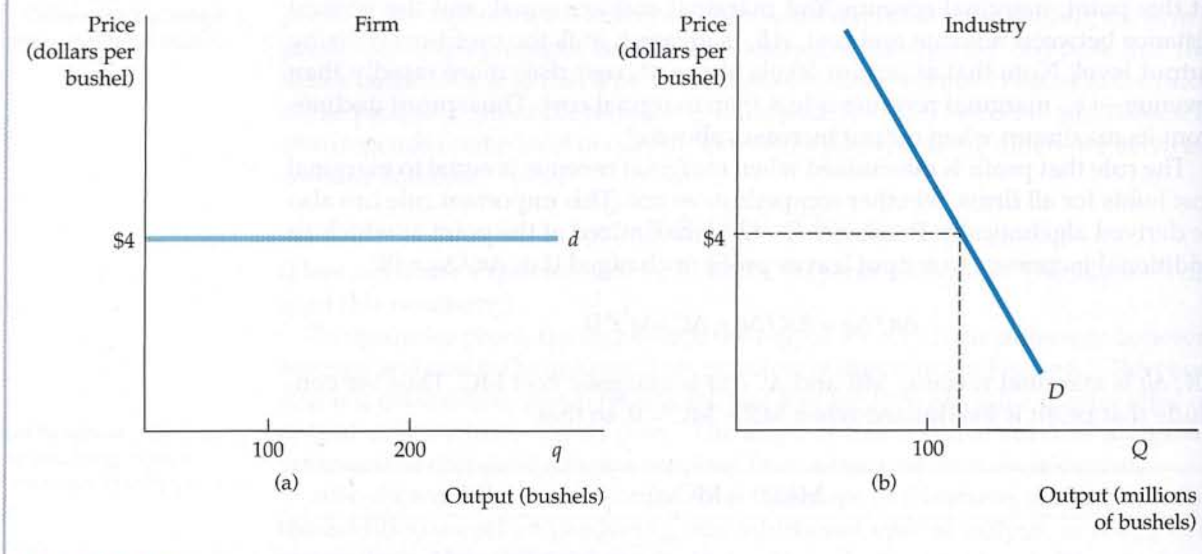

FIGURE 8.2 Demand Curve Faced by a Competitive Firm

A competitive firm supplies only a small portion of the total output of all the firms in an industry. Therefore, the firm takes the market price of the product as given, choosing its output on the assumption that the price will be unaffected by the output choice. In **(a)** the demand curve facing the firm is perfectly elastic, even though the market demand curve in **(b)** is downward sloping.

marginal revenue is constant at \$4. At the same time, *average revenue* received by the firm is also \$4 because every bushel of wheat produced will be sold at \$4. Therefore:

> The demand curve d facing an individual firm in a competitive market is both its average revenue curve and its marginal revenue curve. Along this demand curve, marginal revenue, average revenue, and price are all equal.

Profit Maximization by a Competitive Firm

Because the demand curve facing a competitive firm is horizontal, so that $\text{MR} = P$, the general rule for profit maximization that applies to any firm can be simplified. A perfectly competitive firm should choose its output so that *marginal cost equals price*:

$$\text{MC}(q) = \text{MR} = P$$

Note that because competitive firms take price as fixed, this is a rule for setting output, not price.

The choice of the profit-maximizing output by a competitive firm is so important that we will devote most of the rest of this chapter to analyzing it. We begin with the short-run output decision and then move to the long run.

8.4 CHOOSING OUTPUT IN THE SHORT RUN

How much output should a firm produce over the short run, when its plant size is fixed? In this section we show how a firm can use information about revenue and cost to make a profit-maximizing output decision.

Short-Run Profit Maximization by a Competitive Firm

In the short run, a firm operates with a fixed amount of capital and must choose the levels of its variable inputs (labor and materials) to maximize profit. Figure 8.3 shows the firm's short-run decision. The average and marginal revenue curves are drawn as a horizontal line at a price equal to \$40. In this figure, we have drawn the average total cost curve ATC, the average variable cost curve AVC, and the marginal cost curve MC so that we can see the firm's profit more easily.

> Marginal, average, and total cost are discussed in §7.1.

Profit is maximized at point A, where output is $q^* = 8$ and the price is \$40, because marginal revenue is equal to marginal cost at this point. To see that $q^* = 8$ is indeed the profit-maximizing output, note that at a lower output, say $q_1 = 7$, marginal revenue is greater than marginal cost; profit could thus be increased by increasing output. The shaded area between $q_1 = 7$ and q^* shows the lost profit associated with producing at q_1. At a higher output, say q_2, marginal cost is greater than marginal revenue; thus, reducing output saves a cost that exceeds the reduction in revenue. The shaded area between q^* and $q_2 = 9$ shows the lost profit associated with producing at q_2. When output is $q^* = 8$, profit is given by the area of rectangle ABCD.

The MR and MC curves cross at an output of q_0 as well as q^*. At q_0, however, profit is clearly not maximized. An increase in output beyond q_0 increases profit because marginal cost is well below marginal revenue. We can thus state the condition for profit maximization as follows: *Marginal revenue equals marginal*

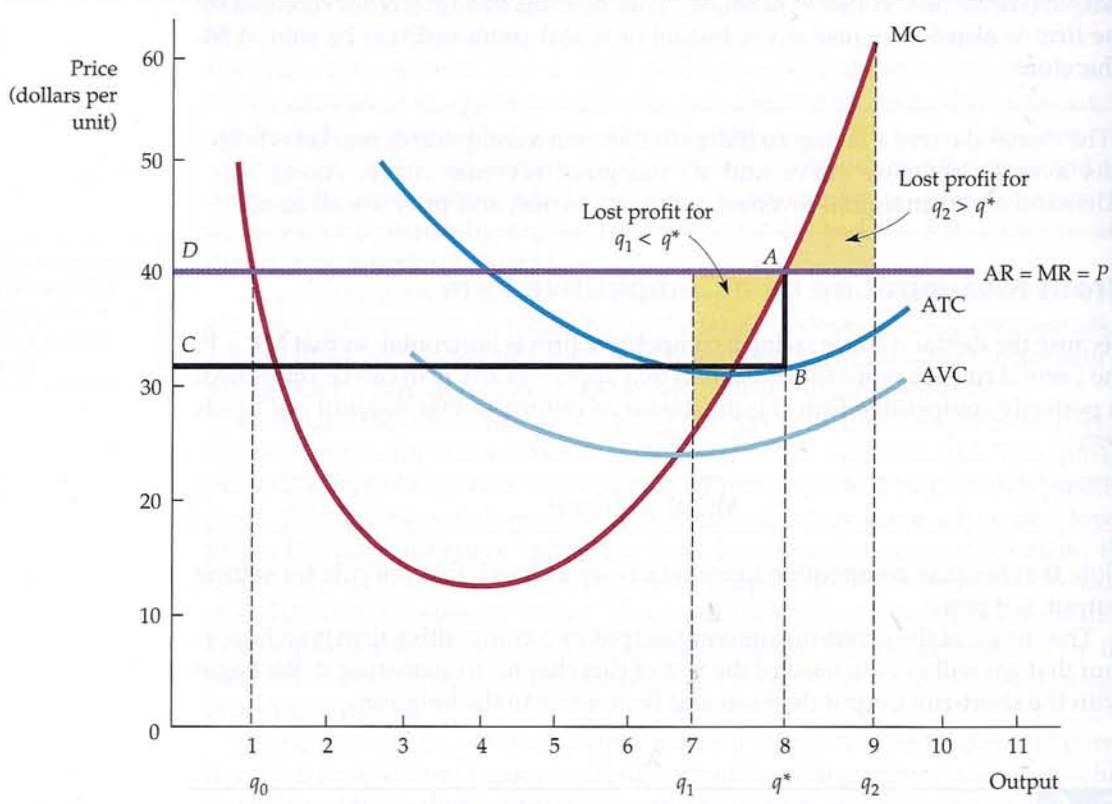

FIGURE 8.3 A Competitive Firm Making a Positive Profit

In the short run, the competitive firm maximizes its profit by choosing an output q^* at which its marginal cost MC is equal to the price P (or marginal revenue MR) of its product. The profit of the firm is measured by the rectangle *ABCD*. Any change in output, whether lower at q_1 or higher at q_2, will lead to lower profit.

cost at a point at which the marginal cost curve is rising. This conclusion is very important because it applies to the output decisions of firms in markets that may or may not be perfectly competitive. We can restate it as follows:

Output Rule: If a firm is producing any output, it should produce at the level at which marginal revenue equals marginal cost.

The Short-Run Profit of a Competitive Firm

Figure 8.3 also shows the competitive firm's short-run profit. The distance *AB* is the difference between price and average cost at the output level q^*, which is the average profit per unit of output. Segment *BC* measures the total number of units produced. Rectangle *ABCD*, therefore, is the firm's profit.

A firm need not always earn a profit in the short run, as Figure 8.4 shows. The major difference from Figure 8.3 is a higher fixed cost of production. This higher fixed cost raises average total cost but does not change the average variable cost and marginal cost curves. At the profit-maximizing output q^*, the price P is less than average cost. Line segment *AB*, therefore, measures the

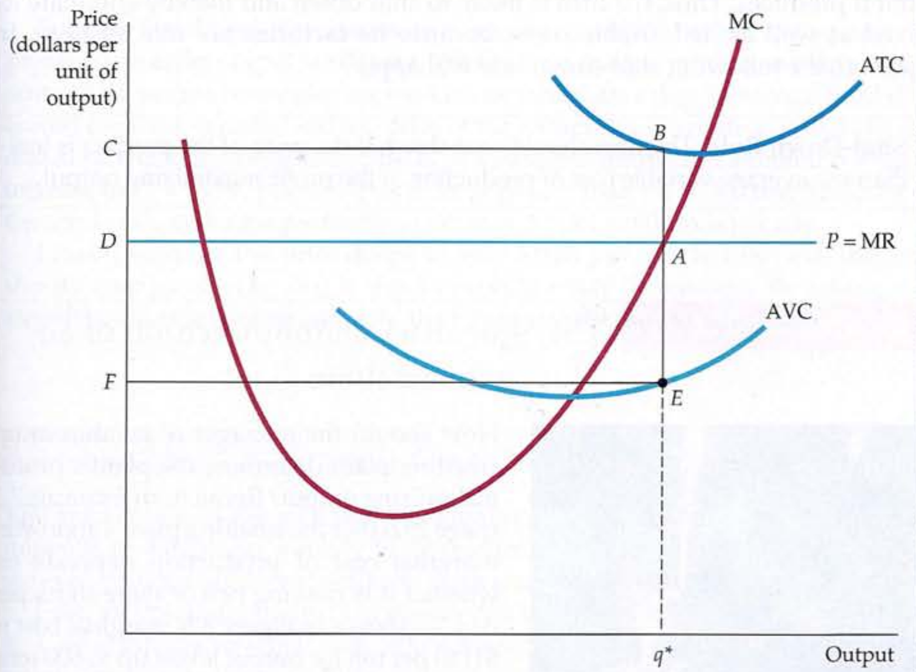

FIGURE 8.4 A Competitive Firm Incurring Losses

A competitive firm should shut down if price is below AVC. The firm may produce in the short run if price is greater than average variable cost.

average *loss* from production. Likewise, the rectangle *ABCD* now measures the firm's total loss.

Why doesn't a firm that is losing money leave an industry entirely? A firm might operate at a loss *in the short run* because it expects to earn a profit in the future, when the price of its product increases or the cost of production falls, and because stopping production and later starting up again would be costly. In fact, a firm has two choices in the short run: It can produce some output, or it can stop producing temporarily. It will compare the profitability of producing with the profitability of not producing and choose the preferred outcome.

If the price of the product is greater than average total cost, this decision is easy because the firm will earn profits if it continues to produce but nothing if it stops producing. But suppose the price is *less* than average total cost but greater than average variable cost, as shown in Figure 8.4. If it continues to produce, the firm minimizes its losses at output q^*. Note that in Figure 8.4, because of the presence of fixed costs, average variable cost is less than average total cost and the firm is indeed losing money. Should the firm shut down and thereby eliminate its fixed costs? If it does shut down—closes its factories, fires its managers, and turns off the lights—it will avoid losses. But should the price increase in the future, re-opening the factories and hiring and training new managers could be quite costly, and the firm would regret its decision to shut down. Furthermore, if it stays in business over the long run, the firm would retain the flexibility to change the amount of capital that it uses and thereby reduce its average total cost. Thus, the firm is unlikely to shut down if it can at least cover its average variable cost.

Remember from §7.1 that a fixed cost is an ongoing cost that does not change with the level of output but is eliminated if the firm shuts down.

What if the price of the product is below average variable cost? In this case, the firm should certainly stop producing, because it is losing money on every unit it produces. Thus, the firm is likely to shut down and thereby eliminate its fixed as well as its variable costs, because its factories are idle anyway. In general, the following shut-down rule will apply:

Shut-Down Rule: The firm should shut down if the price of the product is less than the average variable cost of production at the profit-maximizing output.

EXAMPLE 8.2 The Short-Run Output Decision of an Aluminum Smelting Plant

How should the manager of an aluminum smelting plant determine the plant's profit-maximizing output? Recall from Example 7.3 (page 232) that the smelting plant's short-run marginal cost of production depends on whether it is running two or three shifts per day. As shown in Figure 8.5, marginal cost is \$1140 per ton for output levels up to 600 tons per day and \$1300 per ton for output levels between 600 and 900 tons per day.

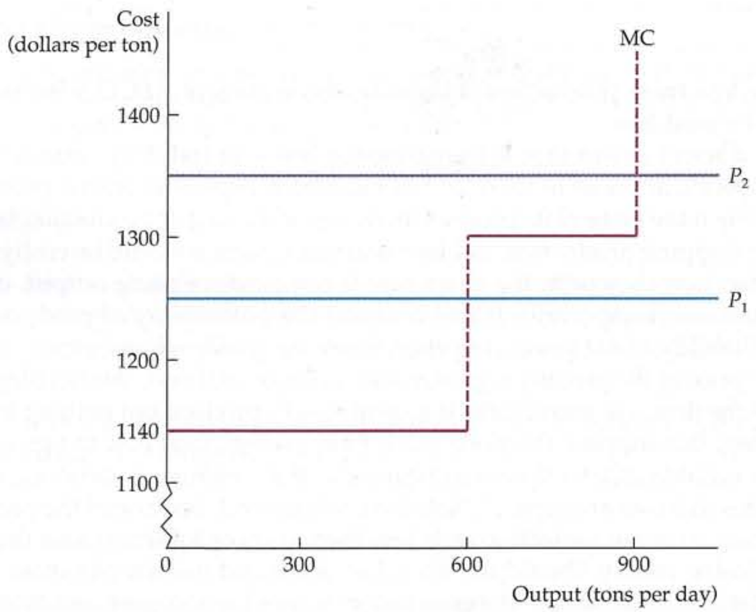

FIGURE 8.5 The Short-Run Output of an Aluminum Smelting Plant

In the short run, the plant should produce 600 tons per day if price is above \$1140 per ton but less than \$1300 per ton. If price is greater than \$1300 per ton, it should run an overtime shift and produce 900 tons per day. If price drops below \$1140 per ton, the firm should stop producing, but it should probably stay in business because the price may rise in the future.

Suppose that the price of aluminum is initially $P_1 = \$1250$ per ton. In that case, the profit-maximizing output is 600 tons; the firm can make a profit above its variable cost of \$110 per ton by employing workers for two shifts a day. Running a third shift would involve overtime, and the price of the aluminum is insufficient to make the added production profitable. Suppose, however, that the price of aluminum were to increase to $P_2 = \$1360$ per ton. This price is greater than the \$1300 marginal cost of the third shift, making it profitable to increase output to 900 tons per day.

Finally, suppose the price drops to only \$1100 per ton. In this case, the firm should stop producing, but it should probably stay in business. By taking this step, it could resume producing in the future should the price increase.

EXAMPLE 8.3 Some Cost Considerations for Managers

The application of the rule that marginal revenue should equal marginal cost depends on a manager's ability to estimate marginal cost.[3] To obtain useful measures of cost, managers should keep three guidelines in mind.

First, except under limited circumstances, *average variable cost should not be used as a substitute for marginal cost*. When marginal and average variable cost are nearly constant, there is little difference between them. However, if both marginal and average cost are increasing sharply, the use of average variable cost can be misleading in deciding how much to produce. Suppose for example, that a company has the following cost information:

Current output	100 units per day, 80 of which are produced during the regular shift and 20 of which are produced during overtime
Materials cost	\$8 per unit for all output
Labor cost	\$30 per unit for the regular shift; \$50 per unit for the overtime shift

Let's calculate average variable cost and marginal cost for the first 80 units of output and then see how both cost measures change when we include the additional 20 units produced with overtime labor. For the first 80 units, average variable cost is simply the labor cost (\$2400 = \$30 per unit × 80 units) plus the materials cost (\$640 = \$8 per unit × 80 units) divided by the 80 units—(\$2400 + \$640)/80 = \$38 per unit. Because average variable cost is the same for each unit of output, marginal cost is also equal to \$38 per unit.

When output increases to 100 units per day, both average variable cost and marginal cost change. The variable cost has now increased; it includes the additional materials cost of \$160 (20 units × \$8 per unit) and the additional labor cost of \$1000 (20 units × \$50 per unit). Average variable cost is therefore the total labor cost plus the materials cost (\$2400 + \$1000 + \$640 + \$160) divided by the 100 units of output, or \$42 per unit.

What about marginal cost? While the materials cost per unit has remained unchanged at \$8 per unit, the marginal cost of labor has now increased to \$50 per unit, so that the marginal cost of each unit of overtime output is \$58 per day.

[3] This example draws on the discussion of costs and managerial decision-making in Thomas Nagle and Reed Holden, *The Strategy and Tactics of Pricing*, 3rd ed. (Upper Saddle River, NJ: Prentice Hall, 2002), ch. 2.

Because marginal cost is higher than average variable cost, a manager who relies on average variable cost will produce too much.

Second, *a single item on a firm's accounting ledger may have two components, only one of which involves marginal cost.* Suppose that a manager is trying to cut back production. She reduces the number of hours that some employees work and lays off others. But the salary of an employee who is laid off may not be an accurate measure of the marginal cost of production when cuts are made. Union contracts, for example, often require the firm to pay laid-off employees part of their salaries. In this case, the marginal cost of increasing production is not the same as the savings in marginal cost when production is decreased. The savings is the labor cost after the required layoff salary has been subtracted.

Third, *all opportunity costs should be included in determining marginal cost.* Suppose a department store wants to sell children's furniture. Instead of building a new selling area, the manager decides to use part of the third floor, which had been used for appliances, for the furniture. The marginal cost of this space is the \$90 per square foot per day in profit that would have been earned had the store continued to sell appliances there. This opportunity cost measure may be much greater than what the store actually paid for that part of the building.

These three guidelines can help a manager to measure marginal cost correctly. Failure to do so can cause production to be too high or too low and thereby reduce profit.

8.5 THE COMPETITIVE FIRM'S SHORT-RUN SUPPLY CURVE

A *supply curve* for a firm tells us how much output it will produce at every possible price. We have seen that competitive firms will increase output to the point at which price is equal to marginal cost, but will shut down if price is below average variable cost. Therefore, the firm's supply curve is *the portion of the marginal cost curve for which marginal cost is greater than average variable cost.*

Figure 8.6 illustrates the short-run supply curve. Note that for any P greater than minimum AVC, the profit-maximizing output can be read directly from the graph. At a price P_1, for example, the quantity supplied will be q_1; and at P_2, it will be q_2. For P less than (or equal to) minimum AVC, the profit-maximizing output is equal to zero. In Figure 8.6 the entire short-run supply curve consists of the crosshatched portion of the vertical axis plus the marginal cost curve above the point of minimum average variable cost.

Short-run supply curves for competitive firms slope upward for the same reason that marginal cost increases—the presence of diminishing marginal returns to one or more factors of production. As a result, an increase in the market price will induce those firms already in the market to increase the quantities they produce. The higher price not only makes the additional production profitable, but also increases the firm's *total* profit because it applies to all units that the firm produces.

In §6.2, we explain that diminishing marginal returns occurs when each additional increase in an input results in a smaller and smaller increase in output.

The Firm's Response to an Input Price Change

When the price of its product changes, the firm changes its output level to ensure that marginal cost of production remains equal to price. Often, however, the product price changes at the same time that the prices of *inputs* change.

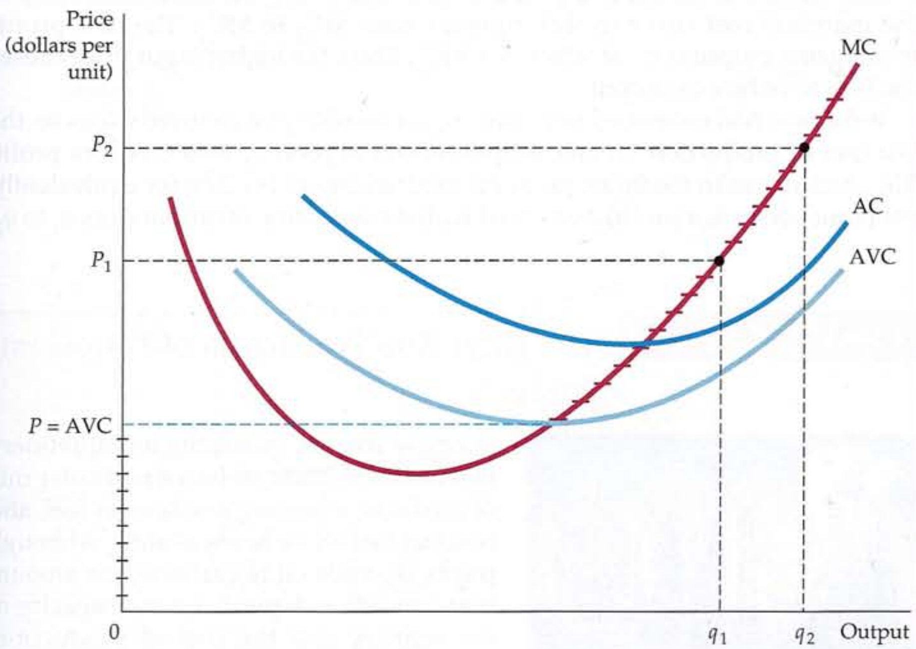

FIGURE 8.6 The Short-Run Supply Curve for a Competitive Firm

In the short run, the firm chooses its output so that marginal cost MC is equal to price as long as the firm covers its average variable cost. The short-run supply curve is given by the crosshatched portion of the marginal cost curve.

In this section we show how the firm's output decision changes in response to a change in the price of one of its inputs.

Figure 8.7 shows a firm's marginal cost curve that is initially given by MC_1 when the firm faces a price of \$5 for its product. The firm maximizes profit by producing an output of q_1. Now suppose the price of one input increases.

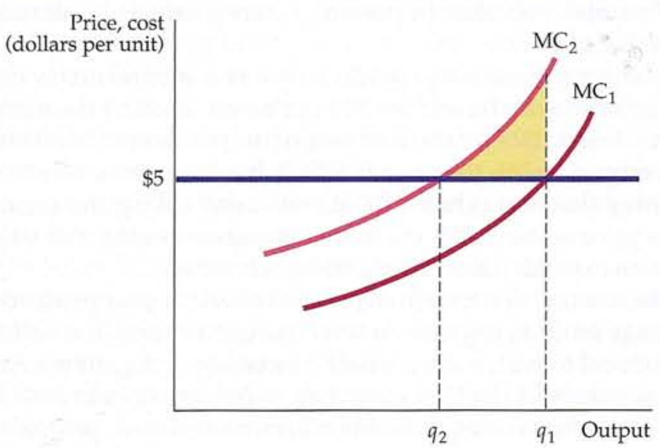

FIGURE 8.7 The Response of a Firm to a Change in Input Price

When the marginal cost of production for a firm increases (from MC_1 to MC_2), the level of output that maximizes profit falls (from q_1 to q_2).

Because it now costs more to produce each unit of output, this increase causes the marginal cost curve to shift upward from MC_1 to MC_2. The new profit-maximizing output is q_2, at which $P = MC_2$. Thus, the higher input price causes the firm to reduce its output.

If the firm had continued to produce q_1, it would have incurred a loss on the last unit of production. In fact, all production beyond q_2 would reduce profit. The shaded area in the figure gives the total savings to the firm (or equivalently, the reduction in lost profit) associated with the reduction in output from q_1 to q_2.

EXAMPLE 8.4 The Short-Run Production of Petroleum Products

Suppose you are managing an oil refinery that converts crude oil into a particular mix of products, including gasoline, jet fuel, and residual fuel oil for home heating. Although plenty of crude oil is available, the amount that you refine depends on the capacity of the refinery and the cost of production. How much should you produce each day?[4]

Information about the refinery's marginal cost of production is essential for this decision. Figure 8.8 shows the short-run marginal cost curve (SMC). Marginal cost increases with output, but in a series of uneven segments rather than as a smooth curve. The increase occurs in segments because the refinery uses different processing units to turn crude oil into finished products. When a particular processing unit reaches capacity, output can be increased only by substituting a more expensive process. For example, gasoline can be produced from light crude oils rather inexpensively in a processing unit called a "thermal cracker." When this unit becomes full, additional gasoline can still be produced (from heavy as well as light crude oil), but only at a higher cost. In the case illustrated by Figure 8.8, the first capacity constraint comes into effect when production reaches about 9700 barrels a day. A second capacity constraint becomes important when production increases beyond 10,700 barrels a day.

Deciding how much output to produce now becomes relatively easy. Suppose that refined products can be sold for $23 per barrel. Because the marginal cost of production is close to $24 for the first unit of output, no crude oil should be run through the refinery when the price is $23. If, however, price is between $24 and $25, the refinery should produce 9700 barrels a day (filling the thermal cracker). Finally, if the price is above $25, the more expensive refining unit should be used and production expanded toward 10,700 barrels a day.

Because the cost function rises in steps, you know that your production decisions need not change much in response to *small* changes in price. You will typically use sufficient crude oil to fill the appropriate processing unit until price increases (or decreases) substantially. In that case, you need simply calculate whether the increased price warrants using an additional, more expensive processing unit.

[4]This example is based on James M. Griffin, "The Process Analysis Alternative to Statistical Cost Functions: An Application to Petroleum Refining," *American Economic Review* 62 (1972): 46–56. The numbers have been updated and applied to a particular refinery.

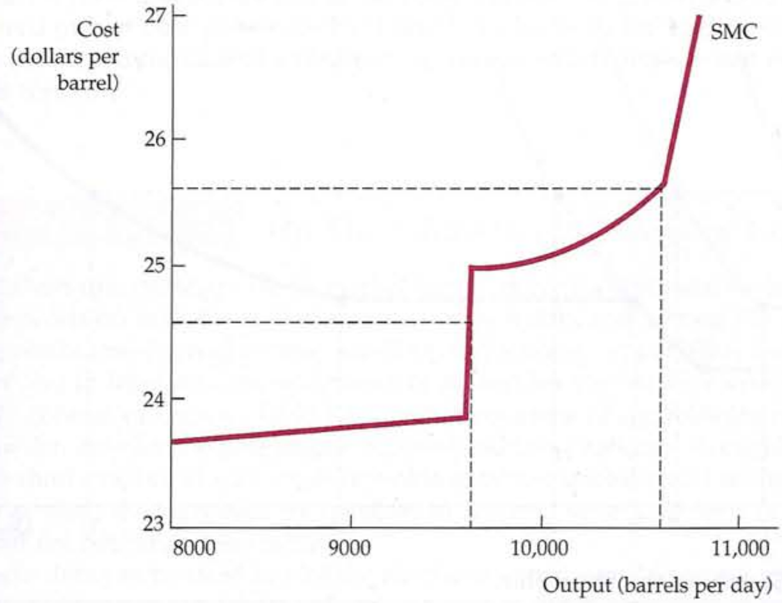

FIGURE 8.8 The Short-Run Production of Petroleum Products

As the refinery shifts from one processing unit to another, the marginal cost of producing petroleum products from crude oil increases sharply at several levels of output. As a result, the output level can be insensitive to some changes in price but very sensitive to others.

8.6 THE SHORT-RUN MARKET SUPPLY CURVE

The *short-run market supply curve* shows the amount of output that the industry will produce in the short run for every possible price. The industry's output is the sum of the quantities supplied by all of its individual firms. Therefore, the market supply curve can be obtained by adding the supply curves of each of these firms. Figure 8.9 shows how this is done when there are only three firms, all of which have different short-run production costs. Each firm's marginal cost curve is drawn only for the portion that lies above its average variable cost curve. (We have shown only three firms to keep the graph simple, but the same analysis applies when there are many firms.)

At any price below P_1, the industry will produce no output because P_1 is the minimum average variable cost of the lowest-cost firm. Between P_1 and P_2, only firm 3 will produce. The industry supply curve, therefore, will be identical to that portion of firm 3's marginal cost curve MC_3. At price P_2, the industry supply will be the sum of the quantity supplied by all three firms. Firm 1 supplies 2 units, firm 2 supplies 5 units, and firm 3 supplies 8 units. Industry supply is thus 15 units. At price P_3, firm 1 supplies 4 units, firm 2 supplies 7 units, and firm 3 supplies 10 units; the industry supplies 21 units. Note that the industry supply curve is upward sloping but has a kink at price P_2, the lowest price at which all three firms produce. With many firms in the market, however, the kink becomes unimportant. Thus we usually draw industry supply as a smooth, upward-sloping curve.

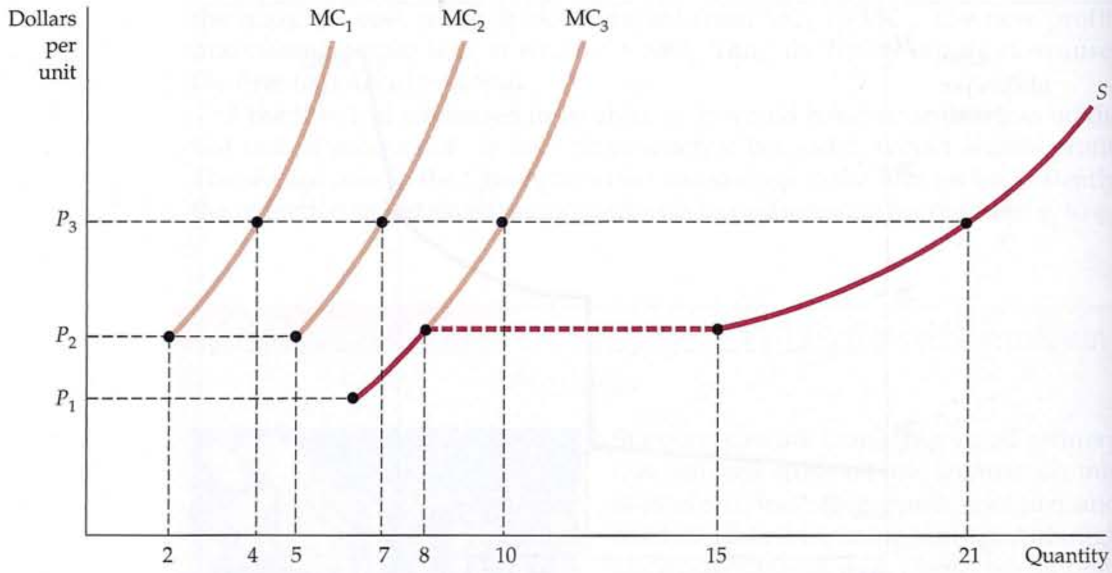

FIGURE 8.9 Industry Supply in the Short Run

The short-run industry supply curve is the summation of the supply curves of the individual firms. Because the third firm has a lower average variable cost curve than the first two firms, the market supply curve S begins at price P_1 and follows the marginal cost curve of the third firm MC_3 until price equals P_2, when there is a kink. For P_2 and all prices above it, the industry quantity supplied is the sum of the quantities supplied by each of the three firms.

Elasticity of Market Supply

Unfortunately, finding the industry supply curve is not always as simple as adding up a set of individual supply curves. As price rises, all firms in the industry expand their output. This additional output increases the demand for inputs to production and may lead to higher input prices. As we saw in Figure 8.7, increasing input prices shifts a firm's marginal cost curve upward. For example, an increased demand for beef could also increase demand for corn and soybeans (which are used to feed cattle) and thereby cause the prices of these crops to rise. In turn, higher input prices will cause firms' marginal cost curves to shift upward. This increase lowers each firm's output choice (for any given market price) and causes the industry supply curve to be less responsive to changes in output price than it would otherwise be.

In §2.4, we define the elasticity of supply as the percentage change in quantity supplied resulting from a 1-percent increase in price.

The price elasticity of market supply measures the sensitivity of industry output to market price. The elasticity of supply E_s is the percentage change in quantity supplied Q in response to a 1-percent change in price P:

$$E_s = (\Delta Q/Q)/(\Delta P/P)$$

Because marginal cost curves are upward sloping, the short-run elasticity of supply is always positive. When marginal cost increases rapidly in response to increases in output, the elasticity of supply is low. In the short run, firms are capacity-constrained and find it costly to increase output. But when marginal cost increases slowly in response to increases in output, supply is relatively elastic; in this case, a small price increase induces firms to produce much more.

At one extreme is the case of *perfectly inelastic supply*, which arises when the industry's plant and equipment are so fully utilized that greater output can be achieved only if new plants are built (as they will be in the long run). At the other extreme is the case of *perfectly elastic supply*, which arises when marginal cost is constant.

EXAMPLE 8.5 The Short-Run World Supply of Copper

In the short run, the shape of the market supply curve for a mineral such as copper depends on how the cost of mining varies within and among the world's major producers. Costs of mining, smelting, and refining copper differ because of differences in labor and transportation costs and because of differences in the copper content of the ore. Table 8.1 summarizes some of the relevant cost and production data for the nine largest copper-producing nations.[5] Remember that in, the short run, because the costs of building mines, smelters, and refineries are taken as sunk, the marginal cost numbers in Table 8.1 reflect the costs of operating (but not building) these facilities.

These data can be used to plot the short-run world supply curve for copper. It is a short-run curve because it takes the existing mines and refineries as fixed. Figure 8.10 shows how the curve is constructed for the nine countries listed in the table. (The curve is incomplete because there are a few smaller and higher-cost producers that we have not included.) Note that the curve in Figure 8.10 is an approximation. The marginal cost number for each country

TABLE 8.1 The World Copper Industry (2006)

Country	Annual Production (Thousand Metric Tons)	Marginal Cost (Dollars Per Pound)
Australia	950	1.15
Canada	600	1.30
Chile	5,400	0.80
Indonesia	800	0.90
Peru	1050	0.85
Poland	530	1.20
Russia	720	0.65
US	1220	0.85
Zambia	540	0.75

Source for Annual Production Data: U.S. Geological Survey, Mineral Commodity Summaries, January 2007. **http://minerals.usgs.gov/minerals/pubs/mcs/2007/mcs2007.pdf.**
Source for Marginal Cost Data: Charles River Associates' Estimates.

[5] Our thanks to James Burrows of Charles River Associates, Inc., who was kind enough to provide data on marginal production cost. Updated data and related information are available on the Web at: **http://minerals.usgs.gov/minerals.**

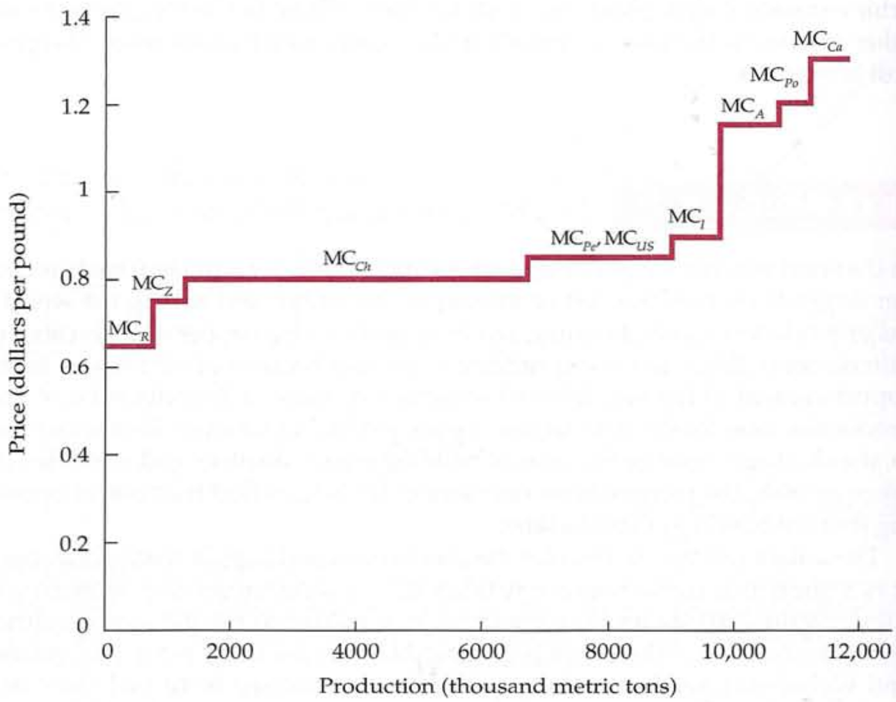

FIGURE 8.10 The Short-Run World Supply of Copper

The supply curve for world copper is obtained by summing the marginal cost curves for each of the major copper-producing countries. The supply curve slopes upward because the marginal cost of production ranges from a low of 65 cents in Russia to a high of $1.30 in Canada.

is an average for all copper producers in that country, and we are assuming that marginal cost and average cost are approximately the same. In the United States, for example, some producers have a marginal cost greater than 85 cents and some less.

The lowest-cost copper is mined in Russia, where the marginal cost of refined copper is roughly 65 cents per pound. The line segment labeled MC_R represents the marginal cost curve for Russia. The curve is horizontal until the total capacity for mining and refining copper in Russia is reached. (That point is reached at a production level of 720 thousand metric tons per year.) Line segment MC_Z represents the marginal cost curve for Zambia, segment MC_{Ch} the marginal cost curve for Chile, and so on.

The world supply curve is obtained by summing each nation's supply curve horizontally. As can be seen from the figure, the elasticity of supply depends on the price of copper. At relatively low prices, such as 65 to 90 cents per pound, the curve is quite elastic because small price increases lead to large increases in the quantity of copper supplied. At higher prices—say, above $1.20 per pound—the curve becomes more inelastic because, at those prices, most producers would be operating close to or at capacity.

Producer Surplus in the Short Run

In Chapter 4, we measured *consumer surplus* as the difference between the maximum that a person would pay for an item and its market price. An analogous concept applies to firms. If marginal cost is rising, the price of the product is greater than marginal cost for every unit produced except the last one. As a result, firms earn a surplus on all but the last unit of output. The **producer surplus** of a firm is the sum over all units produced of the differences between the market price of the good and the marginal cost of production. Just as consumer surplus measures the area below an individual's demand curve and above the market price of the product, producer surplus measures the area above a producer's supply curve and below the market price.

For a review of consumer surplus, see §4.4, where it is defined as the difference between what a consumer is willing to pay for a good and what the consumer actually pays when buying it.

• **producer surplus** Sum over all units produced by a firm of differences between the market price of a good and the marginal cost of production.

Figure 8.11 illustrates short-run producer surplus for a firm. The profit-maximizing output is q^*, where $P = \text{MC}$. The surplus that the producer obtains from selling each unit is the difference between the price and the marginal cost of producing the unit. The producer surplus is then the sum of these "unit surpluses" over all units that the firm produces. It is given by the yellow area under the firm's horizontal demand curve and above its marginal cost curve, from zero output to the profit-maximizing output q^*.

When we add the marginal cost of producing each level of output from 0 to q^*, we find that the sum is the total variable cost of producing q^*. Marginal cost reflects increments to cost associated with increases in output; because fixed cost does not vary with output, the sum of all marginal costs must equal the sum of the firm's variable costs.[6] Thus producer surplus can alternatively be defined as *the difference between the firm's revenue and its total variable cost.*

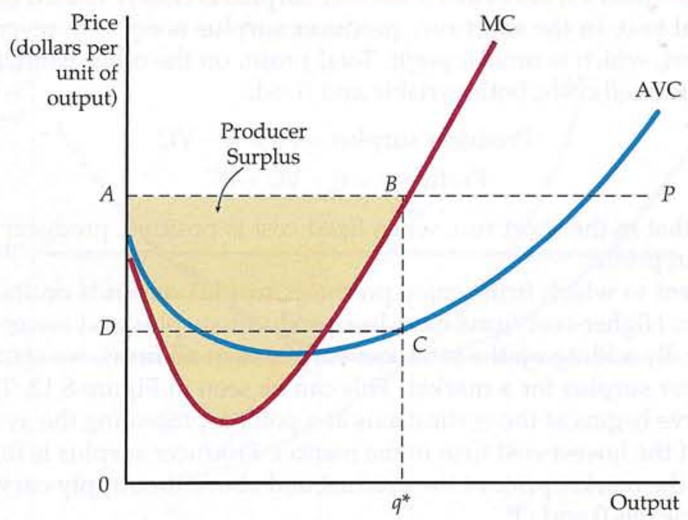

FIGURE 8.11 Producer Surplus for a Firm

The producer surplus for a firm is measured by the yellow area below the market price and above the marginal cost curve, between outputs 0 and q^*, the profit-maximizing output. Alternatively, it is equal to rectangle *ABCD* because the sum of all marginal costs up to q^* is equal to the variable costs of producing q^*.

[6] The area under the marginal cost curve from 0 to q^* is $\text{TC}(q^*) - \text{TC}(0) = \text{TC} - \text{FC} = \text{VC}$.

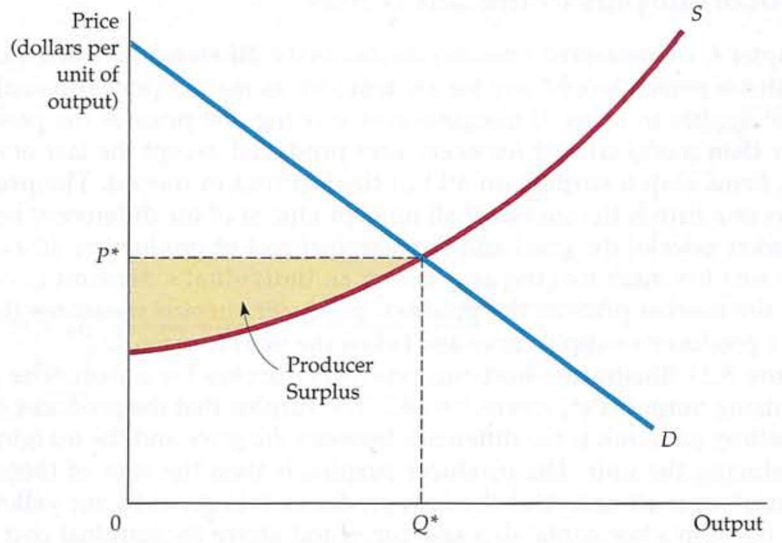

FIGURE 8.12 Producer Surplus for a Market

The producer surplus for a market is the area below the market price and above the market supply curve, between 0 and output Q^*.

In Figure 8.11, producer surplus is also given by the rectangle *ABCD*, which equals revenue ($0ABq^*$) minus variable cost ($0DCq^*$).

Producer Surplus versus Profit Producer surplus is closely related to profit but is not equal to it. In the short run, producer surplus is equal to revenue minus variable cost, which is *variable profit*. Total profit, on the other hand, is equal to revenue minus *all* costs, both variable and fixed:

$$\text{Producer surplus} = \text{PS} = R - \text{VC}$$
$$\text{Profit} = \pi = R - \text{VC} - \text{FC}$$

It follows that in the short run, when fixed cost is positive, producer surplus is greater than profit.

The extent to which firms enjoy producer surplus depends on their costs of production. Higher-cost firms have less producer surplus and lower-cost firms have more. By adding up the producer surpluses of all firms, we can determine the producer surplus for a market. This can be seen in Figure 8.12. The market supply curve begins at the vertical axis at a point representing the average variable cost of the lowest-cost firm in the market. Producer surplus is the area that lies below the market price of the product and above the supply curve between the output levels 0 and Q^*.

8.7 CHOOSING OUTPUT IN THE LONG RUN

In the short run, one or more of the firm's inputs are fixed. Depending on the time available, this may limit the flexibility of the firm to adapt its production process to new technological developments, or to increase or decrease its scale of operation as economic conditions change. In contrast, in the long run, a firm can alter all its inputs, including plant size. It can decide to shut down (i.e., to *exit* the industry) or to begin producing a product for the first time (i.e., to *enter* an industry). Because we are concerned here with competitive markets, we allow for *free entry* and *free exit*. In other words, we are assuming that firms may enter or exit without legal restriction or any special costs associated with entry. (Recall from Section 8.1 that this is one of the key assumptions underlying perfect competition.) After analyzing the long-run output decision of a profit-maximizing firm in a competitive market, we discuss the nature of competitive equilibrium in the long run. We also discuss the relationship between entry and exit, and economic and accounting profits.

Long-Run Profit Maximization

Figure 8.13 shows how a competitive firm makes its long-run, profit-maximizing output decision. As in the short run, the firm faces a horizontal demand curve. (In Figure 8.13 the firm takes the market price of $40 as given.) Its short-run average (total) cost curve SAC and short-run marginal cost curve SMC are low enough for the firm to make a positive profit, given by rectangle *ABCD*, by producing an output of q_1, where SMC = P = MR. The long-run average cost curve LAC reflects the presence of economies of scale up to output level q_2 and diseconomies of scale at higher output levels. The long-run marginal cost curve LMC cuts the long-run average cost from below at q_2, the point of minimum long-run average cost.

In §7.4, we explain that economies of scale arise when a firm can double its output for less than twice the cost.

If the firm believes that the market price will remain at $40, it will want to increase the size of its plant to produce at output q_3, at which its *long-run* marginal cost equals the $40 price. When this expansion is complete, the profit margin will increase from *AB* to *EF*, and total profit will increase from *ABCD* to *EFGD*.

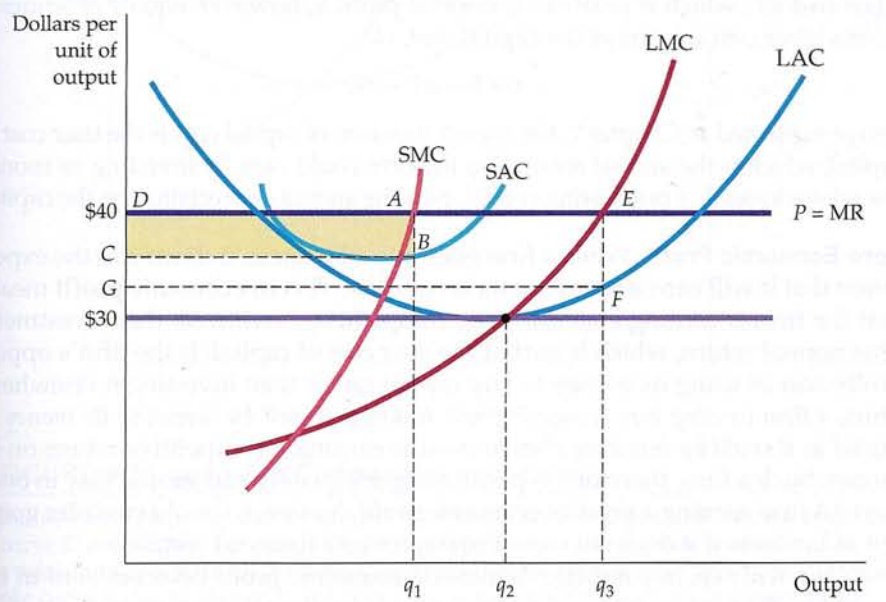

FIGURE 8.13 Output Choice in the Long Run

The firm maximizes its profit by choosing the output at which price equals long-run marginal cost LMC. In the diagram, the firm increases its profit from *ABCD* to *EFGD* by increasing its output in the long run.

Output q_3 is profit-maximizing because at any lower output (say, q_2), the marginal revenue from additional production is greater than the marginal cost. Expansion is, therefore, desirable. But at any output greater than q_3, marginal cost is greater than marginal revenue. Additional production would therefore reduce profit. In summary, *the long-run output of a profit-maximizing competitive firm is the point at which long-run marginal cost equals the price.*

Note that the higher the market price, the higher the profit that the firm can earn. Correspondingly, as the price of the product falls from \$40 to \$30, the profit also falls. At a price of \$30, the firm's profit-maximizing output is q_2, the point of long-run minimum average cost. In this case, because $P = \text{ATC}$, the firm earns zero economic profit.

Long-Run Competitive Equilibrium

For an equilibrium to arise in the long run, certain economic conditions must prevail. Firms in the market must have no desire to withdraw at the same time that no firms outside the market wish to enter. But what is the exact relationship between profitability, entry, and long-run competitive equilibrium? We can see the answer by relating economic profit to the incentive to enter and exit a market.

Accounting Profit and Economic Profit As we saw in Chapter 7, it is important to distinguish between accounting profit and economic profit. Accounting profit is measured by the difference between the firm's revenues and its cash flows for labor, raw materials, and interest plus depreciation expenses. Economic profit takes into account opportunity costs. One such opportunity cost is the return to the firm's owners if their capital were used elsewhere. Suppose, for example, that the firm uses labor and capital inputs; its capital equipment has been purchased. Accounting profit will equal revenues R minus labor cost wL, which is positive. Economic profit π, however, equals revenues R minus labor cost wL minus the capital cost, rK:

$$\pi = R - wL - rK$$

As we explained in Chapter 7, the correct measure of capital cost is the user cost of capital, which is the annual return that the firm could earn by investing its money elsewhere instead of purchasing capital, plus the annual depreciation on the capital.

• **zero economic profit** A firm is earning a normal return on its investment—i.e., it is doing as well as it could by investing its money elsewhere.

Zero Economic Profit When a firm goes into a business, it does so in the expectation that it will earn a return on its investment. A **zero economic profit** means that the firm is earning a *normal*—i.e., competitive—return on that investment. This normal return, which is part of the user cost of capital, is the firm's opportunity cost of using its money to buy capital rather than investing it elsewhere. Thus, *a firm earning zero economic profit is doing as well by investing its money in capital as it could by investing elsewhere*—it is earning a competitive return on its money. Such a firm, therefore, is performing adequately and should stay in business. (A firm earning a *negative* economic profit, however, should consider going out of business if it does not expect to improve its financial picture.)

As we will see, in competitive markets economic profit becomes zero in the long run. Zero economic profit signifies not that firms are performing poorly, but rather that the industry is competitive.

Entry and Exit Figure 8.13 shows how a \$40 price induces a firm to increase output and realize a positive profit. Because profit is calculated after subtracting the opportunity cost of capital, a positive profit means an unusually high return on a financial investment, which can be earned by entering a profitable industry. This high return causes investors to direct resources away from other industries and into this one—there will be *entry* into the market. Eventually the increased production associated with new entry causes the market supply curve to shift to the right. As a result, market output increases and the market price of the product falls.[7] Figure 8.14 illustrates this. In part (b) of the figure, the supply curve has shifted from S_1 to S_2, causing the price to fall from P_1 ($40) to P_2 ($30). In part (a), which applies to a single firm, the long-run average cost curve is tangent to the horizontal price line at output q_2.

A similar story would apply to exit. Suppose that each firm's minimum long-run average cost remains $30 but the market price falls to $20. Firms will lose money, causing *exit* from the market. Eventually the decreased production will cause the market supply curve to shift to the left. Market output will decrease and the price of the product will rise until an equilibrium is reached at a break-even price of $30. To summarize:

In a market with entry and exit, a firm enters when it can earn a positive long-run profit and exits when it faces the prospect of a long-run loss.

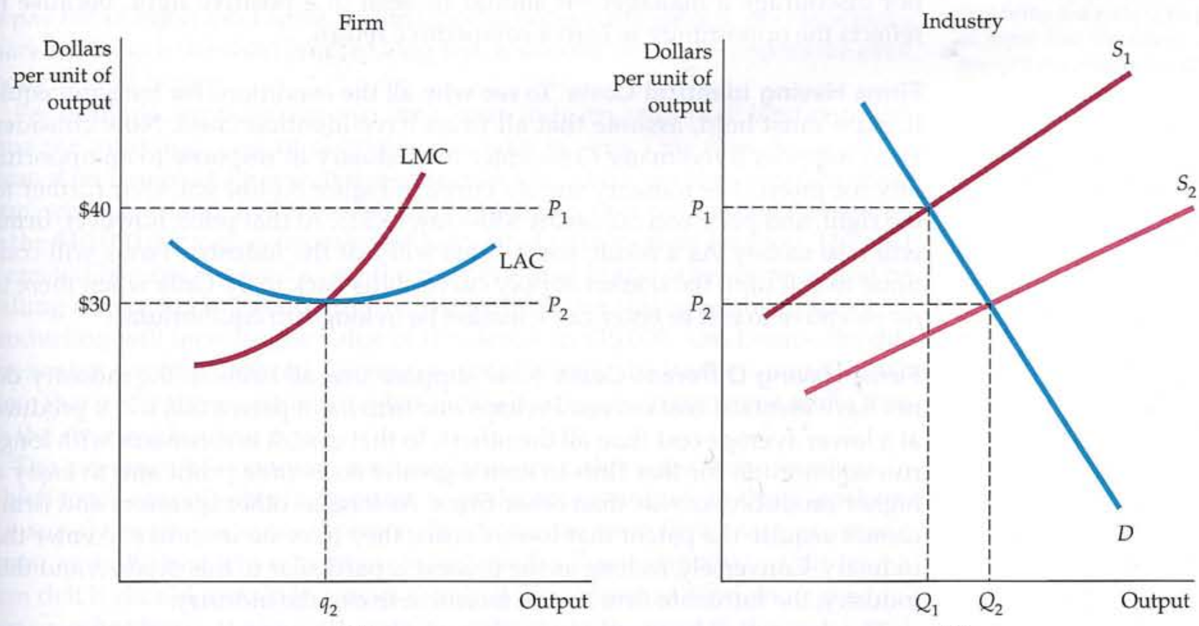

FIGURE 8.14 Long-Run Competitive Equilibrium

Initially the long-run equilibrium price of a product is $40 per unit, shown in (b) as the intersection of demand curve D and supply curve S_1. In **(a)** we see that firms earn positive profits because long-run average cost reaches a minimum of $30 (at q_2). Positive profit encourages entry of new firms and causes a shift to the right in the supply curve to S_2, as shown in **(b)**. The long-run equilibrium occurs at a price of $30, as shown in **(a)**, where each firm earns zero profit and there is no incentive to enter or exit the industry.

[7] We discuss why the long-run supply curve might be upward sloping in the next section.

• **long-run competitive equilibrium** All firms in an industry are maximizing profit, no firm has an incentive to enter or exit, and price is such that quantity supplied equals quantity demanded.

When a firm earns zero economic profit, it has no incentive to exit the industry. Likewise, other firms have no special incentive to enter. A **long-run competitive equilibrium** occurs when three conditions hold:

1. All firms in the industry are maximizing profit.
2. No firm has an incentive either to enter or exit the industry because all firms are earning zero economic profit.
3. The price of the product is such that the quantity supplied by the industry is equal to the quantity demanded by consumers.

The dynamic process that leads to long-run equilibrium may seem puzzling. Firms enter the market because they hope to earn a profit, and likewise they exit because of economic losses. In long-run equilibrium, however, firms earn zero economic profit. Why does a firm enter a market knowing that it will eventually earn zero profit? The answer is that zero economic profit represents a competitive return for the firm's investment of financial capital. With zero economic profit, the firm has no incentive to go elsewhere because it cannot do better financially by doing so. If the firm happens to enter a market sufficiently early to enjoy an economic profit in the short run, so much the better. Similarly, if a firm exits an unprofitable market quickly, it can save its investors money. Thus the concept of long-run equilibrium tells us the direction that a firm's behavior is likely to take. The idea of an eventual zero-profit, long-run equilibrium should not discourage a manager—it should be seen in a positive light, because it reflects the opportunity to earn a competitive return.

Firms Having Identical Costs To see why all the conditions for long-run equilibrium must hold, assume that all firms have identical costs. Now consider what happens if too many firms enter the industry in response to an opportunity for profit. The industry supply curve in Figure 8.14(b) will shift further to the right, and price will fall below \$30—say, to \$25. At that price, however, firms will lose money. As a result, some firms will exit the industry. Firms will continue to exit until the market supply curve shifts back to S_2. Only when there is no incentive to exit or enter can a market be in long-run equilibrium.

Firms Having Different Costs Now suppose that all firms in the industry do not have identical cost curves. Perhaps one firm has a patent that lets it produce at a lower average cost than all the others. In that case, it is consistent with long-run equilibrium for that firm to earn a greater *accounting* profit and to enjoy a higher producer surplus than other firms. As long as other investors and firms cannot acquire the patent that lowers costs, they have no incentive to enter the industry. Conversely, as long as the process is particular to this product and this industry, the fortunate firm has no incentive to exit the industry.

The distinction between accounting profit and economic profit is important here. If the patent is profitable, other firms in the industry will pay to use it (or attempt to buy the entire firm to acquire it). The increased value of the patent thus represents an opportunity cost to the firm that holds it. It could sell the rights to the patent rather than use it. If all firms are equally efficient otherwise, the *economic* profit of the firm falls to zero. However, if the firm with the patent is more efficient than other firms, then it will be earning a positive profit. But if the patent holder is otherwise less efficient, it should sell off the patent and exit the industry.

The Opportunity Cost of Land There are other instances in which firms earning positive accounting profit may be earning zero economic profit. Suppose, for example, that a clothing store happens to be located near a large shopping center. The additional flow of customers can substantially increase the store's accounting profit because the cost of the land is based on its historical cost. However, as far as economic profit is concerned, the cost of the land should reflect its opportunity cost, which in this case is the current market value of the land. When the opportunity cost of land is included, the profitability of the clothing store is no higher than that of its competitors.

Thus the condition that economic profit be zero is essential for the market to be in long-run equilibrium. By definition, positive economic profit represents an opportunity for investors and an incentive to enter an industry. Positive accounting profit, however, may signal that firms already in the industry possess valuable assets, skills, or ideas, which will not necessarily encourage entry.

Economic Rent

We have seen that some firms earn higher accounting profit than others because they have access to factors of production that are in limited supply; these might include land and natural resources, entrepreneurial skill, or other creative talent. In these situations, what makes economic profit zero in the long run is the willingness of other firms to use the factors of production that are in limited supply. The positive accounting profits are therefore translated into *economic rent* that is earned by the scarce factors. **Economic rent** is what firms are willing to pay for an input less the minimum amount necessary to buy it. In competitive markets, in both the short and the long run, economic rent is often positive even though profit is zero.

• **economic rent** Amount that firms are willing to pay for an input less the minimum amount necessary to obtain it.

For example, suppose that two firms in an industry own their land outright; thus the minimum cost of obtaining the land is zero. One firm, however, is located on a river and can ship its products for $10,000 a year less than the other firm, which is inland. In this case, the $10,000 higher profit of the first firm is due to the $10,000 per year economic rent associated with its river location. The rent is created because the land along the river is valuable and other firms would be willing to pay for it. Eventually, the competition for this specialized factor of production will increase the value of that factor to $10,000. Land rent—the difference between $10,000 and the zero cost of obtaining the land—is also $10,000. Note that while the economic rent has increased, the economic profit of the firm on the river has become zero.

The presence of economic rent explains why there are some markets in which firms cannot enter in response to profit opportunities. In those markets, the supply of one or more inputs is fixed, one or more firms earn economic rents, and all firms enjoy zero economic profit. Zero economic profit tells a firm that it should remain in a market only if it is at least as efficient in production as other firms. It also tells possible entrants to the market that entry will be profitable only if they can produce more efficiently than firms already in the market.

Producer Surplus in the Long Run

Suppose that a firm is earning a positive accounting profit but that there is no incentive for other firms to enter or exit the industry. This profit must reflect economic rent. How then does rent relate to producer surplus? To begin with, note that while economic rent applies to factor inputs, producer surplus applies to outputs. Note also that producer surplus measures the difference between the market price that a producer receives and the marginal cost of production.

Thus, in the long run, in a competitive market, *the producer surplus that a firm earns on the output that it sells consists of the economic rent that it enjoys from all its scarce inputs.*[8]

Let's say, for example, that a baseball team has a franchise allowing it to operate in a particular city. Suppose also that the only alternative location for the team is a city in which it will generate substantially lower revenues. The team will therefore earn an economic rent associated with its current location. This rent will reflect the difference between what the firm would be willing to pay for its current location and the amount needed to locate in the alternative city. The firm will also be earning a producer surplus associated with the sale of baseball tickets and other franchise items at its current location. This surplus will reflect all economic rents, including those rents associated with the firm's other factor inputs (the stadium and the players).

Figure 8.15 shows that firms earning economic rent earn the same economic profit as firms that do not earn rent. Part (a) shows the economic profit of a baseball team located in a moderate-sized city. The average price of a ticket is $7, and costs are such that the team earns zero economic profit. Part (b) shows the profit of a team that has the same cost curves even though it is located in a larger city. Because more people want to see baseball games, the latter team can sell tickets for $10 apiece and thereby earn an accounting profit of $2.80 above its average cost of $7.20 on each ticket. However, the rent associated with the more desirable location represents a cost to the firm—an opportunity cost—because it could sell its franchise to another team. As a result, the economic profit in the larger city is also zero.

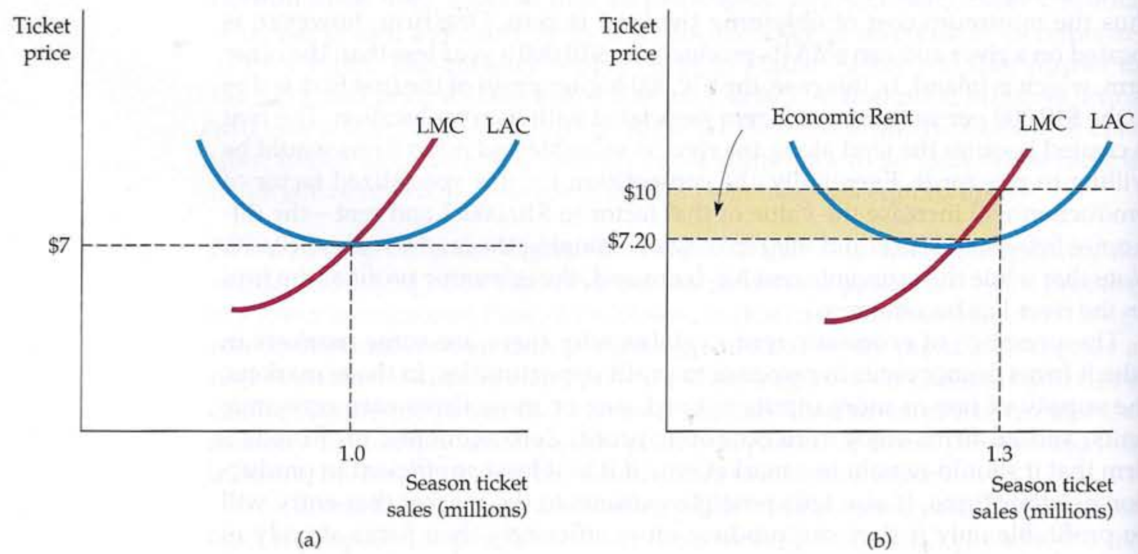

FIGURE 8.15 Firms Earn Zero Profit in Long-Run Equilibrium

In long-run equilibrium, all firms earn zero economic profit. In **(a)**, a baseball team in a moderate-sized city sells enough tickets so that price ($7) is equal to marginal and average cost. In **(b)**, the demand is greater, so a $10 price can be charged. The team increases sales to the point at which the average cost of production plus the average economic rent is equal to the ticket price. When the opportunity cost associated with owning the franchise is taken into account, the team earns zero economic profit.

[8]In a noncompetitive market, producer surplus will reflect economic profit as well as economic rent.

8.8 THE INDUSTRY'S LONG-RUN SUPPLY CURVE

In our analysis of short-run supply, we first derived the firm's supply curve and then showed how the summation of individual firms' supply curves generated a market supply curve. We cannot, however, analyze long-run supply in the same way: In the long run, firms enter and exit markets as the market price changes. This makes it impossible to sum up supply curves—we do not know which firms' supplies to add up in order to get market totals.

The shape of the long-run supply curve depends on the extent to which increases and decreases in industry output affect the prices that firms must pay for inputs into the production process. In cases in which there are economies of scale in production or cost savings associated with the purchase of large volumes of inputs, input prices will decline as output increases. In cases where diseconomies of scale are present, input prices may increase with output. The third possibility is that input costs may not change with output. In any of these cases, to determine long-run supply, we assume that all firms have access to the available production technology. Output is increased by using more inputs, not by invention. We also assume that the conditions underlying the market for inputs to production do not change when the industry expands or contracts. For example, an increased demand for labor does not increase a union's ability to negotiate a better wage contract for its workers.

In our analysis of long-run supply, it will be useful to distinguish among three types of industries: *constant cost*, *increasing cost*, and *decreasing cost*.

Constant-Cost Industry

• **constant-cost industry** Industry whose long-run supply curve is horizontal.

Figure 8.16 shows the derivation of the long-run supply curve for a **constant-cost industry**. A firm's output choice is given in (a), while industry output is shown in (b). Assume that the industry is initially in equilibrium at the intersection of market demand curve D_1 and short-run market supply curve S_1. Point A at the intersection of demand and supply is on the long-run supply curve S_L because it tells us that the industry will produce Q_1 units of output when the long-run equilibrium price is P_1.

To obtain other points on the long-run supply curve, suppose the market demand for the product unexpectedly increases (say, because of a reduction in personal income taxes). A typical firm is initially producing at an output of q_1, where P_1 is equal to long-run marginal cost and long-run average cost. But because the firm is also in short-run equilibrium, price also equals short-run marginal cost. Suppose that the tax cut shifts the market demand curve from D_1 to D_2. Demand curve D_2 intersects supply curve S_1 at C. As a result, price increases from P_1 to P_2.

Part (a) of Figure 8.16 shows how this price increase affects a typical firm in the industry. When the price increases to P_2, the firm follows its short-run marginal cost curve and increases output to q_2. This output choice maximizes profit because it satisfies the condition that price equal short-run marginal cost. If every firm responds this way, each will be earning a positive profit in short-run equilibrium. This profit will be attractive to investors and will cause existing firms to expand operations and new firms to enter the market.

As a result, in Figure 8.16(b) the short-run supply curve shifts to the right from S_1 to S_2. This shift causes the market to move to a new long-run equilibrium at the intersection of D_2 and S_2. For this intersection to be a long-run equilibrium, output must expand enough so that firms are earning zero profit and the incentive to enter or exit the industry disappears.

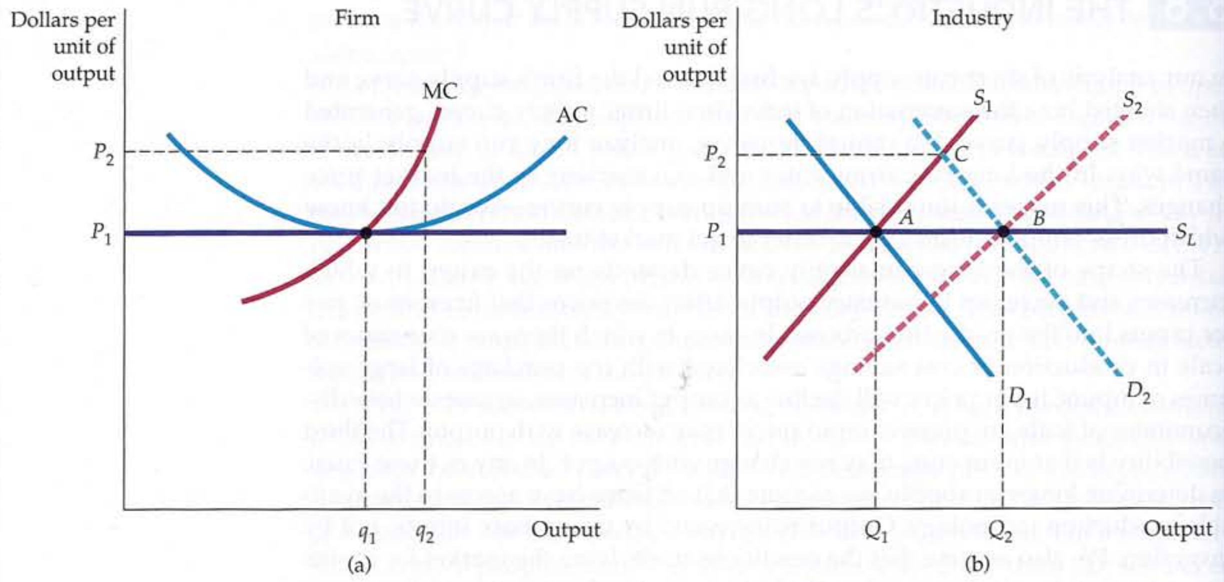

FIGURE 8.16 Long-Run Supply in a Constant-Cost Industry

In **(b)**, the long-run supply curve in a constant-cost industry is a horizontal line S_L. When demand increases, initially causing a price rise (represented by a move from point A to point C), the firm initially increases its output from q_1 to q_2, as shown in **(a)**. But the entry of new firms causes a shift to the right in industry supply. Because input prices are unaffected by the increased output of the industry, entry occurs until the original price is obtained (at point B in **(b)**).

In a constant-cost industry, the additional inputs necessary to produce higher output can be purchased without an increase in per-unit price. This might happen, for example, if unskilled labor is a major input in production, and the market wage of unskilled labor is unaffected by the increase in the demand for labor. Because the prices of inputs have not changed, firms' cost curves are also unchanged; the new equilibrium must be at a point such as B in Figure 8.16(b), at which price is equal to P_1, the original price before the unexpected increase in demand occurred.

The long-run supply curve for a constant-cost industry is, therefore, a horizontal line at a price that is equal to the long-run minimum average cost of production. At any higher price, there would be positive profit, increased entry, increased short-run supply, and thus downward pressure on price. Remember that in a constant-cost industry, input prices do not change when conditions change in the output market. Constant-cost industries can have horizontal long-run average cost curves.

Increasing-Cost Industry

• **increasing-cost industry** Industry whose long-run supply curve is upward sloping.

In an **increasing-cost industry** the prices of some or all inputs to production increase as the industry expands and the demand for the inputs grows. Diseconomies of scale in the production of one or more inputs may be the explanation. Suppose, for example, that the industry uses skilled labor, which becomes in short supply as the demand for it increases. Or, if a firm requires mineral resources that are available only on certain types of land, the cost of land as an input increases with output. Figure 8.17 shows the derivation of

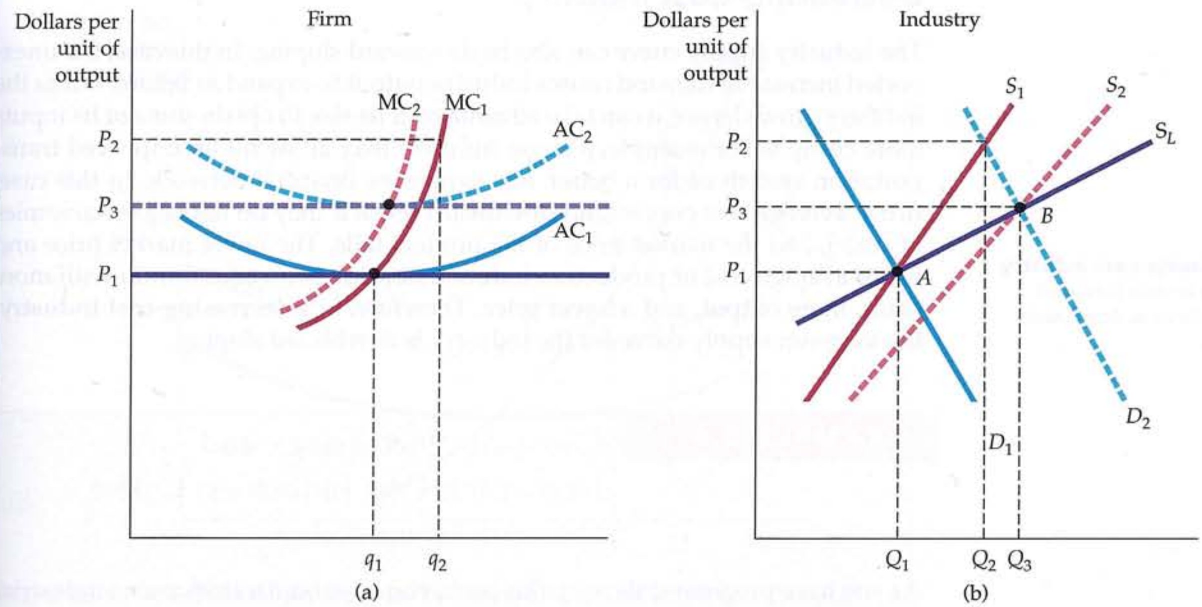

FIGURE 8.17 Long-Run Supply in an Increasing-Cost Industry

In **(b)**, the long-run supply curve in an increasing-cost industry is an upward-sloping curve S_L. When demand increases, initially causing a price rise, the firms increase their output from q_1 to q_2 in **(a)**. In that case, the entry of new firms causes a shift to the right in supply from S_1 to S_2. Because input prices increase as a result, the new long-run equilibrium occurs at a higher price than the initial equilibrium.

long-run supply, which is similar to the previous constant-cost derivation. The industry is initially in equilibrium at A in part (b). When the demand curve unexpectedly shifts from D_1 to D_2, the price of the product increases in the short run to P_2, and industry output increases from Q_1 to Q_2. A typical firm, as shown in part (a), increases its output from q_1 to q_2 in response to the higher price by moving along its short-run marginal cost curve. The higher profit earned by this and other firms induces new firms to enter the industry.

As new firms enter and output expands, increased demand for inputs causes some or all input prices to increase. The short-run market supply curve shifts to the right as before, though not as much, and the new equilibrium at B results in a price P_3 that is higher than the initial price P_1. Because the higher input prices raise the firms' short-run and long-run cost curves, the higher market price is needed to ensure that firms earn zero profit in long-run equilibrium. Figure 8.17(a) illustrates this. The average cost curve shifts up from AC_1 to AC_2, while the marginal cost curve shifts to the left, from MC_1 to MC_2. The new long-run equilibrium price P_3 is equal to the new minimum average cost. As in the constant-cost case, the higher short-run profit caused by the initial increase in demand disappears in the long run as firms increase output and input costs rise.

The new equilibrium at B in Figure 8.17(b) is, therefore, on the long-run supply curve for the industry. *In an increasing-cost industry, the long-run industry supply curve is upward sloping*. The industry produces more output, but only at the higher price needed to compensate for the increase in input costs. The term "increasing cost" refers to the upward shift in the firms' long-run average cost curves, not to the positive slope of the cost curve itself.

Decreasing-Cost Industry

The industry supply curve can also be downward sloping. In this case, the unexpected increase in demand causes industry output to expand as before. But as the industry grows larger, it can take advantage of its size to obtain some of its inputs more cheaply. For example, a larger industry may allow for an improved transportation system or for a better, less expensive financial network. In this case, firms' average cost curves shift downward (even if they do not enjoy economies of scale), and the market price of the product falls. The lower market price and lower average cost of production induce a new long-run equilibrium with more firms, more output, and a lower price. Therefore, in a **decreasing-cost industry**, the long-run supply curve for the industry is downward sloping.

• **decreasing-cost industry** Industry whose long-run supply curve is downward sloping.

EXAMPLE 8.6 Constant-, Increasing-, and Decreasing-Cost Industries: Coffee, Oil, and Automobiles

As you have progressed through this book, you have been introduced to industries that have constant, increasing, and decreasing long-run costs. Let's look back at some of these industries, beginning with one that has constant long-run costs. In Example 2.7 (page 46), we saw that the supply of coffee is extremely elastic in the long run (see Figure 2.18c—page 48). The reason is that land for growing coffee is widely available and the costs of planting and caring for trees remains constant as the volume of coffee produced grows. Thus, coffee is a constant-cost industry.

Now consider the case of an increasing-cost industry. We explained in Example 2.9 (page 54) that the oil industry is an increasing cost industry with an upward-sloping long-run supply curve (see Figure 2.23b page 57). Why are costs increasing? Because there is a limited availability of easily accessible, large-volume oil fields. Consequently, as oil companies increase output, they are forced to obtain oil from increasingly expensive fields.

Finally, a decreasing-cost industry. We discussed the demand for automobiles in Examples 3.1 (page 77) and 3.3 (page 89), but what about supply? In the automobile industry, certain cost advantages arise because inputs can be acquired more cheaply as the volume of production increases. Indeed, the major automobile manufacturers—such as General Motors, Toyota, Ford, and DaimlerChrysler—acquire batteries, engines, brake systems, and other key inputs from firms that specialize in producing those inputs efficiently. As a result, the average cost of automobile production decreases as the volume of production increases.

The Effects of a Tax

In Chapter 7, we saw that a tax on one of a firm's inputs (in the form of an effluent fee) creates an incentive for the firm to change the way it uses inputs in its production process. Now we consider ways in which a firm responds to a tax on its output. To simplify the analysis, assume that the firm uses a fixed-proportions production technology. If it's a polluter, the output tax might encourage the firm to reduce its output, and therefore its effluent, or it might be imposed merely to raise revenue.

First, suppose the output tax is imposed only on this firm and thus does not affect the market price of the product. We will see that the tax on output encourages the firm to reduce its output. Figure 8.18 shows the relevant short-run cost

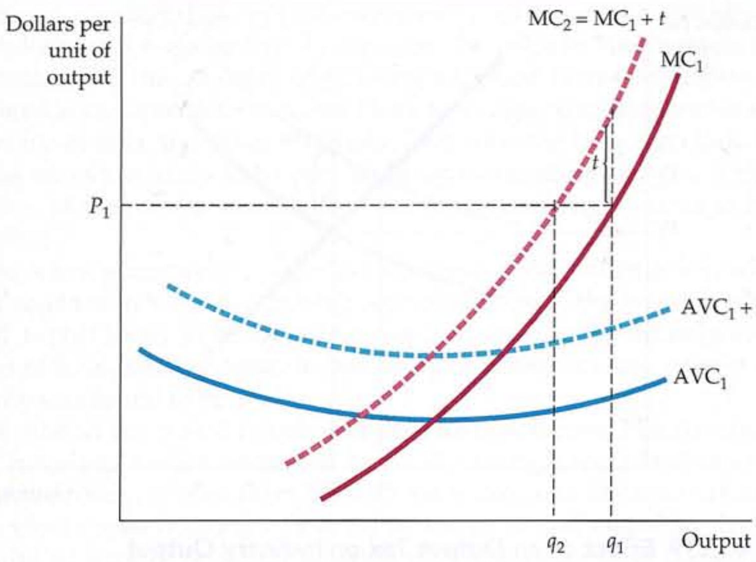

FIGURE 8.18 Effect of an Output Tax on a Competitive Firm's Output

An output tax raises the firm's marginal cost curve by the amount of the tax. The firm will reduce its output to the point at which the marginal cost plus the tax is equal to the price of the product.

curves for a firm enjoying positive economic profit by producing an output of q_1 and selling its product at the market price P_1. Because the tax is assessed for every unit of output, it raises the firm's marginal cost curve from MC_1 to $MC_2 = MC_1 + t$, where t is the tax per unit of the firm's output. The tax also raises the average variable cost curve by the amount t.

The output tax can have two possible effects. If the firm can still earn a positive or zero economic profit after the imposition of the tax, it will maximize its profit by choosing an output level at which marginal cost plus the tax is equal to the price of the product. Its output falls from q_1 to q_2, and the *implicit* effect of the tax is to shift its supply curve upward (by the amount of the tax). If the firm can no longer earn an economic profit after the tax has been imposed, it will choose to exit the market.

Now suppose that every firm in the industry is taxed and so has increasing marginal costs. Because each firm reduces its output at the current market price, the total output supplied by the industry will also fall, causing the price of the product to increase. Figure 8.19 illustrates this. An upward shift in the supply curve, from S_1 to $S_2 = S_1 + t$, causes the market price of the product to increase (by less than the amount of the tax) from P_1 to P_2. This increase in price diminishes some of the effects that we described previously. Firms will reduce their output less than they would without a price increase.

Finally, output taxes may also encourage some firms (those whose costs are somewhat higher than others) to exit the industry. In the process, the tax raises the long-run average cost curve for each firm.

Long-Run Elasticity of Supply

The long-run elasticity of industry supply is defined in the same way as the short-run elasticity: It is the percentage change in output ($\Delta Q/Q$) that results from a percentage change in price ($\Delta P/P$). In a constant-cost industry, the

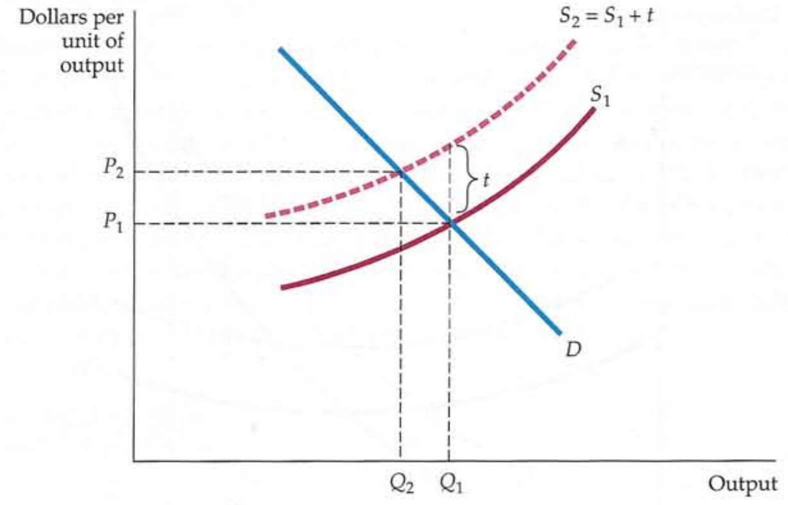

FIGURE 8.19 Effect of an Output Tax on Industry Output

An output tax placed on all firms in a competitive market shifts the supply curve for the industry upward by the amount of the tax. This shift raises the market price of the product and lowers the total output of the industry.

long-run supply curve is horizontal, and the long-run supply elasticity is infinitely large. (A small increase in price will induce an extremely large increase in output.) In an increasing-cost industry, however, the long-run supply elasticity will be positive but finite. Because industries can adjust and expand in the long run, we would generally expect long-run elasticities of supply to be larger than short-run elasticities.[9] The magnitude of the elasticity will depend on the extent to which input costs increase as the market expands. For example, an industry that depends on inputs that are widely available will have a more elastic long-run supply than will an industry that uses inputs in short supply.

EXAMPLE 8.7 The Long-Run Supply of Housing

Owner-occupied and rental housing provide interesting examples of the range of possible supply elasticities. People buy or rent housing to obtain the services that a house provides—a place to eat and sleep, comfort, and so on. If the price of housing services were to rise in one area of the country, the quantity of services provided could increase substantially.

[9] In some cases the opposite is true. Consider the elasticity of supply of scrap metal from a durable good like copper. Recall from Chapter 2 that because there is an existing stock of scrap, the long-run elasticity of supply will be *smaller* than the short-run elasticity.

To begin, consider the supply of owner-occupied housing in suburban or rural areas where land is not scarce. In this case, the price of land does not increase substantially as the quantity of housing supplied increases. Likewise, costs associated with construction are not likely to increase because there is a national market for lumber and other materials. Therefore, the long-run elasticity of the housing supply is likely to be very large, approximating that of a constant-cost industry. In fact, many studies find the long-run supply curve to be nearly horizontal.[10]

Even when elasticity of supply is measured within urban areas, where land costs rise as the demand for housing services increases, the long-run elasticity of supply is still likely to be large because land costs make up only about one-quarter of total housing costs. In one study of urban housing supply, the price elasticity was found to be 5.3.[11]

The market for rental housing is different, however. The construction of rental housing is often restricted by local zoning laws. Many communities outlaw it entirely, while others limit it to certain areas. Because urban land on which most rental housing is located is restricted and valuable, the long-run elasticity of supply of rental housing is much lower than the elasticity of supply of owner-occupied housing. As the price of rental-housing services rises, new high-rise rental units are built and older units are renovated—a practice that increases the quantity of rental services. With urban land becoming more valuable as housing density increases, and with the cost of construction soaring with the height of buildings, increased demand causes the input costs of rental housing to rise. In this increasing-cost case, the elasticity of supply can be much less than 1; in one study, the authors found it to be between 0.3 and 0.7.[12]

SUMMARY

1. Managers can operate in accordance with a complex set of objectives and under various constraints. However, we can assume that firms act as if they are maximizing long-run profit.
2. Many markets may approximate perfect competition in that one or more firms act as if they face a nearly horizontal demand curve. In general, the number of firms in an industry is not always a good indicator of the extent to which that industry is competitive.
3. Because a firm in a competitive market accounts for a small share of total industry output, it makes its output choice under the assumption that its production decision will have no effect on the price of the product. In this case, the demand curve and the marginal revenue curve are identical.
4. In the short run, a competitive firm maximizes its profit by choosing an output at which price is equal to (short-run) marginal cost. Price must, however, be greater than or equal to the firm's minimum average variable cost of production.
5. The short-run market supply curve is the horizontal summation of the supply curves of the firms in an

[10] For a review of the relevant literature, see Dixie M. Blackley, "The Long-Run Elasticity of New Housing Supply in the United States: Empirical Evidence for 1950 to 1994," *Journal of Real Estate Finance and Economics* 18 (1999): 25–42.

[11] See Barton A. Smith, "The Supply of Urban Housing," *Journal of Political Economy* 40 (August 1976): 389–405.

[12] See Frank deLeeuw and Nkanta Ekanem, "The Supply of Rental Housing," *American Economic Review* 61 (December 1971): 806–17, Table 5.2.

industry. It can be characterized by the elasticity of supply: the percentage change in quantity supplied in response to a percentage change in price.

6. The producer surplus for a firm is the difference between its revenue and the minimum cost that would be necessary to produce the profit-maximizing output. In both the short run and the long run, producer surplus is the area under the horizontal price line and above the marginal cost of production.
7. Economic rent is the payment for a scarce factor of production less the minimum amount necessary to hire that factor. In the long run in a competitive market, producer surplus is equal to the economic rent generated by all scarce factors of production.
8. In the long run, profit-maximizing competitive firms choose the output at which price is equal to long-run marginal cost.
9. A long-run competitive equilibrium occurs under these conditions: (a) when firms maximize profit; (b) when all firms earn zero economic profit, so that there is no incentive to enter or exit the industry; and (c) when the quantity of the product demanded is equal to the quantity supplied.
10. The long-run supply curve for a firm is horizontal when the industry is a constant-cost industry in which the increased demand for inputs to production (associated with an increased demand for the product) has no effect on the market price of the inputs. But the long-run supply curve for a firm is upward sloping in an increasing-cost industry, where the increased demand for inputs causes the market price of some or all inputs to rise.

QUESTIONS FOR REVIEW

1. Why would a firm that incurs losses choose to produce rather than shut down?
2. Explain why the industry supply curve is not the long-run industry marginal cost curve.
3. In long-run equilibrium, all firms in the industry earn zero economic profit. Why is this true?
4. What is the difference between economic profit and producer surplus?
5. Why do firms enter an industry when they know that in the long run economic profit will be zero?
6. At the beginning of the twentieth century, there were many small American automobile manufacturers. At the end of the century, there were only three large ones. Suppose that this situation is not the result of lax federal enforcement of antimonopoly laws. How do you explain the decrease in the number of manufacturers? (*Hint*: What is the inherent cost structure of the automobile industry?)
7. Because industry X is characterized by perfect competition, every firm in the industry is earning zero economic profit. If the product price falls, no firm can survive. Do you agree or disagree? Discuss.
8. An increase in the demand for video films also increases the salaries of actors and actresses. Is the long-run supply curve for films likely to be horizontal or upward sloping? Explain.
9. True or false: A firm should always produce at an output at which long-run average cost is minimized. Explain.
10. Can there be constant returns to scale in an industry with an upward-sloping supply curve? Explain.
11. What assumptions are necessary for a market to be perfectly competitive? In light of what you have learned in this chapter, why is each of these assumptions important?
12. Suppose a competitive industry faces an increase in demand (i.e., the demand curve shifts upward). What are the steps by which a competitive market insures increased output? Will your answer change if the government imposes a price ceiling?
13. The government passes a law that allows a substantial subsidy for every acre of land used to grow tobacco. How does this program affect the long-run supply curve for tobacco?
14. A certain brand of vacuum cleaners can be purchased from several local stores as well as from several catalogue or website sources.
    a. If all sellers charge the same price for the vacuum cleaner, will they all earn zero economic profit in the long run?
    b. If all sellers charge the same price and one local seller owns the building in which he does business, paying no rent, is this seller earning a positive economic profit?
    c. Does the seller who pays no rent have an incentive to lower the price that he charges for the vacuum cleaner?

EXERCISES

1. The data in the table on page 307 give information about the price (in dollars) for which a firm can sell a unit of output and the total cost of production.
    a. Fill in the blanks in the table.
    b. Show what happens to the firm's output choice and profit if the price of the product falls from \$60 to \$50.

		R		π	MC	MR	R	MR	π
q	P	$P = 60$	C	$P = 60$	$P = 60$	$P = 60$	$P = 50$	$P = 50$	$P = 50$
0	60		100						
1	60		150						
2	60		178						
3	60		198						
4	60		212						
5	60		230						
6	60		250						
7	60		272						
8	60		310						
9	60		355						
10	60		410						
11	60		475						

2. Using the data in the table, show what happens to the firm's output choice and profit if the fixed cost of production increases from \$100 to \$150 and then to \$200. Assume that the price of the output remains at \$60 per unit. What general conclusion can you reach about the effects of fixed costs on the firm's output choice?

3. Use the same information as in Exercise 1.
   a. Derive the firm's short-run supply curve. (*Hint*: You may want to plot the appropriate cost curves.)
   b. If 100 identical firms are in the market, what is the industry supply curve?

4. Suppose you are the manager of a watchmaking firm operating in a competitive market. Your cost of production is given by $C = 200 + 2q^2$, where q is the level of output and C is total cost. (The marginal cost of production is $4q$; the fixed cost is \$200.)
   a. If the price of watches is \$100, how many watches should you produce to maximize profit?
   b. What will the profit level be?
   c. At what minimum price will the firm produce a positive output?

5. Suppose that a competitive firm's marginal cost of producing output q is given by $MC(q) = 3 + 2q$. Assume that the market price of the firm's product is \$9.
   a. What level of output will the firm produce?
   b. What is the firm's producer surplus?
   c. Suppose that the average variable cost of the firm is given by $AVC(q) = 3 + q$. Suppose that the firm's fixed costs are known to be \$3. Will the firm be earning a positive, negative, or zero profit in the short run?

6. A firm produces a product in a competitive industry and has a total cost function $C = 50 + 4q + 2q^2$ and a marginal cost function $MC = 4 + 4q$. At the given market price of \$20, the firm is producing 5 units of output. Is the firm maximizing its profit? What quantity of output should the firm produce in the long run?

7. Suppose the same firm's cost function is $C(q) = 4q^2 + 16$.
   a. Find variable cost, fixed cost, average cost, average variable cost, and average fixed cost. (*Hint*: Marginal cost is given by $MC = 8q$.)
   b. Show the average cost, marginal cost, and average variable cost curves on a graph.
   c. Find the output that minimizes average cost.
   d. At what range of prices will the firm produce a positive output?
   e. At what range of prices will the firm earn a negative profit?
   f. At what range of prices will the firm earn a positive profit?

*8. A competitive firm has the following short-run cost function: $C(q) = q^3 - 8q^2 + 30q + 5$.
   a. Find MC, AC, and AVC and sketch them on a graph.
   b. At what range of prices will the firm supply zero output?
   c. Identify the firm's supply curve on your graph.
   d. At what price would the firm supply exactly 6 units of output?

*9. **a.** Suppose that a firm's production function is $q = 9x^{1/2}$ in the short run, where there are fixed costs of \$1000, and x is the variable input whose cost is \$4000 per unit. What is the total cost of producing a level of output q? In other words, identify the total cost function $C(q)$.
   b. Write down the equation for the supply curve.
   c. If price is \$1000, how many units will the firm produce? What is the level of profit? Illustrate your answer on a cost-curve graph.

*10. Suppose you are given the following information about a particular industry:

$$Q^D = 6500 - 100P \qquad \text{Market demand}$$
$$Q^S = 1200P \qquad \text{Market supply}$$
$$C(q) = 722 + \frac{q^2}{200} \qquad \text{Firm total cost function}$$
$$MC(q) = \frac{2q}{200} \qquad \text{Firm marginal cost function}$$

Assume that all firms are identical and that the market is characterized by perfect competition.
   a. Find the equilibrium price, the equilibrium quantity, the output supplied by the firm, and the profit of each firm.
   b. Would you expect to see entry into or exit from the industry in the long run? Explain. What effect will entry or exit have on market equilibrium?
   c. What is the lowest price at which each firm would sell its output in the long run? Is profit positive, negative, or zero at this price? Explain.
   d. What is the lowest price at which each firm would sell its output in the short run? Is profit positive, negative, or zero at this price? Explain.

*11. Suppose that a competitive firm has a total cost function $C(q) = 450 + 15q + 2q^2$ and a marginal cost function

$MC(q) = 15 + 4q$. If the market price is $P = \$115$ per unit, find the level of output produced by the firm. Find the level of profit and the level of producer surplus.

*12. A number of stores offer film developing as a service to their customers. Suppose that each store offering this service has a cost function $C(q) = 50 + 0.5q + 0.08q^2$ and a marginal cost $MC = 0.5 + 0.16q$.
   a. If the going rate for developing a roll of film is \$8.50, is the industry in long-run equilibrium? If not, find the price associated with long-run equilibrium.
   b. Suppose now that a new technology is developed which will reduce the cost of film developing by 25 percent. Assuming that the industry is in long-run equilibrium, how much would any one store be willing to pay to purchase this new technology?

*13. Consider a city that has a number of hot dog stands operating throughout the downtown area. Suppose that each vendor has a marginal cost of \$1.50 per hot dog sold and no fixed cost. Suppose the maximum number of hot dogs that any one vendor can sell is 100 per day.
   a. If the price of a hot dog is \$2, how many hot dogs does each vendor want to sell?
   b. If the industry is perfectly competitive, will the price remain at \$2 for a hot dog? If not, what will the price be?
   c. If each vendor sells exactly 100 hot dogs a day and the demand for hot dogs from vendors in the city is $Q = 4400 - 1200P$, how many vendors are there?
   d. Suppose the city decides to regulate hot dog vendors by issuing permits. If the city issues only 20 permits and if each vendor continues to sell 100 hot dogs a day, what price will a hot dog sell for?
   e. Suppose the city decides to sell the permits. What is the highest price that a vendor would pay for a permit?

*14. A sales tax of \$1 per unit of output is placed on a particular firm whose product sells for \$5 in a competitive industry with many firms.
   a. How will this tax affect the cost curves for the firm?
   b. What will happen to the firm's price, output, and profit?
   c. Will there be entry or exit in the industry?

*15. A sales tax of 10 percent is placed on half the firms (the polluters) in a competitive industry. The revenue is paid to the remaining firms (the nonpolluters) as a 10 percent subsidy on the value of output sold.
   a. Assuming that all firms have identical constant long-run average costs before the sales tax-subsidy policy, what do you expect to happen (in both the short run and the long run), to the price of the product, the output of firms, and industry output? (*Hint*: How does price relate to industry input?)
   b. Can such a policy *always* be achieved with a balanced budget in which tax revenues are equal to subsidy payments? Why or why not? Explain.