CHAPTER

9

Market Power and Monopoly

If you were in the market for a tablet computer when the iPad first came out, that was the only option. It didn't even come in a choice of colors. Apple couldn't have been happier. It had introduced a product that people literally lined up to buy—iPad was the only game in town. Other technology companies soon rushed their own tablets into production and distribution, but this took time. It also took considerable persuading to convince many wannabe iPad owners to abandon their plans and buy a different product when other tablets became available.

This sort of situation doesn't fit the perfectly competitive model of a firm's supply behavior we covered in Chapter 8. In a perfectly competitive market, a firm's output is so small relative to the total market that its choice of whether or how much to produce does not have a noticeable impact on the total supply in the market. But such was not the case for Apple when it introduced the iPad. After all, Apple *was* the market supply. By adjusting the number of iPads it produced for the market, the firm could cause movements along the market demand curve. If Apple produced only a few iPads, for example, the low quantity supplied would meet the demand curve at a high price, and quantity demanded would also be low. If it produced more, the quantity supplied would equal quantity demanded further down the demand curve, at a lower price. Therefore, Apple's choice of the quantity of iPads it supplied to the market gave the company effective control over the price at which the iPad sold.

In this chapter, we begin to look at firms' production choices when they have some ability to control the price at which their product sells. *A firm's ability to influence the market price of its product* is its **market power**. The most extreme version of market power is a **monopoly**, a *market that is served by only one firm*. Apple basically had a monopoly in the tablet computer market when the iPad first came out. A firm that has a monopoly is a **monopolist**, the *sole supplier and price setter of a good on the market*. A monopolist has the most market power because its decision about how much to supply completely determines the market price. As we saw in Chapter 8, a firm in a perfectly competitive market is a *price taker*; it has no market power because it has no influence over the market price.

market power A firm's ability to influence the market price of its product.

monopoly A market served by only one firm.

monopolist The sole supplier and price setter of a good on the market.

Firms with market power do not behave in the same way as perfectly competitive firms do. They recognize that their supply decisions will influence the price at which they can sell their output, so such companies take this into account when choosing how much to produce and sell. We will learn how to measure the degree of market power and see that as a firm's market power falls, its supply behavior becomes more and more like that of a perfectly competitive firm.

9.1 Sources of Market Power: Barriers to Entry

Some industries, like mobile phone companies and car manufacturers, for example, invariably end up with only a few companies and substantial market power. A key element of sustainable market power is that something must prevent competitors from entering when prices are high. A firm with market power can generate a substantial amount of producer surplus and profit in a way that a competitive firm cannot. (Remember that producer surplus equals a firm's profit plus its fixed cost. In the long run, when fixed cost is zero, profit and producer surplus are equal.) As we saw in Chapter 8, however, producer surplus should be an irresistible draw for other firms to enter the market and try to capture some of it. **Barriers to entry** are the *factors that keep entrants out of a market despite the existence of a large producer surplus.* We start by thinking about the nature of these barriers.

barriers to entry Factors that keep entrants out of a market despite the existence of a large producer surplus.

Extreme Scale Economies: Natural Monopoly

natural monopoly A market in which it is efficient for a single firm to produce the entire industry output.

The existence of a *natural monopoly* is one barrier to entry. A **natural monopoly** is a *market in which it is efficient for a single firm to produce the entire industry output.* In this market, the cost curve of a firm exhibits economies of scale at any output level. In other words, the firm's long-run average total cost curve is always downward-sloping—the bigger the firm gets, the lower is its average total cost, even if it sells the entire market quantity itself.

In this situation, it is efficient (from a production standpoint) for society if a single firm produces the entire industry output; splitting output across more firms would raise the average total cost of production. Suppose a company could produce as large a quantity as it wants at a constant marginal cost of $10 per unit and has a fixed cost of $100. In this case, average total cost (total costs divided by output) declines across all quantities of output. In equation form,

$$TC = FC + VC = 100 + 10Q$$

so

$$ATC = \frac{TC}{Q} = \frac{100 + 10Q}{Q} = \frac{100}{Q} + 10$$

The larger the firm's quantity produced, Q, the lower is its average total cost. If all of the firms in an industry have this same cost structure, the lowest-total-cost way to serve industry demand is for one firm to produce everything. If more than one firm produces, the industry's average total cost of producing output is higher because each firm that operates has to pay the fixed cost of $100 to produce anything at all. Having only one firm in the industry saves the replication of those fixed costs. That's why it is more cost-effective from society's perspective to have only one producer in the industry. Furthermore, at a more practical level, it's difficult in these types of markets for new firms to enter and compete with the incumbent, because the incumbent's size usually gives it a cost advantage. Therefore, in markets with cost curves like this (high fixed cost and constant or slowly rising marginal cost), one firm will tend to become very large and dominate the industry with its low cost.

All that said, it is important to realize that even natural monopolies can disappear if demand changes sufficiently over time. Demand can rise so much that average total cost eventually rises enough to enable new firms to enter the market. This happened in a number of markets people used to consider natural monopolies, such as the markets for telephone and cable television service.

Application: Natural Monopoly in Electricity Transmission

Electricity transmission is a classic example of a natural monopoly. Building a network of transmission lines, substations, meters, and so on to supply homes and businesses is a huge fixed cost. Once the network is built, the marginal cost of delivering another kilowatt-hour of electricity is almost constant. That means the average cost to deliver a kilowatt-hour on

a network steadily falls (down to the marginal cost) as the quantity of delivered electricity rises. If even just two competing firms operated in the transmission market in a geographic area, two separate sets of power lines would run everywhere, and the combined fixed costs of the two firms would be an enormous waste of resources.

We might therefore expect a single firm to handle electrical transmission in a given market. And we often observe that. This used to mean a local monopoly utility that generated power and delivered it to customers. These utilities were typically regulated by the government to limit their ability to exercise the market power that their natural monopoly gave them. (Later in the chapter, we discuss why the government often regulates the behaviors of firms with market power whether their market power is the result of a natural monopoly or not.)

More recently, however, there has been a recognition that although electricity transmission might be a natural monopoly, electricity *generation* is not. As our power plant supply curve analysis from Chapter 8 showed, marginal costs in generation rise with output, eventually leading to increasing average costs at higher quantities. As a result, locations have restructured their electricity markets over the years so that a number of competing electricity generators sell their output to a regulated transmission monopolist. (Sometimes these transmission companies are even set up as nonprofit businesses.) The part of the industry that is the natural monopoly has been separated from the parts that are not. ■

Switching Costs

A second common type of barrier to entry is the presence of consumer switching costs. If customers must give something up to switch to a competing product, this will tend to generate market power for the incumbent and make entry difficult. Think of a consumer who flies one airline regularly and has built up a preferred status level in the airline's frequent-flyer program. Even if a competing airline enters the market with lower prices, it may have a hard time convincing that person to fly with it, because the customer might lose her privileged status (shorter lines, upgrades, no checked-bag fees, etc.) on the current carrier. This lost status is a cost that inhibits the consumer's ability to switch to a competitor, raising the incumbent airline's market power.

For some products, the switching cost comes from technology. For example, once you buy a DIRECTV satellite dish and install it on your house, the only way to switch to the DISH Network is to get a new satellite dish and converter box installed. For other products, switching costs arise from the costs of finding an alternative. If you have your car insurance with one company, it can be very time consuming to research different competitors' rates to find out whether you could save money, and then fill out the paperwork required to actually switch. If you type in all your addresses with a photo service like Shutterfly for mailing holiday cards, switching to a new service would require you to enter them all once again.

Switching costs are not insurmountable barriers to entry. For example, some companies invest in making the switch as easy as possible as a way to convince people to go with their (often) cheaper product. But switching costs don't need to be insurmountable to be effective. To reduce the threat of competition and give the incumbent firm some market power, switching costs only need to be high enough to make entry costly, not impossible.

Perhaps the most extreme version of switching costs exists with a **network good:** a *good whose value to each customer increases with the number of other consumers who use the product.* With network goods, each new consumer creates a benefit for every other consumer of the good. Instagram is one example of a network good. If you are the only person in the world on Instagram, your account will not prove to be that much fun. If you're one of hundreds of millions with accounts, however, now you'll be talking (. . . to each other).

network good A good whose value to each consumer increases with the number of other consumers of the product.

The combination of large economies of scale (at or approaching natural monopoly levels) and network goods' attributes creates powerful entry barriers. Social networks like Facebook are prone to become monopolies because they both have major economies of scale in production (software is a high-fixed-cost, low-marginal-cost production process) and are network goods.

Product Differentiation

Even if firms sell products that compete in the same market, all consumers might not see each firm's product as a perfect substitute for other firms' versions. For example, all bicycle makers operate in what could be thought of as the same market, but not every potential bike buyer will see a $500 Trek as exactly the same thing as a $500 Cannondale. That means firms can price slightly above their competition without losing all their sales to their competitors. There is a segment of consumers who have a particular preference for one firm's product and will be willing to pay a premium for it (a limited premium, but a premium nonetheless). This *imperfect substitutability across varieties of a product* is called **product differentiation,** and it is another source of market power.

product differentiation Imperfect substitutability across varieties of a product.

In some industries, product differentiation can be spatial. When location matters, some sellers are in more convenient, appealing, or noticeable locations for certain customers than others. Those sellers will have some market power because even if their price is a bit higher than that of another more distant competitor, not all their customers will be willing to switch to the other seller. Likewise, their competitor has some customers who prefer its location, giving it some market power as well.

Product differentiation exists in one form or the other in most industries. Regardless of its specific source, it prevents new firms from entering the market and capturing most of the market demand just by pricing their version of the product slightly below the incumbents'. We will discuss product differentiation in greater detail in Chapter 11.

Absolute Cost Advantages or Control of Key Inputs

Another common barrier to entry is a firm's absolute cost advantage over other firms in obtaining a key input, meaning it has some special asset that other firms do not have—a secret formula or scarce resource. Controlling this input allows a firm to keep its costs lower than those of any competitor. To give an extreme example, suppose one firm owns the only oil well in town and can prevent anyone else from drilling a well. That would be a major advantage, because everyone else's cost of producing oil is infinite. The control of the input does not need to be that extreme, though. If a firm has one oil well whose production cost is substantially below that of everyone else's wells, that would be a cost advantage, too. These other firms would find it difficult to take away business from the low-production-cost firm, thus preserving its market power.

Application: Controlling a Key Input—The Troubled History of Fordlandia, Brazil

In the 1800s, there was no synthetic rubber. All rubber came from trees, and Brazil's rubber trees (*Hevea brasiliensis*) were the world's leading source. Rubber was one of Brazil's great exports.

In their natural state, the trees were often miles apart and hard to reach. In addition, because South American leaf-blight fungus (which attacks rubber trees in Brazil) could spread so easily from one tree to another, people could not plant the trees closer together.

Gavin Hellier/Alamy

Rubber trees planted close together on a plantation in Malaysia.

Colin McPherson/Corbis Historical/Getty Images

Fordlandia ruins in Brazil.

In 1876 an Englishman named Henry Wickham stole 70,000 rubber seeds for the British, who then planted them in concentrated plantations in what is now Malaysia. The innovation of planting the trees close together in a place with no leaf-blight fungus dramatically reduced the cost of harvesting rubber, gave the British an absolute cost advantage over everyone else in the rubber industry, and conferred market power on British rubber producers. By the early 1900s, Britain's plantations in Asia met 95% of the world's demand for rubber. It was "the first worldwide monopoly of a strategic resource in human history."[1]

In 1927 Henry Ford needed rubber for car tires and tried to copy the British approach. He set up a rubber plantation city in the Amazon and called it Fordlandia. Unfortunately, because Ford never consulted with any experts on rubber trees, the Fordlandia plantation rapidly fell prey to the leaf-blight fungus, culture clash, social unrest, and other ills. Repeated efforts to start new plantations all failed. As a result, Ford was unable to match the success of the British, and no rubber from Fordlandia was ever used in a Ford car.

Britain's market power from the absolute cost advantage of controlling this key input (rubber plants not threatened by the fungus) survived until the development of cheap synthetic rubber after World War II. It's still true, though, that if you travel from Brazil to Malaysia, the Malaysian government requires you to walk through a fungicide treatment at the airport and irradiates your luggage with ultraviolet radiation to kill any South American leaf blight you might be harboring. ■

Government Regulation

A final important form of entry barrier is government regulation. If you want to drive a cab in New York City, you need to have a medallion (a chunk of metal that is actually riveted to a car's hood to show that the New York Taxi & Limousine Commission has granted the cab a license to operate). The number of medallions is fixed; currently, there are just over 13,000 available. If you want to enter this industry, you need to buy a medallion from its current owner, and the price runs in the hundreds of thousands of dollars. That's a considerable entry barrier for a taxi driver.

Uber, a ridesharing service, created a way around this barrier (at least for now; the cab industry in New York City has been trying to limit Uber's ability to operate). An Uber driver can offer a service that is similar to a cab without having to buy a medallion. As a result, a medallion doesn't offer as much market power as it once did, and prices have fallen to reflect that. Medallion prices fell by as much as 70–80% in the five years after Uber's entry into New York City and other major U.S. cities like Boston, Chicago, and Philadelphia.

There are numerous other rules that prevent entry, such as licensing requirements in many occupations and industries. Note, however, that some regulatory barriers are intentional and probably good, as we discuss later in the chapter when we consider government

[1] Joe Jackson, *The Thief at the End of the World: Rubber, Power and the Seeds of Empire,* New York: Viking, 2008.

responses to monopoly. Examples include things like patents and copyrights, which explicitly give companies protection from entry by forbidding direct competitors.

Where There's a Will (and Producer Surplus), There's a Way

One important aspect to remember about barriers to entry is that they seldom last forever. If the producer surplus protected by entry barriers is large, competitors can often eventually find their way around even the most formidable barriers to entry. DuPont invented Nylon, the synthetic material, and patented it. In theory, this should have prevented entry. In reality, other companies figured out ways to develop competing, though not identical, synthetic fabrics that ultimately undermined the Nylon monopoly. Because there is no limit to the inventive capacity of the human mind, in the long run entrepreneurs and entrepreneurial firms will often find ingenious ways to encroach on other firms' protected positions.

9.2 Market Power and Marginal Revenue

Most firms have some sort of market power, even if they are not complete monopolists. The competitive market model is more of a useful starting point for studying market structures than it is a literal description of most industries.

A firm has market power if its individual demand curve is not flat. In a competitive market, firms are price takers. If they charge more than the market price, they lose all their demand. If their choice of output influences the price, they aren't price takers. Suppose the car manufacturer Tesla cuts production of all its vehicle models to one-fifth its current level. Prices would likely rise but not cut Tesla's demand to zero. So, Tesla's choice of output level can influence its price, and it is able to decide how many cars to make. That's the same idea we discussed with regard to Apple and the original iPad. We can describe the firm's decision in terms of choosing either its profit-maximizing price or its profit-maximizing level of output; either way, we (and the firm) obtain the same result.

Market Power and Monopoly

We made the argument that Apple was, effectively, a monopolist in the tablet computer market when it first introduced the iPad, but clearly we couldn't say the same about Tesla. It competes against other automakers. However, the basic lessons of this chapter apply whenever a firm has any market power, even if it isn't a pure monopolist. *The key element of our analysis in this chapter is that a firm with market power faces a downward-sloping demand curve.* In other words, its output level and price are interrelated. For a perfectly competitive firm, output level and price are not related.

We will see in Chapter 11 that **oligopoly** (a *market structure characterized by competition among a small number of firms*) and **monopolistic competition** (*a type of imperfect competition where a large number of firms have some market power, but each makes zero economic profit in the long run*) are other market types where individual demand curves slope downward. The difference between monopoly and these other two cases is that in an oligopoly and in monopolistic competition, the particular shape of the demand curve faced by any given firm (even though it still slopes down) depends on the supply decisions of the *other* firms in the market. In this chapter, we look at monopoly/market power in which there are no such interactions between firms. We will analyze how a firm in those kinds of markets chooses its production (or price) level *if other firms won't change their behaviors in response to its choices.* Having made this assumption, as long as the firm's

oligopoly Market structure characterized by competition among a small number of firms

monopolistic competition A type of imperfect competition where a large number of firms have some market power, but each makes zero economic profit in the long run.

FREAKONOMICS

Why Drug Dealers Want Peace, Not War

When it comes to gaining market power, monopolists have been extremely creative in the strategies they employ: lobbying governments for privileged access to markets, temporarily pricing below marginal cost to keep out rivals, and artificially creating entry barriers, just to name a few. But murder?

Can you imagine the CEO of Anheuser-Busch InBev ordering a hit man to take out the board of directors of MillerCoors? No chance. Yet, not too long ago, when Prohibition laws made it illegal to produce and consume alcohol, such actions were commonplace among the "firms" that produced alcohol. For gangsters like Al Capone, violence was key to establishing and maintaining market power.

The crack cocaine trade offers a modern example of the same phenomenon. Because crack is illegal, crack markets function without legal property rights or binding contracts. Violence becomes a means of enforcing contracts and establishing market power for drug gangs. And because these gangsters are already working illegally, the costs of murder aren't nearly as high as they are in legal ventures. Researchers estimate that roughly one-third of *all* the homicides that occur in the United States—nearly 5,000 per year—are carried out by drug dealers fighting over property rights. But in a study based on the actual financial records of a Chicago gang over a three-year period, Steven Levitt and Sudhir Venkatesh showed that gang leaders try to avoid excessive use of violence.* Why? Because it's bad for business! The shootings associated with a gang war scare away customers, reducing revenues by nearly 30%. During gang wars, the drug gang actually generated negative profits, on average.

Violence is one of the biggest costs of the illegal drug trade. Reducing this violence is one of the benefits touted by advocates of drug legalization. Simple economics suggests an alternative way to reduce the illegal drug trade and its effects. It is the high demand for drugs that makes drug sellers willing to take such extreme actions to establish market power. If the demand for illegal drugs were reduced, the ills associated with these markets would shrink, too. Several approaches along these lines have been tried—harsher punishments for users, education campaigns about drugs' health effects, and telling people to "Just Say No." These policies have met with mixed success, at best. Still, it's worth thinking about how to design better ways to reduce illegal drug demand, given the enormous benefits a sustained demand reduction would create.

*Steven D. Levitt and Sudhir Alladi Venkatesh, "An Economic Analysis of a Drug-Selling Gang's Finances," *Quarterly Journal of Economics* 115, no. 3 (August 2000): 755–789.

demand curve slopes downward, our analysis is the same whether this demand curve can be moved around by a competitor's actions (as in an oligopoly or monopolistically competitive market) or not (as in a monopoly). As a result, we sometimes interchange the terms "market power" and "monopoly power" even if the firm we are analyzing is not literally a monopolist. The point is that once the firm's demand curve is determined, its decision-making process is the same whether it is a monopoly, an oligopolistic firm, or a monopolistically competitive firm.[2]

Marginal Revenue

The key to understanding how a firm with market power acts is to realize that, because it faces a downward-sloping demand curve, it can only sell more of its good by reducing its price. This one fact enters into every decision such firms make. As we learn later in the chapter, because firms with market power recognize the relationship between output

[2] This similarity between the supply behavior of a monopolist and nonmonopoly firms that face downward-sloping demand curves is very handy, because it is often difficult to say definitively whether a firm is a monopolist or not. A key element of defining monopoly is deciding what the relevant market is, and drawing the boundaries can be arbitrary. Apple introduced the iPad, giving it a monopoly in the tablet market, but it was just one of many players in the market for computing devices. Fortunately, all that matters here is that the firm faces a downward-sloping demand curve for any reason.

and price, they will restrict output in a way that perfectly competitive firms won't. They do so to keep prices higher (and thereby make more money).

To see why, remember the concept of a company's marginal revenue, the additional revenue a firm earns from selling one more unit. At first, that just sounds like the price of the product. And as we saw in Chapter 8, for a firm with no market power, this is exactly the case; the price is the marginal revenue. If a hotdog vendor walking the stands at a football game (a "firm" that can reasonably be thought of as a price taker) sells another hotdog, his total revenue goes up by whatever price he sells the hotdog for. The price doesn't depend on how many hotdogs he sells; he is a price taker. He could sell hundreds of hotdogs and it wouldn't change the market price, so his marginal revenue is just market price *P*.

But for a seller with market power, the concept of marginal revenue is more subtle. The extra revenue from selling another unit is no longer just the price. Yes, the firm can get the revenue from selling one more unit, but because the firm faces a downward-sloping demand curve, the more it chooses to sell, the lower the price will be for *all* units it sells, not just that one extra unit. (*Important note:* We are assuming the firm makes the decision all at once and can't charge different prices to each customer. We will figure out what to do with differential pricing in Chapter 10.) This reduces the revenue the firm receives for the other units it sells. When computing the marginal revenue from selling that last unit, then, the firm must also subtract the loss it suffers on every other unit.

For example, consider Durkee-Mower, Inc., the Massachusetts firm that makes Marshmallow Fluff. Fluff has been around since 1920 and maintains a dominant position in the marshmallow creme market in the northeastern United States (you may have had some in a Fluffernutter sandwich, a s'more, or a Rice Krispies bar). This prominence in the market means that Durkee-Mower faces a downward-sloping demand curve for Fluff. If it makes more Fluff, its market price will fall, because the only way to get consumers to buy up the extra Fluff is to lower its price.

Table 9.1 shows how the quantity of Fluff produced this year varies with its price. As the quantity produced rises, the price falls because of the downward-sloping demand curve. The third column in Table 9.1 shows the total revenue for the year for each level of output. The marginal revenue of an additional unit of output (in this example, a unit is a million pounds) is shown in the last column. It equals the difference between total revenue at that level of output minus the total revenue had Durkee-Mower made one fewer unit.

If Durkee-Mower makes only 1 million pounds of Fluff, its price is $5 per pound, and its revenue is $5 million. Because total revenue would be zero if the firm didn't produce anything, the marginal revenue of the first million pounds is $5 million. If Durkee-Mower makes 2 million pounds of Fluff instead, the market price falls to $4 per pound—the lower price makes consumers willing to buy another million pounds of Fluff. Total revenue in this case is $8 million. Therefore, the marginal revenue of increasing output from 1 to 2 million pounds is $3 million, or $3 per pound. Note that this is less than the $4 per pound price that it sells for at the quantity of 2 million pounds.

Table 9.1 Marginal Revenue for Marshmallow Fluff

Quantity (millions of pounds) (Q)	Price ($/pound) ($P$)	Total Revenue ($ millions) ($TR = P \times Q$)	Marginal Revenue ($ millions) $\left(MR = \frac{\Delta TR}{\Delta Q}\right)$
0	6	0	—
1	5	5	5
2	4	8	3
3	3	9	1
4	2	8	–1
5	1	5	–3

As we discussed earlier, the lower marginal revenue reflects the fact that a firm with market power must reduce the price of its product when it produces more. Therefore, the marginal revenue isn't just the price multiplied by the extra quantity, which would be ($4 per pound × 1 million pounds) = $4 million. It also subtracts the $1 million loss of revenue because the firm now sells the previous million units at a price that is $1 lower. Thus, the marginal revenue from producing 1 million more pounds of Fluff is $3 million: $4 million of revenue on the additional million pounds minus the $1 million lost from the price reduction on the initial million pounds sold.

If Durkee-Mower produces 3 million pounds, the market price drops to $3 per pound. Total revenue at this quantity is $9 million. The marginal revenue is now only $1 million. Again, this marginal revenue is less than the product of the market price and the extra quantity because producing more Fluff drives down the price that Durkee-Mower can charge for every unit it sells.

If the firm chooses to make still more Fluff, say, 4 million pounds, the market price drops further, to $2 per pound. Total revenue is now $8 million. That means in this case, Durkee-Mower has actually *reduced* its revenue (from $9 million to $8 million) by producing *more* Fluff, and marginal revenue is now negative (–$1 million) even though it sells the extra Fluff for $2 per pound. The problem is that the revenue loss due to the dropped price on all units outweighs the revenue gains from selling more. If Durkee-Mower insists on making 5 million pounds, the price drops to $1 per pound and total revenue falls to $5 million. Again, the marginal revenue of this million-pound unit is negative, –$3 million, because the revenue loss due to price reductions outweighs the extra units sold.

Why Does the Price Have to Fall for Every Unit the Firm Sells? One thing about marginal revenue that can be confusing at first glance is why the seller has to lower the price on all its sales if it decides to produce one more unit. For instance, in the Marshmallow Fluff example, why can't Durkee-Mower sell the first million pounds for $5 per pound, and then the second million pounds for $4 a pound, the third million for $3 a pound, and so on? That way, marginal revenue would always equal the price.

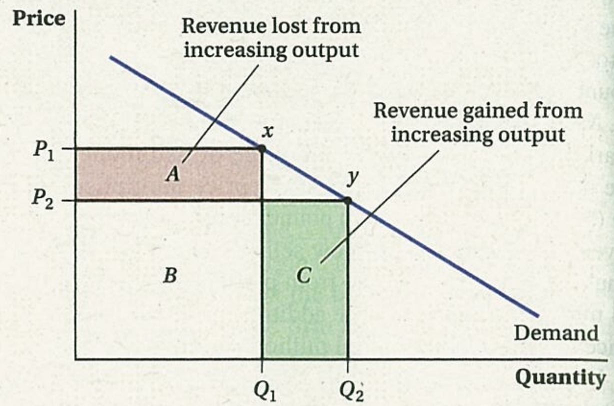
The firm's decision here is not sequential. Durkee-Mower isn't deciding whether to sell a second million pounds after it has already sold its first million at $5 per pound. Instead, the firm is deciding whether to produce 1 million *or* 2 million pounds in this period. If it makes 1 million pounds, the price will be $5 per pound and revenue will be $5 million. The demand curve is at a specific point in time. We will discuss the reasons you might not be able to charge different prices to different people in more detail in Chapter 10. However, those reasons include not being able to identify the customers who are willing to pay more, and not being able to prevent the ones that buy cheap from reselling to other customers.

Marginal Revenue: A Graphical Approach The idea that marginal revenue is different from the price is easy to see in a graph like **Figure 9.1**. On the downward-sloping demand curve, we can measure the total revenue *TR* (price × quantity) at two different points, *x* and *y*. At point *x*, the quantity sold is Q_1 and the price at which each unit is sold is P_1. The total revenue is price times quantity, seen in the figure as the rectangle *A* + *B*.

If the firm decides to produce more, say, by increasing output from Q_1 to Q_2, it will move to point *y* on the demand curve. The firm sells more units, but in doing so, the price

Figure 9.1 Understanding Marginal Revenue

For a firm with market power, the marginal revenue from producing an additional unit of a good is not equal to the good's price. When the firm decides to increase production from point x on the demand curve (quantity Q_1) to point y (Q_2), the price of the good decreases from P_1 to P_2. The firm's initial total revenue ($P_1 \times Q_1$) is equal to the area $A + B$. At the new production point, total revenue ($P_2 \times Q_2$) is equal to the area $B + C$. The firm's marginal revenue is the difference between the initial total revenue and the new total revenue, equal to $C - A$.



falls to P_2. The new total revenue is $P_2 \times Q_2$ or the rectangle $B + C$. Therefore, the marginal revenue of this output increase is the new revenue minus the old revenue:

$$TR_2 = P_2 \times Q_2 = B + C$$
$$TR_1 = P_1 \times Q_1 = A + B$$
$$MR = TR_2 - TR_1$$
$$MR = (B + C) - (A + B) = C - A$$

The area C contains the extra revenue that comes from selling more goods at price P_2, but this alone is not the marginal revenue of the extra output. We must also subtract area A, the revenue the firm loses because it now sells all units (not just the marginal unit) for the lower price P_2 instead of P_1. In fact, as we saw in the Fluff example, if the price-lowering effect from increasing output is large enough, marginal revenue could even be less than zero. In other words, selling more product could actually end up reducing a firm's revenue.

Marginal Revenue: A Mathematical Approach We can compute the firm's marginal revenue using the logic we just discussed. As we saw, there are two effects when the firm sells an additional unit of output. Each of these will account for a component of the marginal revenue formula.

The first effect comes from the additional unit being sold at the market price P. In Figure 9.1, if we define $Q_2 - Q_1$ to be 1 unit, then this effect would be area C.

The second effect occurs because the additional unit drives down the market price for all the units the firm makes. To figure out how to express this component of marginal revenue, let's first label the change in price ΔP. In Figure 9.1, we're looking at the effect of a price cut, so $\Delta P < 0$. Let's also label the quantity before adding the incremental unit of output as Q and the incremental output as ΔQ. The second component of marginal revenue is therefore $\left(\frac{\Delta P}{\Delta Q}\right) \times Q$, the change in price caused by selling the additional unit of revenue times the quantity sold before adding the incremental unit. In Figure 9.1, this is area A. Note that because price falls as quantity rises—remember, the firm faces a downward-sloping demand curve—the term $\Delta P/\Delta Q$ is negative. This conforms to our logic

above that this second component of marginal revenue is negative. It is the loss in revenue resulting from having to sell the non-incremental units at a lower price.

Putting together these components, we have the formula for marginal revenue (MR) from producing an additional quantity (ΔQ) of output (notice that we add the two components together even though the second represents a loss in revenue because $\Delta P/\Delta Q$ is already negative):

$$MR = P + \left(\frac{\Delta P}{\Delta Q}\right) \times Q$$

This negative second component means that marginal revenue will always be less than the market price. If we map this equation into Figure 9.1, the first term is the additional revenue from selling an additional unit at price P (area C) and the second is area A.

The end-of-chapter appendix derives a firm's marginal revenue using calculus.

Looking more closely at this formula reveals how the shape of the demand curve facing a firm affects its marginal revenue. The change in price corresponding to a change in quantity, $\Delta P/\Delta Q$, is a measure of how steep the demand curve is. When the demand curve is really steep, price falls a lot in response to an increase in output. $\Delta P/\Delta Q$ is a large negative number in this case. This will drive down MR and can even make it negative. On the other hand, when the demand curve is flatter, price is not very sensitive to quantity increases. In this case, because $\Delta P/\Delta Q$ is fairly small in magnitude, the first (positive) component P of marginal revenue plays a larger relative role, keeping marginal revenue from falling too much as output rises. In the special case of perfectly flat demand curves, $\Delta P/\Delta Q$ is zero, and therefore marginal revenue equals the market price of the good. We know from Chapter 8 that when a firm's marginal revenue equals price, the firm is a price taker: Whatever quantity it sells will be sold at the market price P. This is an important insight that we return to below. Perfect competition is just the special case in which the firm's demand curve is perfectly elastic, so $MR = P$.

This connection between the slope of the demand curve and the level of a firm's marginal revenue is important in understanding how firms with market power choose the output levels that maximize their profits. We study this profit-maximization problem in detail in the next section, but it's useful to reflect a bit now on what the marginal revenue formula implies about it. Firms that face steep demand curves obtain small revenue gains (or even revenue losses, if MR is negative) when they increase output. This makes high output levels less profitable. Firms facing flatter demand curves obtain relatively large marginal revenues when raising output. This contrast suggests that (holding all else equal) having a steeper demand curve tends to reduce a firm's profit-maximizing output level. In the next section, we see that this is exactly the case.

We can apply the marginal revenue formula to any demand curve. For nonlinear demand curves, the slope $\Delta P/\Delta Q$ is the slope of a line tangent to the demand curve at quantity Q. But the formula is especially easy for linear demand curves, because $\Delta P/\Delta Q$ is constant. For any linear (inverse) demand curve of the form $P = a - bQ$, where a (the vertical intercept of the demand curve) and b are constants, $\Delta P/\Delta Q = -b$. The inverse demand curve itself relates P (the other component of marginal revenue) to Q, so if we also plug $P = a - bQ$ and $\Delta P/\Delta Q = -b$ into the MR formula above, we arrive at an expression for the marginal revenue of any linear demand curve:

$$MR = P + \left(\frac{\Delta P}{\Delta Q}\right) Q$$
$$= (a - bQ) + (-b)Q = a - 2bQ$$

So here, the marginal revenue curve looks just like the inverse demand curve but with twice the slope. It's only that simple for a linear demand curve, but the more general marginal revenue formula applies to any demand curve.

Figure 9.2 A Linear Demand Curve and Its Marginal Revenue Curve

A linear demand curve has a marginal revenue curve with the same vertical intercept and twice the slope. Here, the demand curve D is given by $P = 100 - 10Q$. The associated marginal revenue curve is therefore $MR = 100 - 20Q$. If $Q = 4$, for example, then $P = \$60$ and $MR = \$20$.

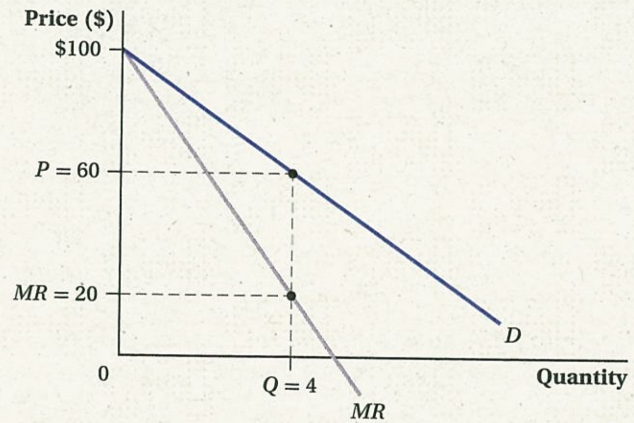


Figure 9.2 shows an example of a demand curve and its marginal revenue curve.[3] The demand curve in the figure is $P = 100 - 10Q$ and therefore the marginal revenue curve is $MR = 100 - 20Q$. If $Q = 4$, as shown, then the demand curve implies $P = \$60$ and $MR = \$20$.

figure it out 9.1

Suppose the demand curve is $Q = 12.5 - 0.25P$.

a. What is the marginal revenue curve that corresponds to this demand curve?

b. Calculate marginal revenue when $Q = 6$. Calculate marginal revenue when $Q = 7$.

Solution:

a. First, we need to solve for the inverse demand curve by rearranging the demand function so that price is on the left side by itself:

$$Q = 12.5 - 0.25P$$
$$0.25P = 12.5 - Q$$
$$P = 50 - 4Q$$

Thus, we know that the inverse demand curve is $P = 50 - 4Q$, with $a = 50$ and $b = 4$. Because $MR = a - 2bQ$, we know that $MR = 50 - 8Q$.

b. We can plug these values into our MR equation to solve for marginal revenue:

When $Q = 6$, $MR = 50 - 8(6) = 50 - 48 = 2$

When $Q = 7$, $MR = 50 - 8(7) = 50 - 56 = -6$

Note that, as we discussed above, MR falls as Q rises and can even become negative.

[3] If you know calculus, you can see that the multiplier of 2 comes from the derivative of the total revenue function. For a linear inverse demand curve $P = a - bQ$, the total revenue curve (the firm's revenue as a function of its quantity produced) that corresponds to it is $P \times Q$, or $aQ - bQ^2$. To find marginal revenue using the demand curve, we could compute the marginal revenue by taking the derivative of this total revenue function with respect to Q. Doing so gives $MR = a - 2bQ$.

9.3 Profit Maximization for a Firm with Market Power

Once you know how to compute marginal revenue, you can figure out the profit-maximizing output level for a firm with market power. At first glance, you might think it should produce until the marginal revenue hits zero and then stop. That's true only if there are no costs of production. A firm with market power should pay attention to its marginal revenue, but has to balance that against the production cost.

How to Maximize Profit

In Chapter 8, we discussed the two basic elements of firm profit — revenue and cost — and how each of these is determined by the firm's choice of how much output to produce. We saw that the profit-maximizing output was the one that set marginal revenue equal to marginal cost, and that marginal revenue for a perfectly competitive firm equals the market price, so maximizing profit meant producing the quantity at which price equals marginal cost. The firm should produce more if the additional revenue it would earn exceeds the additional cost and cut back on production if it's losing money on those extra units.

The same underlying logic works for firms with market power except that *marginal revenue no longer equals price*. To maximize its profit, a firm should choose its quantity where its marginal revenue equals its marginal cost:

$$MR = MC$$

If marginal revenue is above marginal cost, a firm, by producing more, can earn more revenue than the extra cost of production and increase its profit. If marginal revenue is below marginal cost, a firm can reduce its output, lose less revenue than it saves in cost, and again raise its profit. Only when these two marginal values are equal does changing output not increase profit.

The end-of-chapter appendix uses calculus to solve the firm's profit-maximization problem.

Setting $MR = MC$ gives us the quantity, Q^*, that maximizes the firm's profit, and from that we figure out the profit-maximizing price. The height of the demand curve at that profit-maximizing quantity Q^* tells us the market price for the firm's output.

For a firm with market power, we can think of the firm choosing a profit-maximizing quantity as equivalent to choosing a profit-maximizing price. The demand curve ties together price and quantity, so picking one implies the other. The monopolist can either produce the profit-maximizing quantity of output and let the market determine the price (which will be the profit-maximizing price), or it can set the profit-maximizing price and let the market determine the quantity (which will be the profit-maximizing quantity).

An important factor to remember is that even though firms with market power have an ability to set any price for their output, that doesn't mean they can get away with it profitably. A firm with market power still is constrained by the demand curve. Customers will stop buying if the price gets too high, even if there aren't other competitors.

When Apple had market power as the only tablet producer, it could not charge whatever price it wanted. If Apple charged $20,000 for each iPad, almost no one would have bought one (even though it was the only tablet available). A monopolist doesn't lose business to direct competitors by raising the price for its product since a monopolist has no direct competitors. However, it loses business by driving its customers out of the market. A monopolist cannot charge anything it wants, but *will* charge a higher price than a more competitive firm.

Profit Maximization with Market Power: A Graphical Approach

We can apply the exact logic of the previous analysis to graphically derive the profit-maximizing output and price of a firm with market power, given the firm's demand and marginal cost curves. Let's assume we are again looking at the market for iPads and that marginal cost is constant at \$200. Specifically, a firm with market power will follow these steps:

Step 1: Derive the marginal revenue curve from the demand curve. For a linear demand curve, this will be another straight line with the same vertical intercept that is twice as steep. In **Figure 9.3**, the marginal revenue curve is shown as *MR*.

Step 2: Find the output quantity at which marginal revenue equals marginal cost. This is the firm's profit-maximizing quantity of output. In Figure 9.3, Apple's profit-maximizing level of output is Q^*, or 80 million iPads.

Step 3: Determine the profit-maximizing price by locating the point on the demand curve at that optimal quantity level. To determine the price Apple should charge consumers to maximize its profit, just follow Q^* up to the demand curve and then read the price off the vertical axis. If Apple produces the profit-maximizing output level of 80 million, the market price will be \$600. (Or equivalently, if Apple charges a price of \$600, it will sell 80 million iPads.)

That's it. Once we have the firm's *MR* curve, we can use the profit-maximization rule $MR = MC$ to find the firm's optimal level of output and price.

Profit Maximization with Market Power: A Mathematical Approach

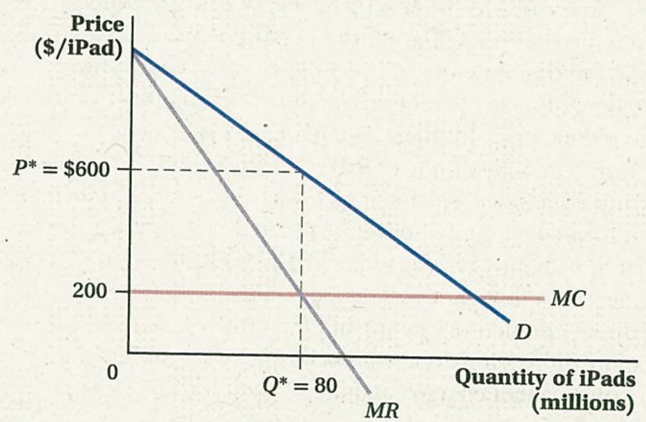
We can also solve for the profit-maximizing quantity and price mathematically, given equations for the firm's demand and marginal cost curves.

Suppose Apple's marginal cost of producing iPads is constant at \$200, and the demand curve for iPads (where Q is in millions and P in dollars) is $Q = 200 - 0.2P$. How much should Apple charge for iPads, and how many will it sell at that price? (Again, because of the equivalence of choosing price and choosing output level for firms with market power, we could ask how many iPads Apple should produce and at what price the iPads would sell, and the answer would be the same.)

We can figure this out using the same three-step process described above: Derive the marginal revenue curve, find the quantity at which marginal revenue equals marginal cost, and then determine the profit-maximizing price by computing the price at that quantity on the demand curve.

Figure 9.3 How a Firm with Market Power Maximizes Profit

Apple will maximize its profit from the iPad by producing where $MR = MC$. Therefore, Apple will sell 80 million iPads at a price of \$600 each, well above Apple's marginal cost of \$200 per iPad.



Step 1: Derive the marginal revenue curve from the demand curve. Let's start by obtaining the inverse demand curve by rearranging the demand curve so that price is a function of quantity rather than the other way around:

$$Q = 200 - 0.2P$$
$$0.2P = 200 - Q$$
$$P = 1{,}000 - 5Q$$

This is a linear inverse demand curve of the form $P = a - bQ$, where $a = 1{,}000$ and $b = 5$. Earlier we learned that $MR = a - 2bQ$ is the marginal revenue curve for this type of demand curve.[4] So for this demand curve, Apple's marginal revenue curve is

$$MR = 1{,}000 - 2(5Q) = 1{,}000 - 10Q$$

Step 2: Find the quantity at which marginal revenue equals marginal cost. Apple's marginal cost is constant at \$200. Therefore, we just set the marginal revenue curve equal to this value and solve for Q:

$$MR = MC$$
$$1{,}000 - 10Q = 200$$
$$800 = 10Q$$
$$Q^* = 80$$

Thus, Apple's profit-maximizing quantity of iPads is 80 million.

Step 3: Determine the profit-maximizing price by locating the point on the demand curve at that optimal quantity level. Find the profit-maximizing price by plugging the optimal quantity into the demand curve. This tells us at what price the optimal quantity (80 million iPads) will be sold:

$$P^* = 1{,}000 - 5Q^*$$
$$= 1{,}000 - 5(80)$$
$$= 1{,}000 - 400 = 600$$

Given this demand curve and a constant marginal cost of \$200 per iPad, then, Apple can maximize its profits by charging \$600 per unit. It will sell 80 million iPads at this price. Notice that this price is well above Apple's marginal cost of \$200, the price Apple would be charging in a perfectly competitive market. That's why firms like to have market power. The idea is simple: Reduce output. Raise prices. Make money.

[4] If we had a more complicated demand curve, we could compute the marginal revenue curve by using calculus. We would start with calculating total revenue by multiplying the inverse demand curve by Q. Then we would take the derivative with respect to Q to get the marginal revenue.

figure it out 9.2

Babe's Bats (BB) sells baseball bats for children around the world. The firm faces a demand curve of $Q = 10 - 0.4P$, where Q is measured in thousands of bats and P is dollars per bat. BB has a marginal cost curve that is equal to $MC = 5Q$.

a. Solve for BB's profit-maximizing level of output. Show the firm's profit-maximization decision graphically.

b. What price will BB charge to maximize its profit?

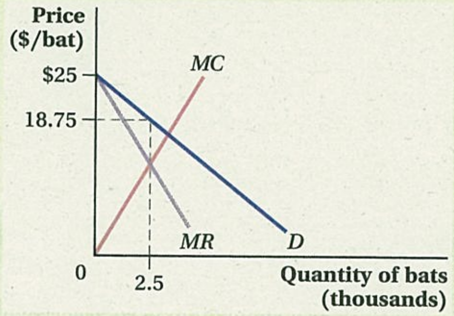
Solution:

a. To solve this problem, we should follow the three-step procedure outlined in the text. First, we need to derive the marginal revenue curve for BB bats. Because the firm faces a linear demand curve, the easiest way to obtain the marginal revenue curve is to start by solving for the firm's inverse demand curve:

$$Q = 10 - 0.4P$$
$$0.4P = 10 - Q$$
$$P = 25 - 2.5Q$$

For this inverse demand curve, $a = 25$ and $b = 2.5$. Therefore, since $MR = a - 2bQ$, we know that BB's MR curve will be

$$MR = 25 - 2(2.5Q) = 25 - 5Q$$



To solve for the profit-maximizing level of output, we can follow the profit-maximization rule $MR = MC$:

$$MR = MC$$
$$25 - 5Q = 5Q$$
$$10Q = 25$$
$$Q^* = 2.5$$

Therefore, BB should produce 2,500 bats. This profit-maximization decision is shown in the figure to the left. Profit is maximized at the output level at which the marginal revenue and marginal cost curves intersect.

b. To find BB's optimal price, we plug its profit-maximizing level of output ($Q^* = 2.5$) into its inverse demand curve:

$$P^* = 25 - 2.5Q^*$$
$$= 25 - 2.5(2.5)$$
$$= 25 - 6.25 = 18.75$$

BB should charge a price of $18.75 per bat. This is also demonstrated on the figure by following $Q^* = 2.5$ up to the demand curve and over to the vertical axis.

A Markup Formula for Companies with Market Power: The Lerner Index

We can take the logic we've just learned even further to come up with a rule-of-thumb for pricing that firms can use to determine profit-maximizing prices and output levels. Start with the definition of MR from above:

$$MR = P + \left(\frac{\Delta P}{\Delta Q}\right) \times Q$$

We know that the firm maximizes its profits by setting $MR = MC$, so plug that in:

$$MR = P + \left(\frac{\Delta P}{\Delta Q}\right) \times Q = MC$$

Now use a math trick and multiply the second term on the left side of the equation by P/P. This doesn't change the value of the equation, because multiplying by P/P is just another way of multiplying by 1. This changes our expression to

$$P + \left(\frac{\Delta P}{\Delta Q}\right) \times \frac{P}{P} \times Q = MC \quad \text{or} \quad P + \left(\frac{\Delta P}{\Delta Q} \times \frac{Q}{P}\right) \times P = MC$$

If the section in parentheses looks familiar to you, it's because it is the inverse of the elasticity of demand. Remember that in Chapter 2 we defined the price elasticity of demand E^D as $\frac{\Delta Q/Q}{\Delta P/P}$ or $\frac{\Delta Q}{\Delta P} \times \frac{P}{Q}$. The inverse of this value is $\frac{1}{E^D} = \frac{\Delta P}{\Delta Q} \times \frac{Q}{P}$. Substituting the inverse elasticity into the profit-maximization condition gives us

$$P + \left(\frac{\Delta P}{\Delta Q} \times \frac{Q}{P}\right) \times P = MC$$
$$P + \frac{1}{E^D} \times P = MC$$

A final bit of rearranging yields

$$P - MC = -\left(\frac{1}{E^D}\right) \times P \quad \text{or} \quad \frac{P - MC}{P} = -\frac{1}{E^D}$$

The left-hand side of this equation equals the firm's profit-maximizing **markup,** the *percentage of the firm's price that is greater than (or "marked up" from) its marginal cost.* What this equation indicates is that such a markup should depend on the price elasticity of demand that the firm faces. Specifically, as demand becomes more elastic—that is, as E^D becomes more negative, or equivalently, larger in absolute value—the optimal markup as a fraction of price falls. (If you can't quite see this in the equation, notice that elastic demand means a large negative number for E^D is in the denominator, making the right-hand side of the equation small.) On the other hand, as demand becomes less elastic, E^D becomes smaller in absolute value, indicating that the markup should be a larger fraction of price.

markup The percentage of the firm's price that is greater than (or "marked up" from) its marginal cost.

If we stop to think about these implications for a minute, they make perfect sense. When demand is quite inelastic, consumers' purchases of the firm's product are not sensitive to changes in price. This makes it easier for the firm to increase its profit by raising its price—it will sell fewer units, but not *that* many fewer, and it will make a higher margin on every unit it does sell. The firm should mark up its price more with less elastic demand. A firm facing relatively elastic demand, on the other hand, will suffer a greater loss in quantity sold when it raises its price, so high markups over cost benefit them less.

The measure of the markup given by the equation above has a special name: the *Lerner index* (after Abba Lerner, the economist who proposed it in 1934). As we just discussed, assuming the firm is trying to maximize its profit, the Lerner index tells us something about the nature of the demand curve facing the firm. When the index is high (i.e., when the markup accounts for a large fraction of the price), the demand for the firm's product is relatively inelastic. When the index is low, the firm faces relatively elastic demand. Because the ability to price above marginal cost is the definition of market power, the **Lerner index** is a *measure of a firm's markup and of its market power.* The higher it is, the greater the firm's ability to price above its marginal cost.

Lerner index A measure of a firm's markup and of its market power.

When demand is perfectly elastic—the firm faces a horizontal demand curve and any effort to charge a price higher than the demand curve will result in a loss of all sales—then

$E^D = -\infty$. As we see in the equation above, the Lerner index is zero in this case, which means the markup is also zero. The firm sells at a price equal to marginal cost, and the firm becomes a price taker.

When E^D lies between 0 and –1, that is, when the firm faces a demand curve that is inelastic, the Lerner index is greater than 1, implying $P - MC > P$, or $MC < 0$ which doesn't make sense. In other words, a firm should never operate at a point on its demand curve where demand is inelastic or unit elastic. That's because a price increase in that situation will raise the firm's revenue but reduce the quantity and therefore the cost. In other words, the firm is guaranteed to raise profit by increasing prices if demand is inelastic.

The Lerner index can range anywhere from 0 (perfect competition) to just under 1 (barely elastic—almost unit elastic—demand). It is a summary of the amount of market power a firm has. In comparing degrees of market power across firms, the firm with the highest Lerner index has the most market power; the firm with the second-highest Lerner index has the second-most market power, and so on.

Measuring the Lerner Index Firms with market power know their profit-maximizing markups are tied to the price elasticities they face. The difficulty from a practical standpoint is that firms don't automatically know their Lerner index and ideal markup. So, they often spend considerable effort trying to learn about the shape of the demand and marginal revenue curves they face, because that tells them about the price elasticity of demand of their customers. Amazon has been sued over offering different prices to customers for the same products. In one prominent case, Amazon CEO Jeffrey Bezos apologized by insisting that Amazon was simply randomizing prices to develop a better sense of demand in its market. This chapter shows exactly why Amazon would do this. If a company knows the shape of its own demand curve, it can determine the most profitable price to charge using either the markup formula or the monopoly pricing method.

Application: Market Power versus Market Share

Market power involves more than the size of a particular firm. For example, consider Dr. Brown's, a manufacturer of specialty sodas in the United States that produces a celery-flavored soda called Cel-Ray. Even though the sales of Coca-Cola are thousands of times larger than the sales of Cel-Ray, it turns out that Dr. Brown's has more market power than Coca-Cola by the economist's definition.

How can that be? The key factor to consider is the price elasticity of demand for the two products. Coca-Cola drinkers are, on average, fairly price-sensitive in the short run. The price elasticity of demand for a six-pack of Coke in a grocery store is around –4.1.[5] On the other hand, people who drink Cel-Ray must have a unique preference for the celery flavor. Whereas many substitutes exist for Coca-Cola, there really aren't many substitutes for Cel-Ray. Thus, Cel-Ray drinkers will likely be less price-sensitive than Coke drinkers. A reasonable estimate of the price elasticity of demand for a six-pack of Cel-Ray is about –2.

If we use these two elasticities to measure the Lerner index for each product, we indeed see that Cel-Ray has more market power than Coke:

$$\text{Lerner index for Coke} = -\frac{1}{E^D} = -\frac{1}{-4.1} = 0.244$$

$$\text{Lerner index for Cel-Ray} = -\frac{1}{E^D} = -\frac{1}{-2} = 0.5$$

Robert Takata/Guzzle & Nosh

Dr. Brown's Cel-Ray soda, a lock on its market since 1869.

[5] Jean-Pierre Dubé, "Product Differentiation and Mergers in the Carbonated Soft Drink Industry," *Journal of Economics and Management Strategy* 14, no. 4 (2005): 879–904.

Therefore, Cel-Ray's profit-maximizing price is a higher markup over its marginal costs than Coke's profit-maximizing price. In other words, Coca-Cola's pricing behavior is actually closer to the pricing behavior of a competitive firm than Cel-Ray's. It is not the size of the market or the firm's market share that determines or measures market power; it is the firm's ability to price above its marginal cost. ■

The Supply Relationship for a Firm with Market Power

We now know how to figure out the profit-maximizing quantity and price for a firm with market power, and we can do so for any given marginal cost and demand curves the firm might face. As you might imagine, we could sketch out all combinations of the firm's profit-maximizing quantities and prices implied by any possible set of marginal cost and demand curves.

That sounds a lot like a supply curve—it is, after all, a set of prices and the quantities produced—but it's not. Firms with market power don't have supply curves, strictly speaking. Their profit-maximizing price and quantity combinations are not supply curves because those combinations depend on the demand curve the firm faces. As we saw in Chapter 8, competitive supply curves exist completely independently of demand. They depend only on firms' marginal costs, because a perfectly competitive firm produces the quantity at which the market price (which the firm takes as given) equals its marginal cost. That's why a perfectly competitive firm's supply curve is a portion of its marginal cost curve, and a perfectly competitive industry's supply curve is the industry marginal cost curve. Neither of these supply curves is determined by anything having to do with demand; they are only about costs.

This strict relationship between costs and price isn't true for a firm with market power. Its optimal output level depends on not only the marginal cost curve, but also the firm's marginal revenue curve (which is related to the demand curve). Put another way, a supply curve gives a one-to-one mapping between the price and a firm's output. But for a firm with market power, even holding constant its marginal cost curve, the firm could charge a high price at a given quantity if it faces a steeper demand curve or a lower price at the same quantity if it faced a flatter demand curve. We'll see an example of this in the next section. Therefore, a simple mapping of price and quantity supplied is not possible for a firm with market power and there would be no supply curve.

9.4 How a Firm with Market Power Reacts to Market Changes

Given how profit-maximizing firms with market power should make production and pricing decisions, we can think through the effects of various market changes, much as we did with supply and demand in the competitive setting. Even though firms with market power do not have a supply curve, we will see that in some ways they react similarly to competitive firms, but sometimes quite differently.

Response to a Change in Marginal Cost

First think about the effect of an increase in marginal cost. In the iPad example, marginal cost was constant at \$200 and the inverse demand curve was $P = 1{,}000 - 5Q$ (where Q is in millions). Suppose there's a fire in the plant that manufactures the screen on the iPad, raising the marginal cost of screens, and as a result, the marginal cost of the iPad increases from \$200 to \$250.

To determine the impact of this on the market, we follow the three-step method but with the new marginal cost curve:

Step 1: Derive the marginal revenue curve. The demand curve hasn't changed, so this is the same as before: $MR = 1{,}000 - 10Q$.

Step 2: Find the quantity at which $MR = MC$. The MC is now \$250, so

$$1{,}000 - 10Q = 250$$
$$750 = 10Q$$
$$Q^* = 75$$

The new profit-maximizing quantity is 75 million units, down from 80 million.

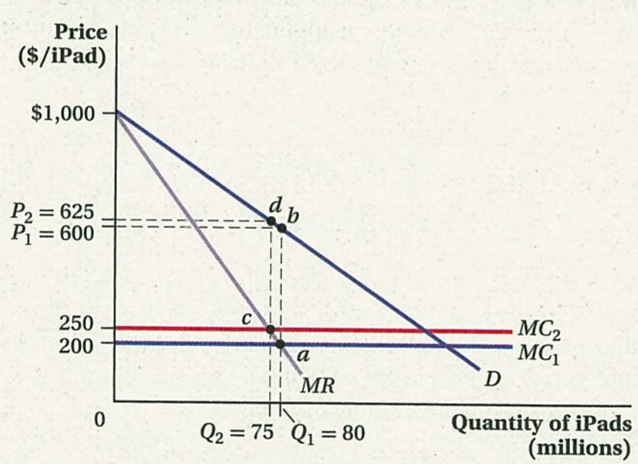
Step 3: Determine the profit-maximizing price using the optimal quantity and the demand curve. The (inverse) demand curve is $P = 1{,}000 - 5Q$. Plugging in the new quantity, we have $P^* = 1{,}000 - 5(75) = \$625$. The new price will be \$625, up from \$600 before the fire.

We illustrate the change from the initial equilibrium to the new one in **Figure 9.4**.

A firm with market power responds to a cost shock in a similar way to how a competitive firm would. When marginal cost rises, prices rise and output falls. But in competition, a change in marginal cost is fully reflected in the market price, because $P = MC$. That doesn't have to be the case when the seller has market power. In the iPad example, the market price rose only \$25 in response to a \$50 increase in marginal cost. To maximize its profit, Apple does not pass along the full increase in its cost to its customers. The drop in quantity that results from the increase in cost is also smaller than the drop that would occur in a perfectly competitive market. Note, however, that the equilibrium quantity is still higher in a competitive market than one with market power, even after the cost increase. It's only the *change* in Q that is smaller.[6]

Figure 9.4 How a Firm with Market Power Reacts to an Increase in Marginal Cost

The initial quantity of 80 million is set by $MR = MC_1$ (\$200) at point *a*. This quantity corresponds to a price of \$600, as indicated at point *b*. After the fire, the marginal cost curve shifts up to \$250 (MC_2). Because the fire only affects the supply side of the market, the consumer's willingness to pay does not change, and the demand and marginal revenue curves do not shift. Now marginal revenue equals marginal cost at point *c*, at a quantity of 75 million. Following that quantity up to the demand curve (at point *d*), we can see that the price of an iPad will rise to \$625.



[6] Exactly how much of a cost change a firm with market power will pass along to its customers depends on the shapes of the marginal cost and marginal revenue curves. Here, the optimal pass-through is half of the cost change. In other situations, it could be more or less than that; in fact, there are conditions where the optimal pass-through is larger than the change in cost. The point is that is can be (and usually is) different than the dollar-for-dollar pass-through of perfect competition.

Response to a Change in Demand

Now suppose that instead of a cost shift, there is a parallel shift in the demand curve. Perhaps a revision of the iPad's OS doubles battery life, increasing demand and shifting out the demand curve. Specifically, let's say the new inverse demand curve is $P = 1{,}400 - 5Q$.

To figure out the impact, we again follow the three-step method. Because the demand curve has shifted, the marginal revenue curve changes as well. The new demand curve is linear, so we know how to derive the marginal revenue curve; we double the number in front of the quantity in the inverse demand curve. So,

$$MR = 1{,}400 - 2(5Q) = 1{,}400 - 10Q$$

Setting this equal to the marginal cost (which we'll assume is back at its original level of \$200) implies

$$1{,}400 - 10Q = 200$$
$$10Q = 1{,}200$$
$$Q^* = 120$$

The quantity produced after the demand shift is now 120 million units, up from 80 million. Finally, we find the new price by plugging this quantity into the inverse demand curve:

$$P^* = 1{,}400 - 5Q^*$$
$$= 1{,}400 - 5(120)$$
$$= 800$$

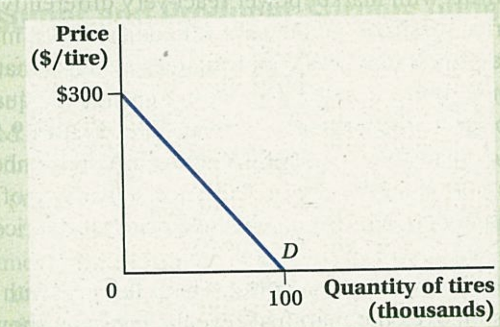
The new price is \$800, up from \$600 before the demand shift.

An outward demand shift leads to an increase in both quantity and price in a market where the seller has market power, the same direction as in perfect competition. But again, the size of the changes differs.

figure it out 9.3

Go online for interactive, step-by-step help in solving the following problem.

The Power Tires Company has market power and faces the demand curve shown in the figure below. The firm's marginal cost curve is $MC = 30 + 3Q$.



a. What is the firm's profit-maximizing output and price?

b. If the firm's demand changes to $P = 240 - 2Q$ while its marginal cost curve remains the same, what is the firm's profit-maximizing level of output and price? How does this compare to your answer for (a)?

c. Draw a diagram showing these two outcomes. Holding marginal cost equal, how does the shape of the demand curve affect the firm's ability to charge a high price?

Solution:

a. To solve for the firm's profit-maximizing level of output, we need to find the firm's marginal revenue curve. But we only have a diagram of the demand curve.

So, we will start by solving for the inverse demand function. The inverse demand function will typically have the form

$$P = a - bQ$$

where a is the vertical intercept and b is the absolute value of the slope $\left(\left|\frac{\Delta P}{\Delta Q}\right|\right)$. We can see from the figure of the demand curve that $a = 300$. In addition, we can calculate the absolute value of the slope of the demand curve as $\left|\frac{\Delta P}{\Delta Q}\right| = \left|\frac{-300}{100}\right| = 3$. Therefore, $b = 3$. This means that the demand for Power Tires is

$$P = 300 - 3Q$$

We know that the equation for marginal revenue (when demand is linear) is $MR = a - 2bQ$. Therefore,

$$MR = 300 - 6Q$$

Setting marginal revenue equal to marginal cost, we find

$$MR = MC$$
$$300 - 6Q = 30 + 3Q$$
$$270 = 9Q$$
$$Q^* = 30$$

To find price, we substitute $Q = 30$ into the firm's demand equation:

$$P = 300 - 3Q$$
$$= 300 - 3(30) = 210$$

The firm should produce 30,000 tires and sell them at a price of $210.

b. If demand changes to $P = 240 - 2Q$, marginal revenue becomes $MR = 240 - 4Q$ because now $a = 240$ and $b = 2$. Setting $MR = MC$, we find

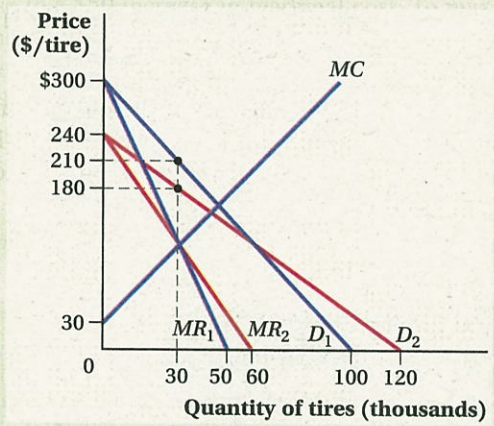
$$240 - 4Q = 30 + 3Q$$
$$210 = 7Q$$
$$Q^* = 30$$

Even with changed demand, the firm should still produce 30 units if it wants to maximize profit. Substituting into the new demand curve, we can see that the price will be

$$P^* = 240 - 2Q^*$$
$$= 240 - 2(30) = 180$$

Here, the equilibrium price is lower even though the profit-maximizing output is the same.

c. The new diagram appears below. Because D_2 is flatter than D_1, the firm must charge a lower price. Consumers are more responsive to price.

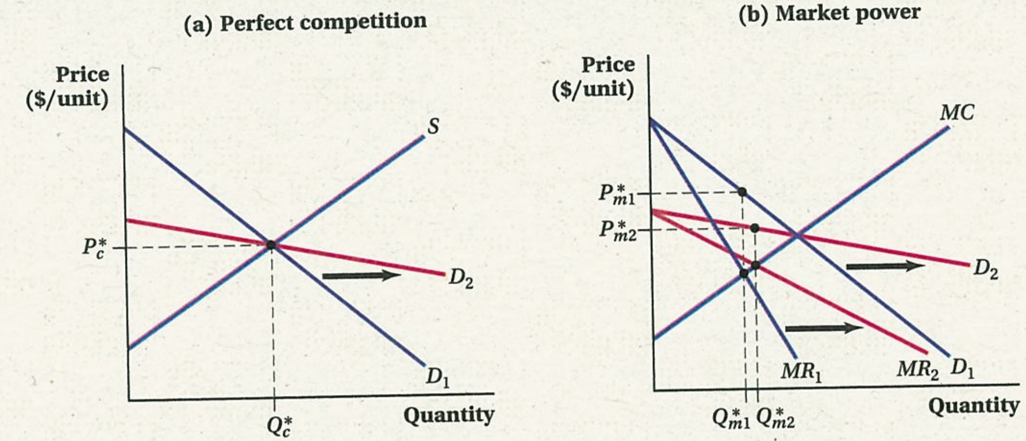


The Big Difference: Changing the Price Sensitivity of Customers

One type of market change to which firms with market power react very differently from competitive firms is a change in the price sensitivity of demand—in other words, making the demand curve steeper or flatter. Say a new competing tablet comes along so that consumers' demand for iPads becomes more price-sensitive but doesn't change the quantity demanded at the current price. With perfect competition, as in panel a of **Figure 9.5**, the flattening of the demand curve does not change the point at which $P = MC$ (as embodied in the supply curve), so neither price nor quantity moves. The price sensitivity of consumers does not impact the sellers' output decisions for competitive firms since price still equals marginal cost.

Things are different, however, for a seller with market power. That's because with market power, the rotation in demand also moves the marginal revenue curve as shown in panel b of Figure 9.5. Here, MR_2 intersects the marginal cost curve at a higher quantity

Figure 9.5 Responses to a Rotation in the Demand Curve



(a) For a perfectly competitive market, a rotation in the demand curve from D_1 to D_2 does not change the equilibrium quantity Q_c^* and price P_c^*.
(b) For a firm with market power, a rotation in the demand curve from D_1 to D_2 rotates the marginal revenue curve from MR_1 to MR_2.

Prior to the rotation, the profit-maximizing quantity and price (Q_{m1}^*, P_{m1}^*) occurred where $MR_1 = MC$. After the rotation, the firm is profit-maximizing at a higher quantity and lower price (Q_{m2}^*, P_{m2}^*) where $MR_2 = MC$.

than did MR_1 (Q_{m2}^* instead of Q_{m1}^*). Therefore, the firm's output rises as a result of the demand curve rotation and the price falls.

The opposite pattern holds when consumers become less price-sensitive and firms have market power: Output falls and price rises. Again, these changes wouldn't happen in perfect competition because suppliers' choices don't depend on the price sensitivity of demand.

9.5 The Winners and Losers from Market Power

Given that a firm with market power charges a price that is above its marginal cost, the market power benefits them. We can compute exactly how beneficial. We can also see how market power affects consumers (*Hint:* badly). We will use the same tools utilized to analyze competitive markets in Chapter 3—consumer and producer surplus. This approach allows us to directly compare markets in which firms have market power to those that are competitive.

Consumer and Producer Surplus under Market Power

Let's return to the original Apple iPad example. Apple had a marginal cost of $200 and an inverse demand curve of $P = 1{,}000 - 5Q$ (where Q was in millions). This demand curve implied a marginal revenue curve $MR = 1{,}000 - 10Q$. We set that equal to marginal cost to solve for Q and found that, to maximize profit, Apple should produce 80 million iPads and set its price at $600 per iPad.

We can compute the consumer and producer surplus when a firm has market power in the same way we computed these surpluses in a competitive market. The consumer surplus is the area under the demand curve and above the price. The producer surplus is the area below the price and above the marginal cost curve (in perfectly competitive firms, remember that marginal cost is the supply curve).

We illustrate these surpluses in **Figure 9.6**. Apple's profit-maximizing price and quantity occur at point *m*. The consumer surplus is the triangle above the price $600 and below the demand curve. This area is labeled *A*. The producer surplus is the rectangle below $600 and above the marginal cost curve. It is labeled *B*.

We can easily compute these surpluses. The consumer surplus triangle has a base equal to the quantity sold and a height equal to the difference between the demand choke price and the market price. The demand choke price is especially easy to calculate from an inverse demand curve; you just plug in $Q = 0$ and solve for the price. In this case, it's $P_{DChoke} = 1{,}000 - 5(0) = 1{,}000$. So, the consumer surplus is

$$CS = \text{Triangle } A = \frac{1}{2} \times 80 \text{ million} \times (\$1{,}000 - \$600) = \$16 \text{ billion}$$

The producer surplus is a rectangle with a base equal to the quantity sold and a height equal to the difference between the monopoly price and marginal cost. Therefore,

$$PS = \text{Rectangle } B = (80 \text{ million}) \times (\$600 - \$200) = \$32 \text{ billion}$$

So far, so good. Consumers earn $16 billion of consumer surplus from buying iPads, a fairly sizable sum, and Apple does well, making $32 billion of surplus.

Consumer and Producer Surplus under Perfect Competition

Now think about how the market would look if Apple behaved like a competitive firm and priced at marginal cost. The price would be $200 because marginal cost is constant at $200. Plugging $200 into the demand curve equation yields a quantity of 160 million. Therefore, in the competitive equilibrium, Apple would sell 160 million iPads at a price of $200 (point *c* in Figure 9.6). Note that because $P = MC$ and MC is constant, Apple would earn zero producer surplus in a competitive market.

With competition, then, iPad prices would be lower, the quantity sold would be higher, and Apple would make a lot less money (producer surplus would fall by $32 billion). It shows the standard result: The competitive market outcome has higher output and lower price than in a market where firms have market power.

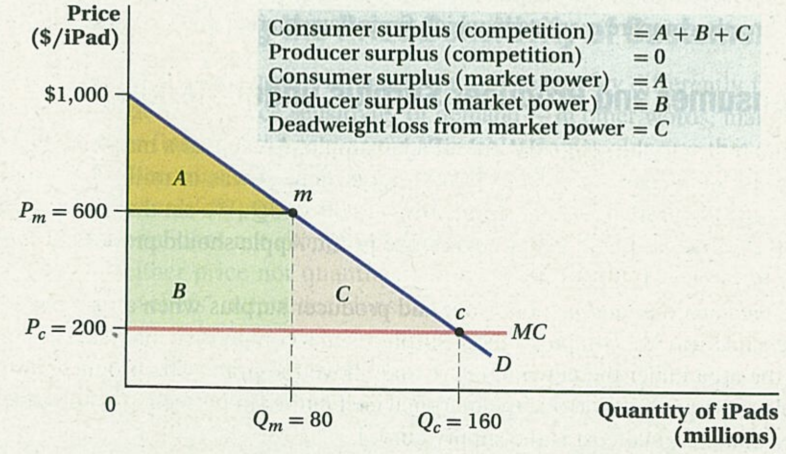
Consumer surplus goes up under perfect competition but producer surplus goes down. In Figure 9.6, consumer surplus under perfect competition is the entire triangular area $A + B + C$ below the demand curve and above the competitive price of $200. The triangle's base is the competitive quantity of 160 million and its height is the difference between the demand choke price of $1,000 and the competitive price. This means consumer surplus under perfect competition is

$$CS = \frac{1}{2} \times 160 \text{ million} \times (\$1{,}000 - 200) = \$64 \text{ billion}$$

Recall that when Apple exercised its market power, consumer surplus was only $16 billion. In this example, consumers have 4 times the consumer surplus under competition than when Apple has market power. On the other side, by exploiting its market power, Apple moves from having no producer surplus to $32 billion of producer surplus. That's why firms want to use their market power whenever they can, even if it costs their customers a large amount of consumer surplus.

Figure 9.6 Surplus from the Apple iPad

We can compute Apple's producer surplus, consumer surplus, and deadweight loss using the marginal cost curve, the demand curve, and the profit-maximizing output and price levels. Consumer surplus is the area of triangle *A*, equal to $\frac{1}{2} \times 80 \text{ million} \times (\$1{,}000 - \$600)$ or $16 billion. The producer surplus, rectangle *B*, is $(80 \text{ million}) \times (\$600 - \$200)$ or $32 billion. The deadweight loss is triangle *C* and can be calculated as $\frac{1}{2} \times (160 \text{ million} - 80 \text{ million}) \times (\$600 - \$200)$ or $16 billion.



Application: Ultra-Low-Cost Carrier Airlines

A fast-growing segment of the airline market is ultra-low-cost carriers (ULCCs). In the United States, airlines like Allegiant, Frontier, and Spirit Airlines (and others that didn't survive) base their business models off of what was arguably the original ULCC, Ryanair. As we discussed before, Ryanair takes low-cost consciousness to the highest degree so it can maintain shockingly low prices. When ULCCs enter a new airport market, they try to build traffic by aggressively undercutting fares offered by incumbent carriers. One way to think about this is that a ULCC's arrival moves an airport from a situation in which incumbents have market power to a situation that is closer to competition.

The impact is sometimes dramatic. Prices can fall by double-digit percentages on routes that the ULCC starts to fly, and the number of passengers flying the route goes up substantially. It's probably no coincidence that among the 25 busiest airports in the United States, the 5 that saw the biggest drops in average inflation-adjusted fares (for all airlines) from 2011 to 2017 were all airports at which a ULCC began to fly or substantially ramped up operations during that period. The lucky passengers were flying into and out of Chicago O'Hare (an average fare drop of 23% during the period), Newark Liberty International (average drop of 22%), Houston's George Bush Intercontinental (average drop of 21%), Dallas/Fort Worth International (average drop of 20%), and Las Vegas' McCarran (average drop of 20%).[7]

Passengers across the country have become familiar with these sorts of changes. They've gotten used to packing lighter luggage (to save on baggage fees), bringing their own food and small-size drinks onboard (there are no free snacks or beverages on a ULCC), and making do with less legroom. They're willing to go along with these changes because they can now fly for less than ever before. We suspect you can almost hear a collective cheer coming from students at schools in the cities where a ULCC has arrived in town. Thanks to competition from ULCCs, their consumer surplus is bound to rise, because returning home to visit mom and dad or heading off to a warm-weather locale for spring break just became more affordable. ■

The Deadweight Loss of Market Power

Exercising market power can be great for firms and bad for consumers. Firms earn more producer surplus by restricting output and raising price, but this costs consumers a sizable chunk of their consumer surplus. That's not the only consequence of market power, though. Notice that, in the example above, the total surplus under market power of

[7] These numbers were taken from data compiled by the Bureau of Transportation Statistics of the U.S. Department of Transportation.

\$48 billion (\$16 billion consumer surplus + \$32 billion producer surplus) is smaller than the total surplus under competition of \$64 billion. That missing \$16 billion of surplus has been destroyed by the firm's exercise of market power. No one gets it. It just disappears. In other words, it is the deadweight loss from market power.

The deadweight loss of market power can be seen in Figure 9.6. It is the area of triangle *C* whose base is the difference between the firm's output with market power and its output under perfect competition, and whose height is the difference between the prices under market power (P_m) and competition (P_c). We know from our comparison of the total surplus of the market power and competitive cases above that this area is \$16 billion. We can confirm that value by calculating the area of triangle *C*:

$$DWL = \frac{1}{2} \times (160 \text{ million} - 80 \text{ million}) \times (\$600 - \$200) = \$16 \text{ billion}$$

The deadweight loss (DWL) is the inefficiency of market power. Note that this cost is exactly like the DWL from a tax or regulation we discussed in Chapter 3—a triangular area below the demand curve and above the marginal cost curve (supply curve, in Chapter 3). A firm with pricing power essentially puts a market power "tax" on consumers and keeps the revenue for itself. The DWL comes about because there are consumers in the market who are willing to buy the product (an iPad in this example) at a price above its cost of production, but who won't because the firm has hiked up prices to increase its profit. Just as with the DWL from taxes and regulations, the size of the DWL from market power is related to the size of the difference between the monopoly and competitive output levels. The more the firm withholds output to maximize profits, the bigger is the efficiency loss.

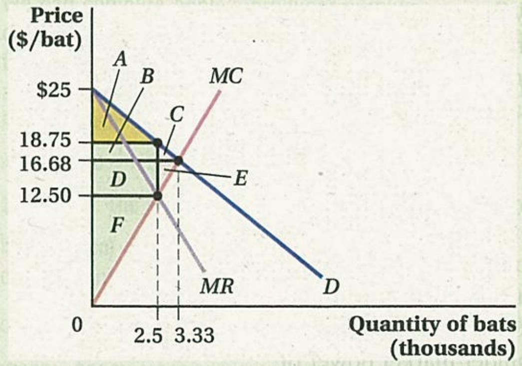
The online appendix to Chapter 3 uses integration to calculate producer surplus and deadweight loss for firms.

figure it out 9.4

Let's return to our earlier problem regarding Babe's Bats (BB). Remember that BB faces an inverse demand curve of $P = 25 - 2.5Q$ and a marginal cost curve $MC = 5Q$. Calculate the deadweight loss from market power at the firm's profit-maximizing level of output.

Solution:

The easiest way to find deadweight loss is to use a diagram. Therefore, we should start by drawing a graph with demand, marginal revenue, and marginal cost:



We know from our earlier problem that the profit-maximizing level of output is 2,500 bats sold at a price of \$18.75.

To find the deadweight loss from market power, we need to consider the consumer and producer surplus and compare them with the competitive outcome. If BB participated in a competitive market, it would set price equal to marginal cost to determine its output:

$$P = MC$$
$$25 - 2.5Q = 5Q$$
$$25 = 7.5Q$$
$$Q^* = 3.33$$

Therefore, BB would sell 3,333 bats. Of course, the price will be lower at this level of output:

$$P^* = 25 - 2.5Q^*$$
$$= 25 - 2.5(3.33)$$
$$= 16.68$$

If the market were competitive, the bats would sell for \$16.68 each. Consumer surplus would be areas $A + B + C$ (the area below the demand curve and above the competitive price), and producer surplus would be areas $D + E + F$ (the area below the competitive price but above the marginal cost curve). Total surplus would be areas $A + B + C + D + E + F$.

When BB exercises its market power, it reduces its output to 2,500 bats and increases its price to \$18.75. In this situation, consumer surplus is only area *A* (the area below demand but above the monopoly price). Producer surplus is areas $B + D + F$ (the area below the monopoly price but above marginal cost). Total surplus under market power is $A + B + D + F$.

So, what happens to areas *C* and *E*? Area *C* was consumer surplus but no longer exists. Area *E* was producer surplus but also has disappeared. These areas are the deadweight loss from market power. We can calculate this area by measuring the area of the triangle that encompasses areas $C + E$. To do so, we have one more important calculation to make. We need to calculate the height of the triangle, so we need to determine the marginal cost of producing 2,500 units:

$$MC = 5Q$$
$$= 5(2.5)$$
$$= 12.5$$

Now, we can calculate the area of the deadweight loss triangle:

$$DWL = \text{Areas } C + E = \frac{1}{2} \times \text{Base} \times \text{Height}$$
$$= \frac{1}{2} \times (3.33 - 2.5) \times (\$18.75 - \$12.50)$$
$$= \frac{1}{2} \times 0.83 \times \$6.25$$
$$= \$2.59375$$

Remember that the quantity is measured in thousands, so the deadweight loss is equal to \$2,593.75.

Differences in Producer Surplus for Different Firms

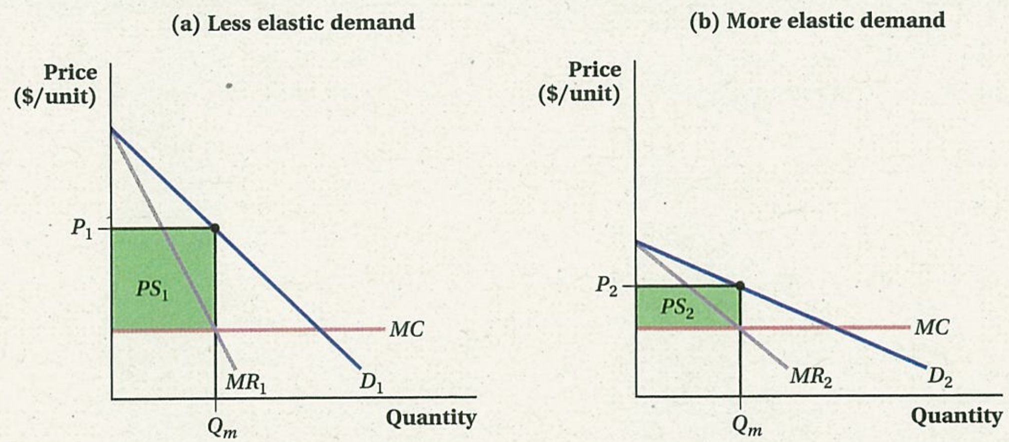
One more important point about the implications of market power concerns how the slope of the demand curve influences the relative size of consumer and producer surplus in the market.

Consider two different markets: one with a relatively steep (inelastic) demand curve and one with a flatter (elastic) one. Each is served by a monopolist. To keep things simple, imagine that both firms have the same constant marginal cost curves, and that it just so happens each firm's profit-maximizing output is the same. We plot this case in **Figure 9.7**.

In the market in panel a of Figure 9.7, buyers aren't very price-sensitive, so the demand curve is steep. In the market in panel b, consumers are quite sensitive to prices, as reflected in the flatter demand curve. The figure also shows the marginal revenue curves in both markets. To maximize their profits, both firms choose quantity and price to set $MR = MC$. It is clear from looking at the figure that for the same-sized market (measured by the total quantity of the good that is produced, which we've set to be the same here), producer surplus is higher when the demand curve is steeper. That's because, as we pointed out earlier, a steeper demand curve raises the firm's profit-maximizing markup of price over marginal cost.

Firms with market power love to operate in markets in which consumers are relatively price-insensitive. If you're a consumer in that market, though, look out: Prices are going to be high.

Figure 9.7 Gains from Market Power under Different Demand Curves



(a) When buyers are not very price-sensitive, the demand curve is steep. At $MR_1 = MC$, the producer supplies quantity Q_m at the relatively high price P_1, and generates the relatively large producer surplus PS_1.

(b) When buyers are price-sensitive, the demand curve is flat. At $MR_2 = MC$, the producer also supplies quantity Q_m, but at the relatively low price P_2, and generates the relatively small producer surplus PS_2.

9.6 Governments and Market Power: Regulation, Antitrust, and Innovation

We've seen the impact that market power can have on an industry—higher prices, smaller output, lower consumer surplus, and deadweight loss. The deadweight loss created by market power can justify government intervention in markets if such regulation can move the market toward a more competitive outcome and reduce deadweight loss. And, indeed, governments attempt to do this in several ways. After thinking about them, we will also explore the ways in which the government sometimes encourages market power and how this, too, can have an economic justification.

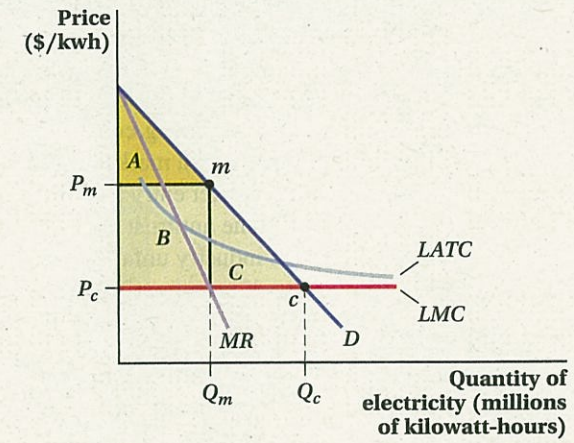
Direct Price Regulation

When a concern exists that firms in an industry have too much market power, governments sometimes directly regulate prices. Often, this occurs in markets considered to be natural monopolies. If there is no way to prevent the existence of a natural monopoly because of the nature of the industry's cost structure, the government will frequently allow only a single firm to operate but will limit its pricing behavior to prevent it from fully exploiting its market power. Governments have used this argument to justify regulating, at various times, the prices of electricity, natural gas, gasoline, cable television, local telephone service, long-distance telephone service, airfares, trucking, and many other products.

To understand the logic behind these actions, consider a typical natural monopoly case as shown in **Figure 9.8**. Let's suppose it is the market for electricity distribution, which we argued earlier may be a natural monopoly. With a demand curve of D, an unregulated electric company would produce at the point where marginal revenue equals marginal cost. This would lead to a price of P_m, substantially higher than the firm's marginal cost. The consumer surplus in this situation will be only the area A, rather than the area $A+B+C$, as would be the case if prices were instead set at P_c, a level equal to the firm's marginal cost.

Figure 9.8 Government Regulation of a Natural Monopoly

Before government regulation, the electric company produces at point m, where quantity is Q_m and price P_m is well above the firm's marginal cost curve. If the government sets a price cap at the level equal to the firm's marginal cost, the firm will produce at the perfectly competitive price (P_c) and quantity (Q_c). Consumer surplus under the regulation will expand from triangle A to the triangle $A+B+C$. However, since P_c falls below the firm's average total cost curve, the firm will be operating with negative profit, and the price cap is not a sustainable regulation.



If the government imposes a price cap regulation that forbids the electric company from charging prices above P_c, output could equal its perfectly competitive level, and consumer surplus will equal area $A+B+C$. But there's a problem. P_c is below the firm's average total cost; if it sells every unit it produces at the regulated price, the firm will earn a negative profit, as it won't be able to cover its fixed cost. Therefore, a simple price regulation requiring competitive pricing is not a sustainable solution in regulating a natural monopoly. However, any regulation that would allow a price above marginal cost in order to permit the natural monopolist to recoup its fixed cost would also lead to a deadweight loss and less consumer surplus than the competitive case (though the deadweight loss may be smaller and the reduction in consumer surplus smaller than in the unregulated monopoly case).[8]

Aside from this problem, there are several other serious difficulties involved in using direct price regulations. First and foremost, only the company knows its true cost structure, so it's difficult to set the regulated price at the perfectly competitive level. The regulator is left to estimate them. Furthermore, the firm has an incentive to pretend its costs are higher than they really are, because this would justify a higher regulated price. In addition, companies that are regulated based on their cost often have no incentive to reduce their costs because the regulator would then reduce the regulated price, destroying any profit gained from the increase in efficiency.

Antitrust

Another approach governments use to address the effects of market power is **antitrust law** (sometimes called *competition policy* outside the United States), *laws designed to promote competitive markets by restricting firms from behaviors that limit competition.*

Antitrust laws are meant to promote competition in a market by restricting firms from certain behaviors that may limit competition, especially if the firm is an established and

antitrust law Laws designed to promote competitive markets by restricting firms from behaviors that limit competition.

[8] There is a way, at least theoretically, that regulation could achieve both the perfectly competitive outcome and allow the firm to pay its fixed costs. This would involve not just a per-unit price P_c, but also a lump-sum payment to the monopolist either from consumers or the government. Many regulated utilities have payment structures that try to replicate this in part, with a fixed monthly fee for service regardless of the quantity used plus an additional fee tied to the quantity the consumer purchases. However, these fee schedules are often only approximations to the true cost structure of the monopolist and can also be constrained by political considerations, so it is difficult to achieve perfectly competitive outcomes exactly.

substantial current player in the industry. In some cases, antitrust laws are used to prevent firms from merging with or acquiring other firms in order to stop them from becoming too dominant. Occasionally, these laws are even used to force the break-up of an established firm that is determined to have too much market power. Antitrust law tends to be strong and well enforced in high-income countries, but is often much weaker elsewhere in the world.

One of the strongest and most common prohibitions in antitrust law is the ban on collusion among competitors with regard to pricing and market allocation (agreements to divide up a market among firms). In the United States, for example, even discussing prices or market entry strategies with your competitors is a criminal act.

The antitrust authorities are also allowed to investigate whether a firm is monopolizing an industry unfairly and, if so, they can sue to change the behavior. There have been many such investigations in recent years—for example, those investigating Intel for its pricing of its CPUs to computer makers; American Express, Visa, and MasterCard for the rules they require merchants to follow when customers want to use credit cards to make purchases; and realtors for the rules they set about who is allowed to list houses for sale.

The drawbacks of antitrust enforcement as a way of preventing market power have to do with the large potential costs and uncertainties involved. The government should not fight mergers and acquisitions that would increase efficiency and make consumers better off, but only those that would harm them. The problem is that it's often difficult to tell those two cases apart ahead of time.

Promoting Monopoly: Patents, Licenses, and Copyrights

Even as the government tries to limit market power through regulation and antitrust policy, it sometimes *encourages* monopolies and helps them legally enforce their market power by conferring patents, licenses, copyrights, trademarks, and other assorted legal rights to exercise market power.

Why would the government do this if it cares about consumers and competitive markets? Pharmaceutical companies, for example, receive patent-based monopolies on all sorts of medicines, which raise the prices people pay. Radio stations and mobile phone companies license broadcast spectrum, which prohibits others from broadcasting. Copyright owners of a book or movie get 125 years of protection from anyone copying their work without obtaining approval and paying royalties in the United States. The Marvel superheroes have similar protection. You might have a great idea for using a superhero in your own movie, but the government has given Marvel (and its owner, Disney) the right to determine how Marvel characters are used commercially.

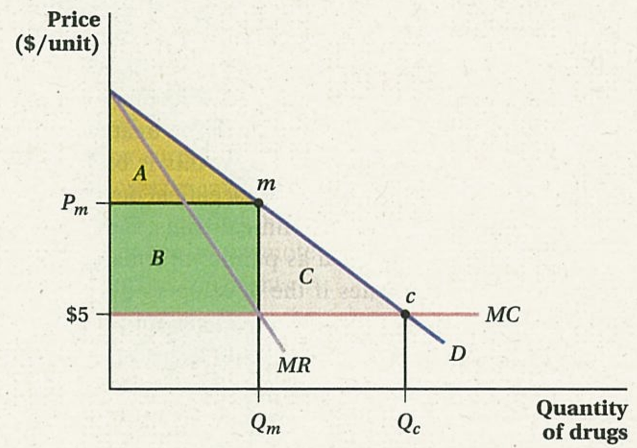
Collectively, all the monopolies created by the government add up to immense amounts of market power that inevitably lead to higher prices and lower quantities than would exist in a competitive market. The reason why it still might make sense for the government to do this is for the sake of encouraging innovation. Giving someone the exclusive right, at least temporarily, to the profits from innovation can provide a powerful incentive to create new things. Governments have decided that the consumer surplus created by these new goods can outweigh the deadweight loss from their producers having market power for a period of time. In some cases, innovation can be the upside of market power.

To see why, think about a company that invents a cure for the common cold. Demand for such a cure is the curve D in **Figure 9.9** and the marginal cost of production, say, is \$5. Without a patent but with a competitive market of producers, consumer surplus would total $A + B + C$ but producer surplus would be zero.

But if developing a new drug has a high fixed cost, the firm will only try to find the cure if it thinks it can make some surplus. In theory, the government could try to subsidize the development cost (and it does subsidize many types of research and development), but all

Figure 9.9 Monopoly Power and Innovation

The government encourages innovation by giving companies monopolies on products. D represents the demand curve for the cure for the common cold. In a perfectly competitive market, the drug would be sold at a price equal to its marginal cost, \$5, and consumer surplus would be $A+B+C$. However, at this price, the firm would be unable to recover the fixed cost of developing the drug and would choose not to invest in the cure for the common cold. By giving the firm a patent, the government allows it to recover the costs of innovation, and the firm produces at the monopoly price P_m and quantity Q_m. The consumer surplus is now the triangle A.



sorts of problems arise, such as trying to figure out what will work, avoiding corruption, and so on. Instead, the government makes a compromise. It promises the firm a monopoly on any drug it develops. The company realizes this means it can produce the quantity level Q_m (where $MR = MC$) and charge a price of P_m, giving it a producer surplus equal to area B from selling a new drug. Therefore, as long as the firm expects the fixed cost of discovering the drug to be smaller than the producer surplus B, it will set out to discover the cure for the common cold. Ultimately, this benefits consumers by giving them a consumer surplus equal to area A. This is lower than the consumer surplus consumers would get in a competitive market ($A + B + C$), but given that the firm would not have developed the drug in the first place if it had to charge a competitive price, consumers are better off with the more limited consumer surplus of A than none at all.

Overall, the economics of intellectual property protection suggest that it will tend to lead to innovations in just the types of goods that people like most. Goods with steeper demand curves tend to be those with the highest consumer surplus. Earlier in this chapter, we observed that the steeper demand curves are exactly those where monopoly profits are largest. So, a patent, license, or copyright that gives innovators a monopoly will tend to encourage innovation in exactly the types of goods that people value. The downside, of course, is that this will tend to lead to high prices as well.

Application: Patent Length and Drug Development

In the United States, as with most countries' patent systems, the monopoly right granted by the patent lasts for a certain period (20 years in the United States). This period begins when the patent application is filed, not when the application is approved or when the product is first sold. This timing detail is important in explaining what kinds of drugs are developed, and often it distorts development away from drugs that could have greater benefits than those that are actually brought to market.

Economists Eric Budish, Benjamin Roin, and Heidi Williams examined how this issue affected the development of cancer drugs.[9] Different drugs are designed to fight cancer

[9] Eric Budish, Benjamin Roin, and Heidi Williams, "Do Firms Underinvest in Long-Term Research? Evidence from Cancer Clinical Trials," *American Economic Review* 105, no. 7 (July 2015): 2044–2085.

at different stages of the disease. Some are more effective for early-stage cancers; others, later-stage cancers. It is easy to imagine that patients would benefit from this entire range of treatments. In fact, early-stage treatments may have even greater value if they can halt or considerably slow the cancer's progression. And a drug that could *prevent* cancer altogether might offer the greatest value of all. However, Budish, Roin, and Williams found that the cancer drugs actually developed and brought to market are disproportionately designed for late-stage treatments.

The reason for this is built into the designs of the patenting and drug development process. Pharmaceutical developers typically apply for a patent on a new drug just before it begins clinical trials, because that is when the drug's chemical compound must be released as public information. This compound could be easily copied by other companies if the developers didn't apply for a patent. At the same time, the pharmaceutical manufacturers cannot start selling the drug just because they've applied for a patent. To do that, the drug has to first earn the approval of the Food and Drug Administration (FDA), which is granted only after the drug has been shown to be safe and effective in clinical trials. This process means that a gap occurs between when a drug's patent application is made (when its 20-year patent clock starts ticking) and when the company can start making money off its monopoly power. The length of this gap depends on how long the drug's clinical trials last.

The length of that gap and how it varies across types of drugs are the key parts of the cancer drug story. The cancer drugs with the shortest clinical trials tend to be those designed to treat late-stage disease. The unfortunate reality is that most patients with late-stage cancer don't survive very long, so clinical trials for drugs to treat such late-stage cancers will show relatively quickly whether a new drug is effective. For example, one of the drugs in the study was a treatment for metastatic prostate cancer that increased expected patient survival from 12.8 months to 16.7 months. In this kind of situation, a drug only needs to be in clinical trials for a few years before it is clear that the drug is effective (in the sense that it is statistically shown to prolong life, even if only for a few months). The trial for this metastatic prostate cancer drug, for instance, lasted three years. Therefore, drugs like this tend to gain FDA approval relatively quickly, allowing the pharmaceutical company more time to sell the drug under patent protection.

The situation is different for early-stage cancer drugs. Because five-year survival rates for most early cancers are quite high, clinical trials for drugs that treat such cancers have to continue quite a while before it is clear if the drugs are effective or not. For these drugs, a longer gap thus exists between patenting and FDA approval. An example from the study involved another prostate cancer drug, but in this case one intended to treat the disease's early stages. This drug required an 18-year-long trial to prove that it was effective. By the time the drug received FDA approval, any patent on it would have expired. For drugs that might prevent cancer, some trials must span decades before their effects are confirmed.

Pharmaceutical companies are well cognizant of this issue. The length of time during which they can sell their drugs under patent protection will be longer for late-stage cancer treatments than early-stage treatments or preventive drugs. They respond to this incentive by developing many more late-stage cancer drugs, even though a lot of patients might, in fact, benefit from preventative or early-stage therapies. This disincentive really matters: Budish, Roin, and Williams estimated that the lost treatment options due to the underinvestment in preventative and early-stage cancer treatments cost the average U.S. cancer patient over a half year of life expectancy. Here, the incentives created by the patent system are literally a matter of life and death. ■

9.7 Conclusion

Unlike the perfectly competitive firms of Chapter 8, firms with market power don't just choose the quantity they supply at some fixed price determined by the market. Monopolies and other types of firms with market power have the ability to influence the prices of their goods. They produce at the profit-maximizing quantity where $MR = MC$. This production level is lower than the quantity a perfectly competitive market would produce, leading to a higher market price, more producer surplus, less consumer surplus, and deadweight loss. To raise consumer surplus and reduce deadweight loss, governments often intervene through direct price regulation and antitrust laws to reduce firms' market power. On the other hand, governments also sometimes encourage market power to promote product innovation, such as through the issuance of patents, trademarks, and copyrights.

Even though the firms we've studied in this chapter have the ability to set the price of their products, they are still limited in one important aspect of pricing. In particular, we assumed that if a firm increased the quantity it produces, this would lead to a decrease in the price on *every* unit of the good sold. But what if a firm could sell its product at different prices to different types of consumers? We will discuss this use of a firm's market power, a strategy broadly categorized as *price discrimination,* in Chapter 10.

Summary

1. Most firms have some **market power,** meaning that the firm's production decisions affect the market price of the good it sells. Firms maintain market power through **barriers to entry** into the market. These barriers include **natural monopolies,** switching costs, **product differentiation,** and absolute cost advantages of key inputs. **[Section 9.1]**
2. A monopoly is the sole supplier of a good in a market and represents the extreme case of a firm with complete market power. Monopolies and other firms with market power base their production decisions, in part, on their marginal revenue, the revenue from selling an additional unit of a good. Unlike perfectly competitive firms, these firms' marginal revenue falls as output rises. As a result, when a firm increases its production of a good, its marginal revenue falls, because it must sell all units of the good (not just the additional unit) at a lower price. **[Section 9.2]**
3. The profit-maximizing output level for a monopolist is found where marginal revenue equals marginal cost, $MR = MC$. A monopoly will charge a price above its marginal cost, meaning that the market price for a monopoly is higher than that for a perfectly competitive firm. The **Lerner index** computes how much a firm should mark up its price; the more inelastic the demand for a product, the higher the firm's Lerner index and markup. **[Section 9.3]**
4. The changes in quantity supplied and price created by cost and demand shocks have the same direction, but different magnitudes, for firms with market power as for perfectly competitive firms. However, firms with market power respond differently to changes in consumers' price sensitivities—that is, rotations in the demand curve—than do perfectly competitive firms. **[Section 9.4]**
5. When a firm exercises its market power, it increases its producer surplus, decreases consumer surplus, and creates a deadweight loss. Producer surplus is greater when consumers are relatively price-insensitive and the demand curve is steep. **[Section 9.5]**
6. Governments often intervene to reduce the deadweight loss created by firms with market power. Direct price regulation and **antitrust laws** are aimed at reducing firms' market power. Conversely, governments also grant market power to firms through patents, copyrights, and other laws as a way of promoting innovation. **[Section 9.6]**

Review Questions

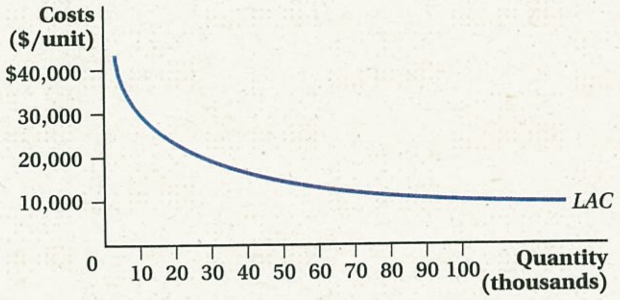
1. When does a firm have market power?
2. Name and describe three barriers to entry to a market.
3. What are the characteristics of a natural monopoly? Why is it efficient for society for a natural monopoly to produce all the output of an entire industry?
4. Describe the connection between the slope of the demand curve for a good and a firm's marginal revenue.
5. What is the profit-maximizing output level for a firm with market power?

6. Compare the consumer and producer surplus of perfectly competitive firms with that of firms with market power.
7. Why does the profit-maximizing strategy of a firm with market power create a deadweight loss?
8. Why do firms with market power have only demand—and not supply—curves?
9. Firms with market power respond differently to changes in consumers' price sensitivity than do perfectly competitive firms. Explain why this is true.
10. Name some regulations the government imposes on firms with market power.

Problems

(Solutions to problems marked an asterisk appear at the back of this book. Problems adapted to use calculus are available online.)

1. Consumers in Carlandia are willing to purchase up to 100,000 cars each year. Suppose the long-run average cost curve for auto producers in Carlandia looks like that shown in the figure below:

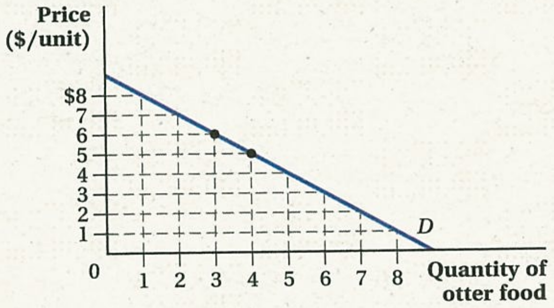


a. If the supply side of Carlandia's auto market has 10 identical firms operating, what is the lowest potential price that consumers might be able to purchase a car for?
b. If the supply side of Carlandia's auto market is served by a monopolist, what is the lowest potential price that consumers might be able to purchase a car for?
c. Conventional wisdom suggests that competition is preferred to a monopoly. Do your answers to (a) and (b) support this widely held view?
d. Suppose the car market in Carlandia is served by a monopolist. One day, fed up with the mediocre quality of the existing supplier's offerings, a resident decides to open a competing car company. What are the new company's chances of lasting in this industry? Explain your reasoning.

2. Identify and explain the sources of market power for each case listed below:
a. In the early 1990s, the DeBeers diamond cartel controlled almost all of the world's rough diamond production.
b. Microsoft's Word has a virtual monopoly in word processing, even though many claim that better word-processing programs exist.
c. Union Pacific dominates the rail shipping market in the north central United States.
d. In Louisiana, people must pass a licensing test before they can arrange flowers for a living.
e. There's a Starbucks on practically every busy corner, in every bookstore, and in every airport; customers willing to walk can find better coffee selling for less.

3. Indicate whether the following statements are true or false, and then explain your answers:
a. The marginal revenue from selling another unit of eggs can never be higher than the price of eggs.
b. Because the price a seller charges is always greater than $0, the marginal revenue from selling another unit must also be greater than $0.

*4. Consider the demand curve for otter food shown below:



a. Indicate the area representing the total revenue Oscar, an otter food seller, would receive if he chose a price of $6.
b. On the same graph, indicate the area representing the total revenue Oscar the seller would receive if he chose a price of $5.
c. You should now have added two rectangles to your graph; however, because of some overlap, it actually appears that you've added three. One of the three is common to both scenarios above. The other two (smaller) rectangles are specific to scenario (a) or scenario (b). Label each rectangle with "A," "B," or "both" to indicate which scenario each rectangle belongs to.
d. Indicate what happens (gain or loss) to rectangle A as Oscar reduces his price from $6 to $5. Why?
e. Indicate what happens (gain or loss) to rectangle B as Oscar reduces his price from $6 to $5. Why?

f. Calculate the area of rectangle A and the area of rectangle B. Then subtract the area of A from the area of B.
g. Calculate the marginal revenue Oscar receives when he sells a 4th unit by subtracting the total revenue from selling 3 units from the total revenue from selling 4 units. Does your answer agree with the number you calculated in (f)? Explain.

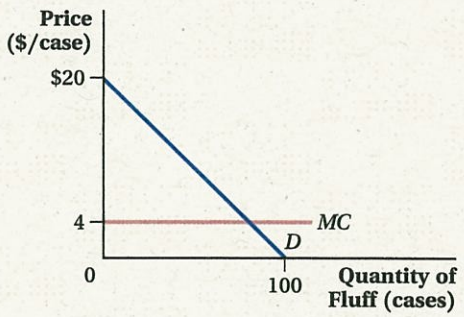
5. In Cleveland, Clive sells 15 cloves at a price of $5 each. If Clive lowers his price by 10%, to $4.50 per clove, he will sell 16, or 6.67% more. In Dallas, Delores sells 15 cloves for $5 each. If Delores lowers her price by 2%, to $4.90, she will sell 16 cloves, or 6.67% more.
a. Classify the demand curves that Clive and Delores face as elastic or inelastic.
b. Determine the marginal revenue of the 16th unit for Clive. Then compute the marginal revenue of the 16th unit for Delores.
c. How does the marginal revenue received by a seller depend on the price elasticity of demand? Explain your answer.

6. In this chapter, we noted that the marginal revenue a seller receives can be expressed as $MR = P + (\Delta P/\Delta Q) \times Q$.
a. Using this formula as a starting point, show that marginal revenue can be expressed as $MR = P(1 + 1/E^D)$, where E^D is the price elasticity of demand.
b. Using your knowledge about the price elasticity of demand, explain why the marginal revenue a firm with market power receives must always be less than the price.
c. Using your knowledge of the price elasticity of demand, explain why the marginal revenue a perfectly competitive firm receives must be equal to the price.

*7. In a small college town, the demand for delivery pizza is given by $Q^D = 800 - 32P$, where Q^D measures the number of pizzas demanded each week.
a. Use the demand function given above to derive the associated marginal revenue function. (In other words, express marginal revenue as a function of Q.)
b. Calculate marginal revenue when $Q = 96$ and when $Q = 480$. How do they differ?
c. At what quantity does $MR = 0$?
d. What is special about the point at which marginal revenue is zero? (*Hint*: Graph the demand and marginal revenue curves.)

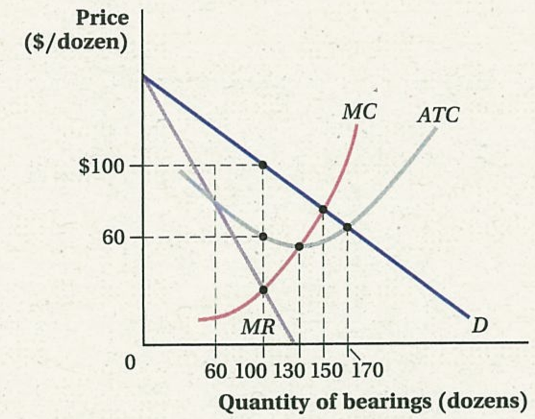
8. Juanita maintains the only greenhouse in isolated Point Barrow, Alaska, and therefore has a monopoly on the sale of fresh flowers. Her hired-gun statistician estimates that the elasticity of demand for her flowers is −0.5. Explain intuitively how you know that Juanita cannot be maximizing profits. (*Hint:* Think about total revenue and total costs.)

9. Consider the graph below, which illustrates the demand for Fluff. Fluff can be produced at a constant marginal and average total cost of $4 per case:



a. Draw in a carefully constructed marginal revenue curve.
b. Apply the $MR = MC$ rule to determine the profit-maximizing level of output. What price must the monopolist charge to maximize profit?
c. Calculate the profit earned by the monopolist.
d. The slope of the demand curve indicates that in order to sell one more unit, the price must fall by 20 cents. Verify that the seller cannot increase profit by reducing price and selling slightly more.
e. The slope of the demand curve indicates that if the price of Fluff increases by 20 cents, consumers will buy one less unit. Verify that the seller cannot increase profit by increasing price and selling slightly less.

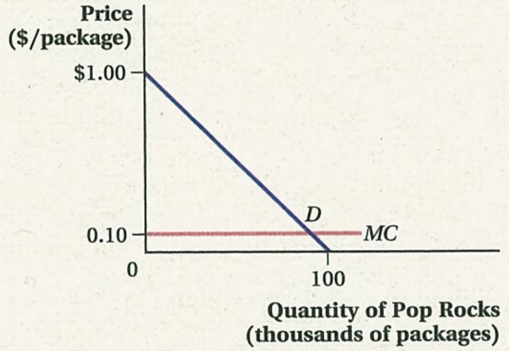
*10. Irwin is a monopoly seller of specialty bearings. Consider the graph on the next page, which illustrates the demand and marginal revenue curves for Irwin's 30-weight ball bearings, along with the marginal and average total costs of producing bearings.
a. Find the monopolist's profit-maximizing level of output.
b. Determine the price the monopolist should charge to maximize profit.
c. Draw an appropriate rectangle on your graph to represent the total revenue the seller receives from selling the profit-maximizing quantity of bearings at the profit-maximizing price.
d. Draw an appropriate rectangle on your graph to represent the total cost of producing ball bearings at the profit-maximizing quantity.
e. The difference in the areas you drew in (c) and (d) represents profit. Calculate the profit Irwin earns from selling 30-weight ball bearings.



11. Suppose that econometricians at Hallmark Cards determine that the price elasticity of demand for greeting cards is –2.
    a. If Hallmark's marginal cost of producing cards is constant and equal to $1.00, use the Lerner index to determine what price Hallmark should charge to maximize profit.
    b. Hallmark hires you to estimate the price elasticity of demand faced by its archrival, American Greetings. Hallmark estimates that American's marginal cost of producing a greeting card is $1.22. You note that American's cards sell for an average of $3.25. Assuming that American Greetings is maximizing profit, calculate its price elasticity of demand.
12. In 2018 pop star Drake was downloaded twice as often as Cardi B. She, in turn, was downloaded twice as often as Bruno Mars. Yet, downloads for these artists all sold for the same price in Apple's iTunes store. Does this suggest that Apple is failing to maximize profits? (*Hint:* Make the reasonable assumption that the marginal cost of supplying a download is a constant $0.25. Then try to construct a graphical example in which very different demand curves produce the same price.)
13. Determine whether the italicized statement below is true or false. Then explain your answer. *A firm with market power will find that the quantity of output that maximizes revenue is lower than the quantity at which profits are maximized.*
14. Suppose that a monopolistic seller of designer handbags faces the following inverse demand curve: $P = 50 - 0.4Q$. The seller can produce handbags for a constant marginal and average total cost of $10.
    a. Calculate the profit-maximizing price for this seller.
    b. Suppose the government levies a $4 tax per unit on sellers of handbags. Calculate how this tax will affect the price the monopolist charges its customers.
    c. Who bears the burden of this tax?
15. The inverse demand for Harley Davidson motorcycles is given by $P = 40{,}000 - 10Q$, where P is the price in dollars and Q measures the number of units sold each month. Harley Davidson is currently producing motorcycles at a constant marginal and average cost of $16,000.
    a. Solve for the profit-maximizing price and quantity of Harley Davidson motorcycles.
    b. Heavy tariffs on imported steel drive up Harley's marginal and average cost by $2,000. How do these tariffs affect Harley's profit-maximizing price and quantity? How will the tariffs affect Harley's profits?

*16. Suppose that the demand for bentonite is given by $Q = 40 - 0.5P$, where Q is in tons of bentonite per day and P is the price per ton. Bentonite is produced by a monopolist at a constant marginal and average total cost of $10 per ton.
    a. Derive the inverse demand and marginal revenue curves faced by the monopolist.
    b. Equate marginal cost and marginal revenue to determine the profit-maximizing level of output.
    c. Find the profit-maximizing price by plugging the ideal quantity back into the demand curve.
    d. How would your answer change if demand increased to $Q = 55 - 0.5P$?

17. Consider the market for Pop Rocks depicted in the diagram below:



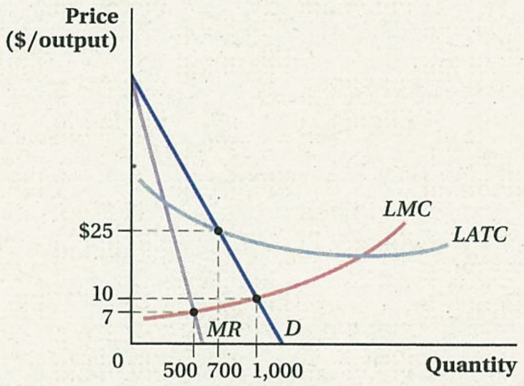
    a. If the Pop Rock industry were competitive, what would the competitive price and quantity be?
    b. If the Pop Rock industry were competitive, what would the consumer and producer surpluses be, respectively?
    c. Suppose that gangland figure Tommy Vercetti monopolizes the Pop Rock market. To maximize his profit, what price and quantity would he choose?
    d. Calculate the consumer and producer surpluses of this Pop Rock monopoly.
    e. Compare your answers in (d) to (b). How big is the deadweight loss of monopoly?

18. The graph in Problem 10 depicts the market demand for 30-weight ball bearings. That particular market segment is monopolized by a single producer named Irwin. Referring to that graph:
    a. how do the monopolist's price and quantity compare to the price and quantity that would prevail under perfect competition?
    b. shade an area in the graph that represents the deadweight loss due to Irwin's monopoly.

*19. Suppose that a monopolistic seller of flux capacitors faces the inverse demand curve $P = 40 - 0.5Q$, and that the monopolist can produce flux capacitors at a constant marginal cost of $5.
    a. How many units will an unregulated monopolist sell?
    b. Suppose that the government imposes a price ceiling of $6. What does this price ceiling do to the monopolist's marginal revenue curve? Specifically, what is the marginal revenue of the 10th unit? The 68th? How about the 69th?
    c. How many units will a profit-maximizing monopolist sell when the price ceiling is in place? At what price?
    d. Compare the deadweight loss of unregulated monopoly to the deadweight losses with the price ceiling. Does the price ceiling improve social welfare?

20. Consider a small isolated town in which a brewery faces the following inverse demand: $P = 15 - 0.33Q$. The brewery can produce beer at a constant marginal and average total cost of $1 per bottle.
    a. Calculate the profit-maximizing price and quantity, as well as producer and consumer surplus and the deadweight loss from market power.
    b. If it were possible to organize the townsfolk, how much would they be willing to pay the brewery to sell beer at a price equal to its marginal cost?
    c. What is the minimum payment the brewery would be willing to accept to sell beer at a price equal to marginal cost?
    d. Is it possible for consumers and the brewery to strike a bargain that results in gains for both?

21. Consider the firm depicted in the following diagram:
    a. Is the firm a natural monopoly? How do you know?
    b. Will this firm earn a profit if it is not subject to regulation? How do you know?
    c. If the government requires the firm to charge no more than its marginal cost of production, how many units will be sold? At what price? What is the problem with the government capping prices at marginal cost?
    d. Suppose the government allows firms to charge no more than their average total costs of production. How many units will this firm sell? At what price? What is the problem with capping prices at average total cost?
    e. Evaluate the deadweight loss under each of the three pricing regimes above. Show each regime's deadweight loss as an area on the graph.



22. Five networks are vying to receive the pay-per-view broadcast rights to the World Series of Yahtzee. Each estimates that the inverse demand for watching this nail-biter of an event is given by $P = 100 - 0.01Q$. Each can provide the broadcast at a constant marginal cost of $1 per viewer.
    a. Calculate the deadweight loss of monopoly in the market for the televised Yahtzee tournament.
    b. Suppose that the governing body for the Yahtzee tournament plans to select one network at its discretion to air the tournament. How much will each network be willing to spend lobbying for the broadcast rights?
    c. Explain why, in this situation, the losses to society are much greater than just the deadweight losses of monopoly.

23. In the early days of navigation, sailors had a tough time figuring out exactly where they were. Pinpointing latitude was easy enough with a sextant, but because Earth was constantly spinning, pinpointing longitude by using celestial bodies was impossible. Anxious for a solution to this problem, the British government sponsored a contest with a prize of £20,000 (about $5 million in today's dollars) to the inventor who could devise a reliable method of calculating longitude. Once invented, the method would be made available to anyone who wanted to use it. Explain the advantages of such a system in maximizing social well-being relative to the traditional system of awarding patents.

Chapter 9 Appendix: The Calculus of Profit Maximization

In Chapters 8 and 9, we saw that all firms—regardless of their degrees of market power—maximize their profits. In particular, the firm faces the optimization problem:

$$\max_{Q} \pi(Q) = TR(Q) - TC(Q)$$

This problem is relatively straightforward compared to the cost-minimization and utility-maximization problems we've focused on previously. Why? Look closely at the problem above, and you'll notice that there aren't any constraints on it. In fact, profit maximization is an *unconstrained* optimization problem and, as such, is much simpler to solve than the constrained optimization problems we've been dealing with so far.

In addition, the profit-maximization problem only has one choice variable: output, Q. Every other variable that factors into a firm's decisions—the quantities and prices of productive inputs, as well as the market price of the good—has already been accounted for in the equations for total revenue and total cost. How? First, total cost is determined only after a firm minimizes its costs, meaning it incorporates information about a firm's productive inputs. Next, consider total revenue, which is the product of price and quantity. For the perfectly competitive firm, price is constant, so given the market price, total revenue only varies with quantity. Firms with market power face variable prices, but we saw that those prices are a function of quantity sold. Therefore, total cost, total revenue, and—by extension—profit are all functions of quantity, holding all else constant.[10]

The Profit-Maximizing Condition

Let's begin by solving for the profit-maximizing condition. We take the first derivative of the profit-maximization problem above with respect to quantity Q to solve for the first-order condition:

$$\frac{d\pi}{dQ} = \frac{dTR}{dQ} - \frac{dTC}{dQ} = 0$$

$$\frac{dTR}{dQ} = \frac{dTC}{dQ}$$

$$MR = MC$$

What does this first-order condition tell us? As we saw in the chapter, *all* firms—firms with some market power, monopolists, and perfectly competitive firms inclusive—produce the profit-maximizing level of output when marginal revenue equals marginal cost.

We do need to check one more condition before considering this result conclusive. Producing where $MR = MC$ doesn't guarantee that the firm is maximizing its profit. It only guarantees that the profit function is at one extreme or another—the firm could actually

[10] We could be very explicit about these functions and always indicate profit, total revenue, and total cost as $\pi(Q)$, $TR(Q)$, and $TC(Q)$; however, this becomes a little cumbersome. So in this appendix, we'll just use π, TR, and TC and remind you now and then that each is a function of Q.

be *minimizing* its profit instead of maximizing it! To make sure we avoid this pitfall, we need to confirm that the second derivative of the profit function is negative:

$$\frac{d^2\pi}{dQ^2} = \frac{d^2(TR-TC)}{dQ^2} = \frac{d^2TR}{dQ^2} - \frac{d^2TC}{dQ^2} = \frac{dMR}{dQ} - \frac{dMC}{dQ} < 0$$

When will $\frac{dMR}{dQ} - \frac{dMC}{dQ} < 0$? This condition holds when

$$\frac{dMR}{dQ} < \frac{dMC}{dQ}$$

or when the *change* in marginal cost exceeds the *change* in marginal revenue. We have seen that marginal cost generally increases with output, while marginal revenue either is constant (for a price taker like the firms we saw in Chapter 8) or decreases as the quantity produced rises (for firms with market power, as we observed in Chapter 9). Therefore, this second-order condition generally is met because

$$\frac{dMR}{dQ} \leq 0 < \frac{dMC}{dQ}$$

The firm has to be careful about assuming this, however. If marginal cost is declining (which can be true of a firm with increasing returns to scale over the range that it is producing), we need to confirm that marginal revenue is decreasing at a faster rate than marginal cost:

$$\left|\frac{dMR}{dQ}\right| > \left|\frac{dMC}{dQ}\right|$$

If this condition does not hold for a firm experiencing increasing returns to scale, the firm is not maximizing its profit. In this context, the firm could increase its profit by producing more output.

Marginal Revenue

We know that all firms maximize profits when marginal revenue equals marginal cost. But what exactly is the marginal revenue of a firm? As we did in the past two chapters, we want to derive the relationship between marginal revenue and price. We'll do this first for firms in general and then look specifically at the case of a perfectly competitive firm.

We will start with the expression for total revenue:

$$TR = PQ$$

Note that, in general, price P is not fixed, but is instead a function of the quantity the firm produces.[11] To find marginal revenue, we take the derivative of the total revenue function with respect to Q using the product rule:

$$\frac{dTR}{dQ} = \frac{dPQ}{dQ} = P\frac{dQ}{dQ} + Q\frac{dP}{dQ}$$

[11] The one exception to the general rule that price is a function of output that we've seen so far is for firms in a perfectly competitive market—price takers. We'll come back to this special case shortly.

Equivalently,

$$MR = P + Q\frac{dP}{dQ}$$

What does this tell us about the relationship between marginal revenue and price? Because a firm with market power faces a downward-sloping demand curve, the good's price *decreases* as the quantity produced increases. Mathematically, $\frac{dP}{dQ} < 0$. Therefore, for a firm with market power,

$$MR < P$$

We can also see this result logically. P is the gain from selling an additional unit of the good at the new price. $Q\frac{dP}{dQ}$ is the loss from lowering the price on all previous units in order to sell the increased quantity. Therefore, the revenue from selling an additional unit of the good is less than the good's market price, because for every gain in revenue (P), there is a corresponding loss $\left(Q\frac{dP}{dQ}\right)$.

Let's work through a generic example to clarify this. Suppose a firm has the inverse demand curve $P = a - bQ$. (We discussed this particular inverse demand curve in footnote 3 in Chapter 9, but we'll go into more detail here.) To find marginal revenue, we first determine total revenue by multiplying P by Q:

$$TR = PQ = (a - bQ)Q = aQ - bQ^2$$

Now, we can take the derivative of total revenue to get marginal revenue:

$$MR = \frac{dTR}{dQ} = \frac{d(aQ - bQ^2)}{dQ} = a - 2bQ$$

As you can see, the marginal revenue curve derived from a linear demand curve is itself linear. It also has the same price intercept (in this case, a) and is twice as steep as the demand curve. As a result, it's clear that

$$a - 2bQ < a - bQ \quad \text{or}$$
$$MR < P$$

But what about the special case of the perfectly competitive firm? Unlike firms with market power, perfectly competitive firms are price takers that face horizontal demand curves. We know from above that the marginal revenue for any firm is

$$MR = P + Q\frac{dP}{dQ}$$

For a perfectly competitive firm, price remains fixed with changes in quantity, meaning $\frac{dP}{dQ} = 0$. Thus, $MR = P$ for all quantities of output.

Therefore, the profit-maximizing condition for the perfectly competitive firm is

$$MR = P = MC$$

This unique relationship is precisely what we showed in Chapter 8.[12]

[12] We can also show the relationship between price, marginal revenue, and marginal cost for the perfectly competitive firm by starting from profit maximization. For the perfectly competitive firm, $\pi = PQ - TC$. Taking the first-order condition with respect to Q gives us $P - MC = 0$ or $P = MC$ because price is independent of the quantity produced.

figure it out 9A.1

Let's reconsider the solution to Figure It Out 9.2 (p. 314) and use the calculus approach we learned here. Babe's Bats (BB) faces a demand curve of $Q = 10 - 0.4P$ and a total cost curve of $TC = 2.5Q^2$. BB's output, Q, is measured in thousands of baseball bats, and P in dollars per bat.

a. Solve for BB's profit-maximizing level of output using calculus.

b. What price will BB charge to maximize its profit?

Solution:

a. First, we need to set up Babe's profit-maximization problem:

$$\max_{Q} \pi = TR - TC = PQ - TC$$

Because Babe's Bats has some market power, its choice of Q affects the price. So, we need to use the demand curve for BB's bats to solve for price as a function of quantity, or the firm's inverse demand curve:

$$Q = 10 - 0.4P$$
$$0.4P = 10 - Q$$
$$P = 25 - 2.5Q$$

Substituting this expression for P and the total cost curve into the profit function, we find

$$\pi = TR - TC = PQ - TC$$
$$= (25 - 2.5Q)Q - 2.5Q^2$$
$$= 25Q - 2.5Q^2 - 2.5Q^2 = 25Q - 5Q^2$$

So, the firm's profit-maximization problem is

$$\max_{Q} \pi = 25Q - 5Q^2$$

The first-order condition for this problem is

$$\frac{d\pi}{dQ} = \frac{d(25Q - 5Q^2)}{dQ} = 0$$
$$25 - 10Q = 0$$
$$10Q = 25$$
$$Q^* = 2.5 \quad \text{or} \quad 2{,}500 \text{ bats}$$

b. Now we need to plug Q^* from (a) into the inverse demand curve to obtain the profit-maximizing price:

$$P^* = 25 - 2.5Q^* = 25 - 2.5(2.5) = \$18.75 \text{ per bat}$$

Babe's Bats is maximizing its profit when it sells 2,500 baseball bats at a price of $18.75 per bat.

A shortcut to solving is to begin with the profit-maximizing condition $MR = MC$, as we did in the chapter. In general, beginning with the profit-maximizing condition is easiest for firms with linear demand curves and simple cost functions. However, some firms have more complicated demand curves and total cost functions. For these firms, solving the profit-maximization problem directly using calculus may save you some work.

Now that we've worked through the calculus of profit maximization for a firm with market power, let's look at an example for a perfectly competitive firm.

figure it out 9A.2

Let's return to Figure It Out 8.1 and to Bob's Barbershop, the perfectly competitive firm with a daily total cost of $TC = 0.5Q^2$. Assume that the market price of a haircut is $15.

a. How many haircuts should Bob give each day if he wants to maximize his profit?

b. If the firm maximizes profit, how much profit will it earn each day?

Solution:

a. Bob's problem is to choose the quantity of haircuts that will maximize his profit or

$$\max_{Q} \pi = TR - TC = PQ - TC = 15Q - 0.5Q^2$$

Solving for the first-order condition gives

$$\frac{d\pi}{dQ} = \frac{d(15Q - 0.5Q^2)}{dQ} = 0$$

$$15 - Q = 0$$

$$Q^* = 15 \text{ haircuts}$$

Let's confirm that this is the same result that we get from choosing the quantity where $P = MC$. In the chapter, the question provided you with the marginal cost, but now we can solve for it by taking the first derivative of the total cost curve with respect to quantity, the firm's choice variable:

$$MC = \frac{dTC}{dQ} = \frac{d0.5Q^2}{dQ}$$

$$= 2(0.5Q) = Q$$

Now finding Bob's optimal quantity of haircuts per day is easy:

$$P = MC$$

$$P = Q$$

$$Q^* = 15 \text{ haircuts}$$

b. At 15 haircuts per day, Bob will earn

$$\pi = TR - TC = PQ - 0.5Q^2$$

$$= 15(15) - 0.5(15)^2 = \$225 - \$112.50 = \$112.50 \text{ per day}$$

Problems

1. Find marginal revenue for the firms that face the following demand curves:
   a. $Q = 1{,}000 - 5P$
   b. $Q = 100P^{-2}$
2. Suppose a firm faces demand of $Q = 300 - 2P$ and has a total cost curve of $TC = 75Q + Q^2$.
   a. What is the firm's marginal revenue?
   b. What is the firm's marginal cost?
   c. Find the firm's profit-maximizing quantity where $MR = MC$.
   d. Find the firm's profit-maximizing price and profit.
3. Suppose that American Borax is a monopolist and the worldwide demand for borax is $Q = 100 - P$, where Q is tons of borax and P is the price per ton. The total cost function for American Borax is $TC = 10Q + 0.5Q^2$.
   a. Write out the firm's total revenue as a function of Q.
   b. What is the profit function for American Borax?
   c. Find the firm's profit-maximizing quantity by applying calculus to the profit function.
   d. Find American Borax's profit-maximizing price and profit.
4. Suppose a firm faces the inverse demand curve $P = 600Q^{-0.5}$. The firm has the total cost curve $TC = 1{,}000 + 0.5Q^{1.5}$. Find the firm's profit-maximizing output, price, and profit.
5. Consider a firm in a perfectly competitive market with total costs given by

$$TC = Q^3 - 15Q^2 + 100Q + 30$$

   a. What is this firm's marginal cost function? Over what range of output are the firm's marginal costs decreasing? Increasing?
   b. Suppose that the market price is \$52. What is this firm's profit-maximizing level of output? How do you know this is the profit-maximizing output? How much profit does this firm earn by producing the profit-maximizing output?