The Behavior of Firms

Individuals demand goods and services; firms supply them. Just as our study of individual consumers' behavior led us to a deeper understanding of demand, a study of firms' behavior will lead us to a deeper understanding of supply.

All firms are created and owned by individuals. Some, like many corner grocery stores, have one owner, whereas others, like the General Electric Corporation, have many thousands of owners (in this case the General Electric stockholders). In some firms, the owner or owners exert considerable day-to-day control over operations, whereas in others salaried managers serve these functions. With such diversity in the size, nature, and organization of firms, you might wonder how it could be possible to make any statements at all about the behavior of firms in general.

There is, however, one grand generalization about firms that economists have found to be extraordinarily powerful: We assume that firms act to maximize profits. There are reasons to question this assumption. Why should individuals, who are interested in many things other than profits, choose to organize firms that pursue profits single-mindedly? Even if the owners view profit maximization as desirable, does it follow that the managers will behave accordingly? Economists have given much thought to these and related questions.[1] However, most economists also believe that the assumption of profit maximization, while only an approximation to the truth, leads to deep insights into the ways in which goods are supplied.

Therefore, we will use the word **firm** to refer to an entity that produces and supplies goods and that seeks to do so in such a way as to maximize the profits that it earns in any given time period. The goal of profit maximization will enter into every decision that the firm makes. In Section 5.1 we will study a simple problem in which a firm must weigh costs against benefits. This will lead us to the equimarginal principle, which is one of the most fundamental concepts in economics and the key to profit maximization. In Section 5.2 we will see how firms use this principle in deciding how much to produce.

Firm

An entity that produces and sells goods, with the goal of maximizing its profits.

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[1] One of the earliest and most enlightening contributions to this literature is R. H. Coase, "On the Nature of the Firm," *Economica* 4 (1937): 386–405.

5.1 Weighing Costs and Benefits

In this section we will examine how firms make decisions by imagining a simple problem that a farmer might face: How many acres of her land should she spray with insecticide? The solution to this problem will reveal one of the key concepts in economics, known as the equimarginal principle. Once this principle has been made explicit, we will see that it applies both to the behavior of firms and to the behavior of individuals.

A Farmer's Problem

Farmer Vickers's farm is a firm—that is, she operates her farm to maximize profits. She owns 6 acres of land planted with wheat, and her immediate problem is to decide how many acres to spray with insecticide.

By spraying 1 acre, Farmer Vickers can save $6 worth of crops. You might guess that by spraying 2 acres, she saves $12 worth. But a more reasonable guess would be something less than $12. Why? Because the 6 acres are not all identical. Some acres are more fertile than others, and some are closer to standing water and therefore more attractive to insects. When Farmer Vickers sprays just 1 acre, she chooses that acre where spraying yields the greatest benefit. When she sprays 2 acres, she chooses the one where spraying yields the biggest benefit and the one where spraying yields the second biggest benefit. So the gain from spraying 2 acres is probably less than twice the gain from spraying 1 acre.

So a reasonable assumption would be that spraying 1 acre saves $6 worth of crops and spraying 2 acres saves a total of $11 worth of crops. We record these numbers in the "Total Benefit" column of the table in Exhibit 5.1, along with the total benefit of spraying 3, 4, 5, and 6 acres. The same numbers are plotted on the curve labeled "Total benefit" in panel A underneath the chart.

Marginal benefit

The additional benefit gained from the last unit of an activity.

The third column of that table, labeled **marginal benefit,** refers to the value of crops saved on the last acre sprayed. For example, spraying 2 acres saves $11 worth of crops and spraying 1 acre saves $6 worth, so the marginal benefit of spraying the second acre is $11 − $6 = $5, which is the second entry in the Marginal Benefit column. Similarly, spraying 4 acres saves $18 worth of crops and spraying 3 acres saves $15 worth, so the marginal benefit of spraying the fourth acre is $18 − $15 = $3, which is the fourth entry in the column. The marginal benefit numbers are plotted on the curve labeled "Marginal benefit" in panel B.

Exercise 5.1 Verify the other numbers in the third column of the table in Exhibit 5.1. Explain why it is reasonable for these numbers to be decreasing. Explain why the sum of the first 3 (or 4 or 5) entries in the Marginal column is equal to the third (or fourth or fifth) entry in the Total column.
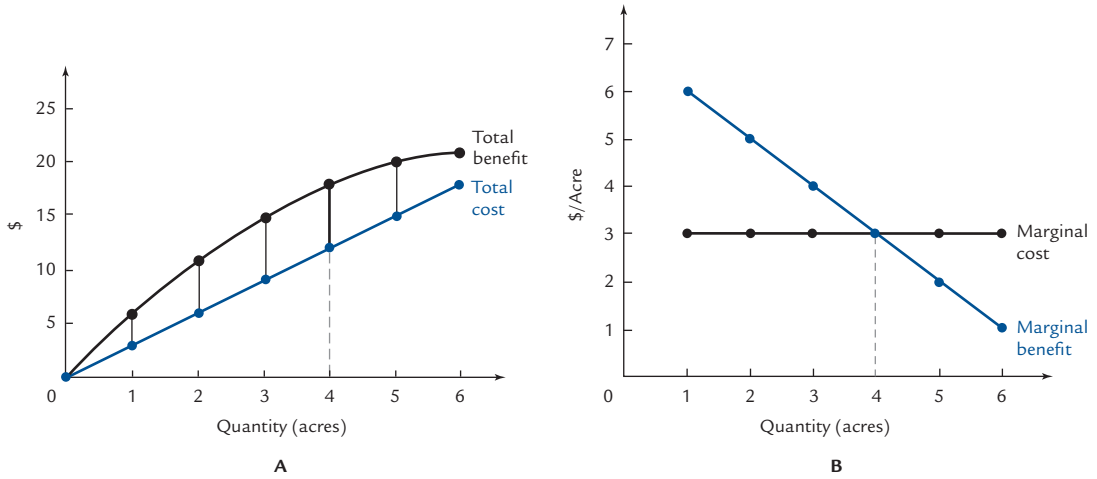
Dangerous Curve

The marginal benefit is the benefit from spraying one additional acre and is therefore properly measured not in dollars, but in dollars per acre. Therefore, it cannot be plotted on the same graph with total benefit, which is measured in dollars.

EXHIBIT 5.1   **Maximizing Net Gain**

No. of Acres Sprayed	Total Benefit	Marginal Benefit	Total Cost	Marginal Cost	Net Gain
0	$0		$0		$0
1	6	$6/acre	3	$3/acre	3
2	11	5	6	3	5
3	15	4	9	3	6
4	18	3	12	3	6
5	20	2	15	3	5
6	21	1	18	3	3

The graphs display the information in the tables. Because Net gain = Total benefit − Total cost, the net gain is equal to the distance between the Total cost and Total benefit curves in panel A. For example, the heavy vertical line has length $6, representing the net gain of $6 when 4 acres are sprayed. Because the heavy line is the longest of the vertical lines (or, in other words, because $6 is the largest number in the net gain column), the farmer maximizes her net gain by spraying 4 acres. An alternative way to reach the same conclusion (called Method II in the text) is to continue spraying as long as marginal benefit exceeds marginal cost and to stop when they become equal at 4 acres.

We have said that the marginal benefit is the additional benefit from the last acre sprayed. It is important to understand what "last" means. When Farmer Vickers sprays 4 acres, the "last" acre is the one she'd have omitted if she'd been spraying only 3 acres. Once she's hired the crop duster to come in and spray, he might spray the acres in any order that's convenient. The last acre is not the last one the crop duster actually sprays; it's the last one the farmer *decides* to spray.

Dangerous
Curve

To decide how many acres farmer Vickers should spray, we need to know not just the benefits but the costs. Let's suppose the farmer can hire a crop duster who charges $3 per acre. In that case, the total cost of spraying 1 acre is $3, the total cost of spraying 2 acres is $6, and so forth. These numbers are recorded in the Total Cost column of Exhibit 5.1 and are plotted on the curve labeled "Total cost" in panel A.

Marginal cost

The additional cost associated with the last unit of an activity.

The next column of the table shows the **marginal cost** associated with each acre sprayed; that is, it shows the additional cost of spraying that last acre. If Farmer Vickers sprays 3 acres, her total cost is $9; if she sprays 4 acres, her total cost is $12. Therefore, the marginal cost of spraying the fourth acre is $12 − $9 = $3. These numbers are plotted on the curve labeled "Marginal cost" in panel B.

The final column in Exhibit 5.1, labeled "Net Gain," is the total value of crops saved minus the total cost of spraying them. For example, if Farmer Vickers sprays 2 acres, her total benefit is $11 and her total cost is $6, so her net gain is $11 − $6 = $5. The net gain numbers are displayed by the vertical bars in the first graph, which indicate the difference between total cost and total benefit. Net gain adds to Farmer Vickers's profits, so net gain is what she wants to maximize. Her problem, remember, is to figure out how many acres to spray. We will give two different methods for solving that problem.

The first and most straightforward method is to look over the net gain column and pick out the biggest number. That number is $6, and it occurs when Farmer Vickers sprays either 3 or 4 acres. Therefore, the solution to her problem is: spray 3 or 4 acres. To remove the ambiguity, let's arbitrarily suppose that whenever she's indifferent between two choices, Farmer Vickers chooses the larger. Thus, the solution to her problem is: spray 4 acres.

Students sometimes get unduly concerned with the question of why we chose 4 acres rather than 3 acres as "the" solution to our problem. Rest assured that the choice is entirely arbitrary; we could as easily have chosen 3 as 4. By sticking to one choice, we will make the subsequent discussion easier to follow:

Dangerous Curve

In any event, either answer—3 or 4—is only an approximation of the truth. Here's why: In real life, Farmer Vickers would have a lot more than six choices. Instead of spraying 2 or 3 or 4 acres, she could spray exactly 3½ acres, or 1.7894 acres, or any other number of acres between 0 and 6. If we allowed all these possibilities, we would find that net gain is actually maximized at some number of acres between 3 and 4, and no arbitrary choice would be necessary. You can view 4 as the "right answer rounded up," which we will treat as exactly equal to the right answer to keep things simple.

So that's one way to solve the farmer's problem: Scan the net gain column and pick the biggest number. Let's call that process *Method I.* Now we'll give an alternative method, which we'll call *Method II.*

To use Method II, look only at the Marginal columns in Exhibit 5.1. Start with the row corresponding to 1 acre. Note that the marginal benefit of spraying the first acre ($6) is greater than the marginal cost ($3). Therefore, Farmer Vickers should spray that first acre.

Now move on to the row corresponding to 2 acres. Again, the marginal benefit ($5) exceeds the marginal cost ($3). Therefore, spraying the second acre is also a good idea; it increases net gain by $5 − $3 = $2.

The third acre yields a marginal benefit of $4 for a marginal cost of $3, which is another good deal! This will add $1 to net gain, so Farmer Vickers should spray this acre.
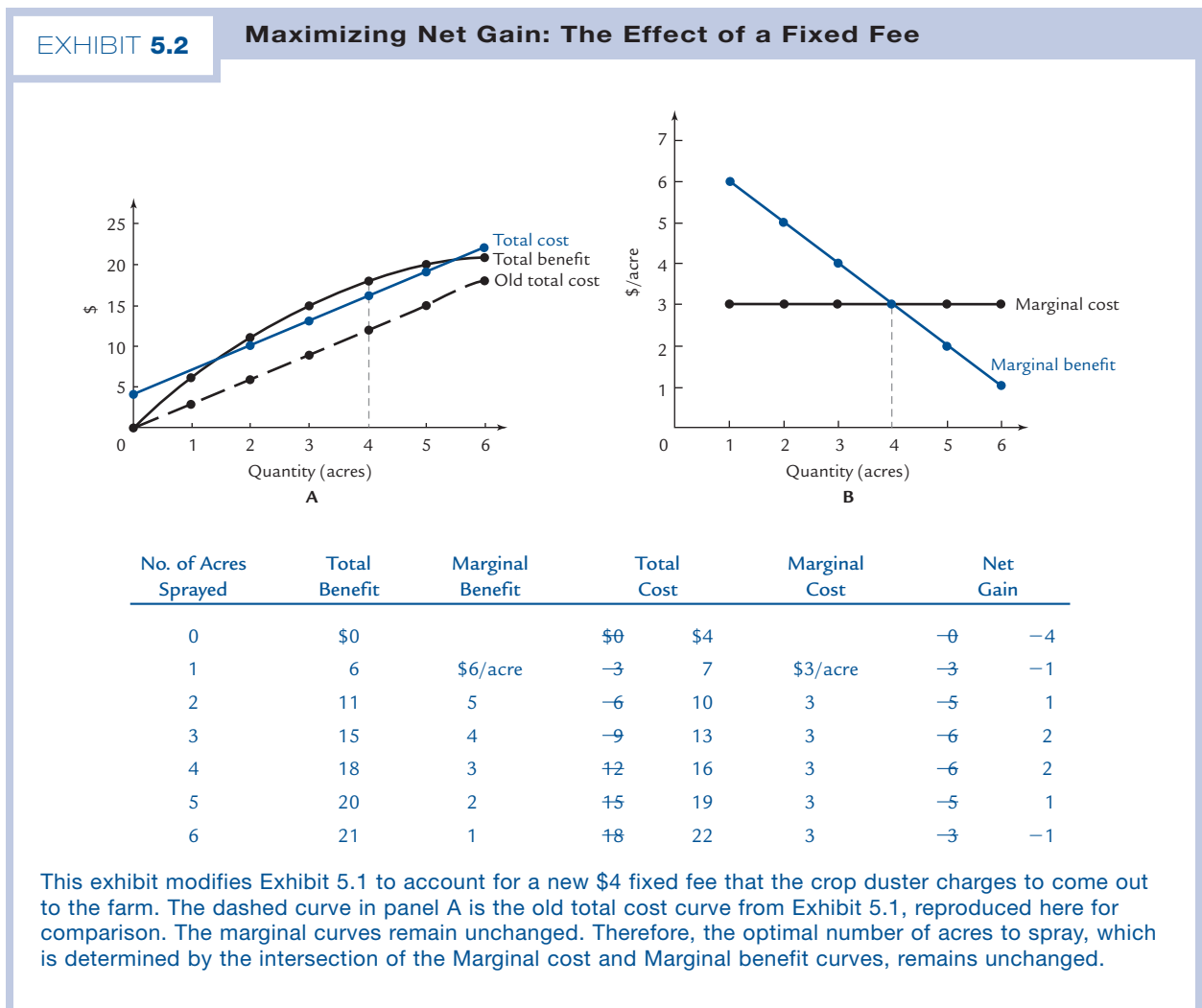
When we get to the fourth acre, we find that the marginal value of the crops saved ($3) is exactly equal to the marginal cost ($3). Therefore, it doesn't matter whether she sprays this acre or not. We've already agreed to eliminate such ambiguities by (arbitrarily) assuming that the farmer moves forward when she is indifferent, so let's suppose she sprays this acre too.

But when it comes to the fifth acre, the marginal benefit ($2) is less than the marginal cost ($3). Spraying this acre would subtract $1 from net gain, so it's a bad idea. Farmer Vickers stops after the fourth acre.

That's Method II: Continue spraying as long as the marginal benefit exceeds the marginal cost, and stop when they become equal. Here's an even briefer summary of Method II: Choose the number of acres that makes the marginal benefit equal to the marginal cost. In terms of the graph in panel B, Method II comes down to choosing the number of acres where the marginal cost and marginal benefit curves cross.

Notice that Methods I and II both yield the same answer: Spray 4 acres. They *must* yield the same answer, because each is a perfectly valid way of maximizing net gain. In view of this, you might wonder why we went to all the trouble of developing Method II when Method I works perfectly well. The answer is that Method II demonstrates the importance of the Marginal columns. It shows that the Marginal information all by itself is enough to guide the farmer's choice. We can say the same thing in a slightly different way: If the Marginal columns don't change, then neither will Farmer Vickers's behavior.

Here's an important application of this last point: Suppose the crop duster changes his pricing policy. He now charges a $4 flat fee for coming out to the farm in addition to the $3 per acre for spraying. ($4 is now the fee for spraying *zero* acres!) Exhibit 5.2 updates Exhibit 5.1 to illustrate the new situation.

EXHIBIT 5.2 **Maximizing Net Gain: The Effect of a Fixed Fee**

No. of Acres Sprayed	Total Benefit	Marginal Benefit	Total Cost		Marginal Cost		Net Gain	
0	$0		$0	$4		~~0~~		−4
1	6	$6/acre	~~3~~	7	$3/acre	~~3~~		−1
2	11	5	~~6~~	10	3	~~5~~		1
3	15	4	~~9~~	13	3	~~6~~		2
4	18	3	~~12~~	16	3	~~6~~		2
5	20	2	~~15~~	19	3	~~5~~		1
6	21	1	~~18~~	22	3	~~3~~		−1

This exhibit modifies Exhibit 5.1 to account for a new $4 fixed fee that the crop duster charges to come out to the farm. The dashed curve in panel A is the old total cost curve from Exhibit 5.1, reproduced here for comparison. The marginal curves remain unchanged. Therefore, the optimal number of acres to spray, which is determined by the intersection of the Marginal cost and Marginal benefit curves, remains unchanged.

Note that although the Total Cost column has changed, with all the numbers increased by $4, the Marginal Cost column is unchanged, as is the Marginal Benefit column. Because the Marginal columns are unchanged, Farmer Vickers's optimum is unchanged: She should spray the number of acres where marginal cost equals marginal benefit, namely, 4 acres. We can confirm this using Method I: Net gain is still maximized when the farmer sprays 4 acres. Graphically, the total cost curve has shifted up parallel to itself a distance of $4, so that the maximum distance between it and the total benefit curve remains at a quantity of 4 acres.

Now here comes the key observation: We could have predicted this result without ever building the table in Exhibit 5.2. All we had to observe was that the change in the crop duster's pricing policy cannot affect either of the Marginal columns in the table and that only these columns are necessary for predicting Farmer Vickers's behavior. Therefore, when the pricing policy changes, her behavior stays unchanged.

It is true that the crop duster's policy is bad news for the farmer: She used to realize a net gain of $6 and now realizes a net gain of only $2. What remains unchanged is the number of acres she sprays: 4 in either case.

Exercise 5.2 Suppose the crop duster changes his policy again, so that he now charges $5 to come out to the farm plus $3 per acre sprayed. How many acres will Farmer Vickers spray now? Figure out the answer without building a table, and explain how you know your answer is correct. Now build a table and confirm your prediction.

Exercise 5.3 Suppose the crop duster lowers his price to $1 per acre sprayed. Does this affect anything marginal? Does it affect Farmer Vickers's decision about how many acres to spray?

There is one exception to the rule we've just learned. The rule is: If nothing marginal changes, then Farmer Vickers's behavior won't change. The exception is: If spraying guarantees a negative net gain, then Farmer Vickers won't spray at all. For example, suppose the crop duster changes his policy to $100 to come out to the farm plus $3 per acre sprayed. If you update the numbers in Exhibit 5.2, you'll see that the Marginal columns remain unchanged, but the largest possible net gain is negative. In that case, Farmer Vickers will not continue to spray 4 acres; she'll give up spraying altogether. So a better way to state the rule is: If nothing marginal changes, and as long as Farmer Vickers continues to spray at all, then her behavior won't change.

The Equimarginal Principle

Equimarginal principle

The principle that an activity should be pursued to the point where marginal cost equals marginal benefit.

Farmer Vickers has discovered the **equimarginal principle,** which is the essence of Method II for deciding how many acres to spray:

If an activity is worth pursuing at all, then it should be pursued up to the point where marginal cost equals marginal benefit.

She has also discovered an important consequence of the principle:

If circumstances change in a way that does not affect anything marginal and if an activity remains worth pursuing at all, then the optimal amount of that activity is unchanged.

The equimarginal principle has broad applicability. It applies not only to firms but also to individuals. Indeed, we have already met the equimarginal principle in Chapter 3, where we studied the consumer's optimum. The consumer moves along her budget line, trading Y for X until the relative price of a unit of X (which is the marginal cost of that unit measured in terms of Y) is equal to the marginal rate of substitution between X and Y (which is the marginal value of that unit measured in terms of Y). Since the benefit to a consumer from owning a unit of X is the same thing as the value to her of that unit, equating marginal cost to marginal value is the same as equating marginal cost to marginal benefit.

Applying the Principle

Occasionally you will read a newspaper editorial that makes an argument along the following lines: "Our town spends only $100,000 per year to run its police department, and the benefits we get from the police are worth far more than that. Police services are a good deal in our town. We should be expanding the police department, not cutting back on it as Mayor McDonald has proposed." This argument is wrong. The editorial writer has observed (we assume correctly) that the total benefit derived from the police department exceeds the total cost of acquiring those benefits. But this is not relevant to the decision between expanding the department or contracting it. For this decision, only marginal quantities matter.

Reconsider Exhibit 5.1. When Farmer Vickers sprays 4 acres, she gets a good deal: Her gains from spraying exceed her costs by $6. Does it follow that she should expand her spraying program and spray a fifth acre? No, because the *marginal* cost of spraying that fifth acre exceeds the *marginal* gain from doing so. It is true that Farmer Vickers's gains exceeded her costs on each of the first 4 acres she decided to spray. However, if she sprayed a fifth acre, the marginal cost of doing so would exceed the marginal benefit by $1, reducing her total net gain from $6 to $5. Spraying the fifth acre is a bad idea.

Imagine Farmer Jefferson, faced with the same opportunities as Farmer Vickers, who has foolishly decided to spray 5 acres. He is considering cutting back his spraying program. The logic of the editorial would have us say: "Your spraying program is costing you only $20 and the value of the crops it saves is far more than that [$2 more, to be exact]. Your spraying program is a good deal. If anything, you should be expanding it, not cutting back." It is true that Farmer Jefferson's spraying program is a good deal overall, but it is also true that spraying the fifth acre is a bad deal (a $3 marginal cost exceeds a $2 marginal benefit). His spraying program will be an even better deal if that fifth acre is eliminated. Although his total gains exceed his total costs, this is beside the point, because for a decision like this only marginal quantities matter.

5.2 Firms in the Marketplace

Armed with our discovery that "only marginal quantities matter," we now set forth to study the behavior of firms in the marketplace.

The Tailor Dress Company produces dresses and sells them in the marketplace. Like all firms in this book, the Tailor Dress Company is interested only in maximizing its profits. The firm's profit in any given period is equal to the revenue it earns from selling dresses minus the cost of producing those dresses. So to understand profit, we have to understand both revenues and costs. We begin with revenues.

Revenue

Revenue

The proceeds collected by a firm when it sells its products.

The **revenue** that a firm earns in a given time period can be computed by the simple formula:

$$\text{Revenue} = \text{Price} \times \text{Quantity}$$

For the Tailor Dress Company, the *price* is the price at which it sells its dresses, and the *quantity* is the number of dresses it sells in the period under consideration.

The firm can choose either the price or the quantity, but it can't choose both independently. The Tailor Dress Company can decide to sell exactly 9 dresses this week, or it can decide to sell dresses at exactly $100 apiece. But it cannot decide to sell exactly 9 dresses at exactly $100 apiece, because it might not find demanders willing to purchase that many dresses at that price. In other words, Tailor's options are limited by the demand curve for Tailor dresses.

Suppose the demand curve is given by the first two columns of Exhibit 5.3. In the past, when we've exhibited demand curves as charts, we've put price in the left-hand column and quantity in the right-hand column. In this case, we've reversed the order. But you should still read these columns as an ordinary demand curve: If the price is $10 per dress, demanders will buy 1 Tailor dress; if the price is $9 per dress, demanders will buy 2 Tailor dresses, and so forth.

Note that this demand curve is *not* the demand curve for dresses generally; it is the demand curve for *Tailor* dresses. Note also that as with any demand curve, there is a time period agreed on in advance; in this case, let us suppose that the quantities on the demand curve are quantities *per week*.

Using this demand curve, we can see (for example) that if Tailor wants to sell exactly 5 dresses per week, it cannot charge more than $6 per dress. In fact, if Tailor wanted to sell exactly 5 dresses, it should charge *exactly* $6 per dress—that is, the highest price at which demanders will take all 5 dresses.

Exercise 5.4 If Tailor wants to sell exactly 3 dresses, what price should it charge? If Tailor wants to sell exactly 8 dresses, what price should it charge?

Total revenue

The same thing as "revenue." It can be computed by the formula Revenue = Price × Quantity.

For any given quantity of dresses, Tailor uses the demand curve to find the corresponding price and then computes its **total revenue** by the formula:

$$\text{Revenue} = \text{Price} \times \text{Quantity}$$

The third column of Exhibit 5.3 shows the total revenue corresponding to each quantity, computed according to the formula.

Exercise 5.5 Verify that the entries in the Total Revenue column are accurate.

Marginal revenue

The additional revenue earned from the last item produced and sold.

The fourth column in Exhibit 5.4 shows the **marginal revenue** associated with each quantity. Marginal revenue is the additional revenue earned from the last item produced and sold. For example, if the firm produces 4 dresses, its total revenue is $28; and if it produces 5 dresses, its total revenue is $30. Thus, the marginal revenue associated with the fifth dress is $2 per dress.

Exercise 5.6 Verify that the entries in the Marginal Revenue column are accurate.

The total revenue and marginal revenue numbers are plotted in panels A and B of Exhibit 5.3.

| EXHIBIT **5.3** | **Maximizing Profits at the Tailor Dress Company** |
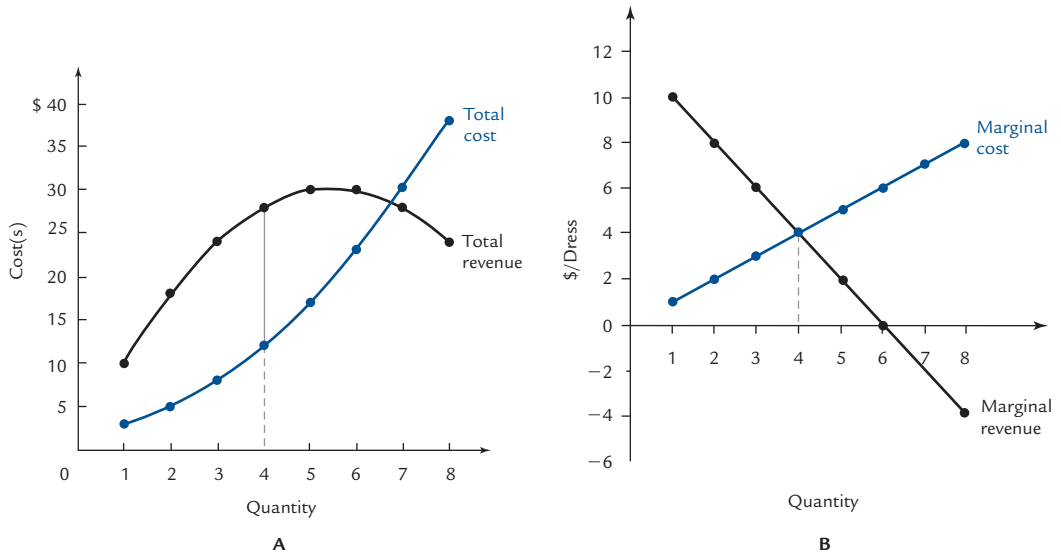
A

B

	Demand Curve					
Quantity of Dresses	Price	Total Revenue	Marginal Revenue	Total Cost	Marginal Cost	Profit
0				$2		
1	$10/dress	$10	$10/dress	3	$1/dress	$7
2	9	18	8	5	2	13
3	8	24	6	8	3	16
4	7	28	4	12	4	16
5	6	30	2	17	5	13
6	5	30	0	23	6	7
7	4	28	−2	30	7	−2
8	3	24	−4	38	8	−14

The first two columns show the demand curve for Tailor dresses (these numbers are invented for the sake of the example). For any given quantity of dresses, Tailor reads a price off the demand curve and computes total revenue as price times quantity. The total revenue curve is plotted in panel A.

The marginal revenue from, say, the third dress is equal to the total revenue from producing three dresses ($24) minus the total revenue from producing two dresses ($18). The marginal revenue curve is plotted in panel B. Marginal revenue measures the slope of the total revenue curve.
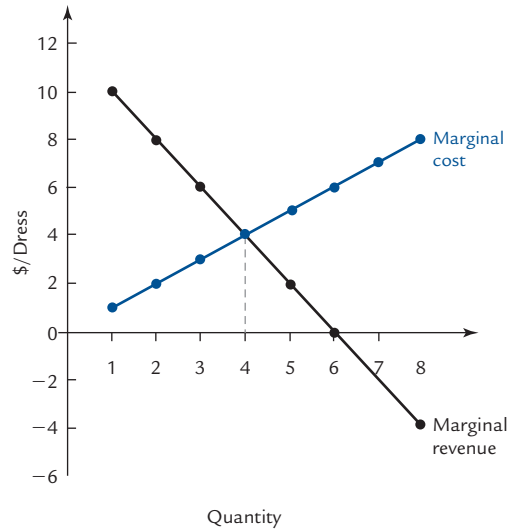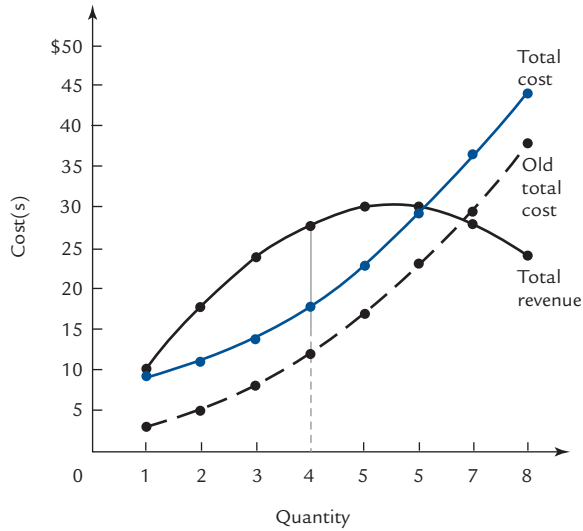
The Total Cost column shows the total cost of producing various quantities of dresses (these numbers are made up for the sake of the example). Total cost consists of fixed cost (in this case $2) plus variable costs. The fixed cost of $2 is the cost of producing zero dresses. The total cost curve is plotted in panel A.

The marginal cost of producing, say, the third dress is equal to the total cost of producing three dresses ($8) minus the total cost of producing two dresses ($5). The marginal cost curve is plotted in panel B. Marginal cost measures the slope of the total cost curve.

There are two ways for Tailor to choose a profit-maximizing quantity, each of which leads to the same conclusion. Using Method I, Tailor scans the Profit column looking for the largest entry. This is the same as looking for the point of maximum distance between the total cost and total revenue curves in panel A. Using Method II, Tailor scans the Marginal columns and chooses the quantity where marginal cost and marginal revenue are equal. This is the same as looking for the point where the marginal cost and marginal revenue curves cross in panel B. Using either method, Tailor chooses to produce 4 dresses and sell them for $7 apiece.

EXHIBIT 5.4   A Change in Fixed Costs

Demand Curve							
Quantity of Dresses	Price	Total Revenue	Marginal Revenue	Total Cost		Marginal Cost	Profit
0					$8		
1	$10/dress	$10	$10/dress	~~−3~~	9	$1/dress	~~−$7~~ $1
2	9	18	8	~~−5~~	11	2	~~−13~~ 7
3	8	24	6	~~−8~~	14	3	~~−16~~ 10
4	7	28	4	~~12~~	18	4	~~−16~~ 10
5	6	30	2	~~17~~	23	5	~~−13~~ 7
6	5	30	0	~~23~~	29	6	~~−7~~ 1
7	4	28	−2	~~30~~	36	7	~~−2~~ −8
8	3	24	−4	~~38~~	44	8	~~−14~~ −20

When fixed costs rise from $2 a week to $8 a week, all of the total cost numbers rise by $6, so the total cost curve shifts upward, parallel to itself, a vertical distance of $6. The marginal cost numbers are unaffected, so the marginal cost curve does not move. The point of maximum profit (4 dresses at $7 apiece) is unaffected.

Dangerous Curve

Total revenue and marginal revenue must be plotted on different graphs because the vertical axes are measured in different units. Total revenue is measured in dollars, while marginal revenue is measured in dollars per unit. In this example, a "unit" is 1 dress.

Marginal Revenue as a Slope

In Exhibit 5.3, when Tailor produces 3 dresses, the total revenue is $24, and when Tailor produces 4 dresses, the total revenue is $28. Thus, the points (3, 24) and

(4, 28) appear on the Total revenue curve. The slope of the line joining those points is:

$$\frac{28 - 24}{4 - 3} = \frac{4}{1} = 4$$

which is the marginal revenue for producing the fourth dress.

The line in question is nearly tangent to the Total revenue curve at the point (4, 28). In general, at any given quantity, you can think of marginal cost as the slope of the Total cost curve near that quantity.

Thus, for example, marginal revenue is positive for all quantities between 1 and 6 inclusive, so total revenue slopes upward in that region. Marginal revenue is negative for quantities 7 and 8, and at these quantities, total revenue has a negative (downward) slope.

Costs

To make a dress, you need a variety of inputs, including fabric, thread, labor, and the use of a sewing machine. The cost of producing a dress is the sum of the costs of the inputs.

Costs come in two varieties. **Fixed costs** are costs that don't vary with the quantity of output (for a dress company, "output" means "dresses"). An example might be rent on the factory, which costs, say, $2 a week whether the firm produces 1 dress or 100—or even if the firm produces no dresses at all.

Fixed costs

Costs that don't vary with the quantity of output.

The other kind of costs are **variable costs,** which do vary with the quantity of output. Examples include the cost of fabric (if you make more dresses you need more fabric) and workers' wages (if you make more dresses you need more workers).

Variable costs

Costs that vary with the quantity of output.

Roughly, you can think of fixed costs as the costs of being in business in the first place and variable costs as the costs of actually producing output. Every component of cost is either a fixed cost or a variable cost.

Thinking about Variable Costs

At the Tailor Dress Company, the variable cost of making 1 dress is $1; that's what the firm pays for enough fabric and enough workers to make 1 dress.

What is the variable cost of making 2 dresses? Your first guess might be $2. But this is not necessarily the case. The firm has a limited amount of factory space and a limited number of sewing machines. When two workers have to share the machines, they might be less efficient than a single worker who has the machines to himself. So the second dress could cost more to produce than the first.

That's not the only reason the second dress might cost more than the first. If Tailor produces 1 dress, it uses the fabric that's most appropriate for the pattern, hires the worker who is most appropriate for the job, and seats that worker at the most appropriate sewing machine. To produce a second dress, Tailor might have to resort to the second most efficient piece of fabric (maybe an odd-shaped piece that requires more careful cutting), the second most efficient worker, and the second most efficient machine.

Similar phenomena occur in every industry. A farmer growing one acre of wheat uses his most fertile acre; the same farmer growing two acres of wheat must resort to his second most fertile acre. A writer producing one short story uses her best ideas and works at the time of day when she's most efficient; if she wants to produce a second short story, she has to work harder.

So it's plausible to assume that the variable cost of producing 2 dresses is more than $2; let's say it's $3. Then the marginal cost of producing that second dress is:

Cost of producing 2 dresses − Cost of producing 1 dress = $3 − $1 = 2

In the fifth column of Exhibit 5.3, we've listed the total cost of producing various quantities of dresses at the Tailor Dress Company. (Like the numbers in the demand curve, these numbers are invented for this example.) We've assumed fixed costs of $2; these fixed costs have to be paid even if there is no output, so $2 is the total cost of producing *zero* dresses. The total cost of producing 1 dress is $3, of which $2 is fixed cost and $1 is variable cost. The total cost of producing 2 dresses is $5, of which $2 is fixed cost and $3 is variable cost.

The corresponding marginal costs are listed in the sixth column.

Exercise 5.7 Check that all of the marginal cost numbers are accurate.

The total and marginal cost numbers are also plotted in panels A and B of the exhibit.

Increasing marginal cost

The condition where each additional unit of an activity is more expensive than the last.

The Tailor Dress company faces the condition of **increasing marginal cost;** in other words, the marginal cost curve in panel B is upward sloping. We've argued already for the plausibility of this assumption, but there are also arguments to be made against it. Perhaps you can construct some. In Chapter 6, we'll make a careful study of how marginal costs arise from the production processes available to the firm, and we'll have much to say about the circumstances in which marginal costs can be expected to increase. Here we'll simply make the assumption of increasing marginal cost.

As with revenue, you can think of marginal cost as the slope of the Total cost curve.

Maximizing Profit

Let's use Exhibit 5.3 to see how the Tailor Dress Company can maximize its profits. Remember that profit is equal to (total) revenue minus (total) cost. The Profit column on the right side of the chart shows how much profit Tailor can earn for each quantity of dresses it might produce. For example, if Tailor produces 2 dresses, its profit is $18 − $5 = $13.

Exercise 5.8 Check that the numbers in the Profit column are accurate.

To maximize profits, Tailor must choose the right quantity of dresses. There are two ways to do this. Method I is the direct method: Scan the Profit column and choose the largest number. Graphically, this is equivalent to finding the point where the distance between the total cost and total revenue curves is the largest. This occurs at a quantity of either 3 or 4, where the profit is $16. As in Section 5.1, we arbitrarily assume that when firms are indifferent between two choices, they take a larger of the two. Therefore, Tailor produces 4 dresses and sells them at $7 apiece, $7 being the highest price at which demanders would be willing to buy 4 dresses.

Method II consists of scanning only the Marginal columns. Taking them row by row, Tailor first asks: Is the first dress worth making? The answer is yes, because the marginal revenue earned from selling that dress ($10) exceeds the marginal cost ($1). Next, the company asks if the second dress is worth making. Here again the marginal revenue ($8) exceeds the marginal cost ($2), so the answer is yes. A third dress also makes sense ($6 is greater than $3). When it comes to the fourth dress, marginal revenue and marginal cost are equal (at $4), so it is a matter of indifference whether to produce that fourth dress. We assume Tailor goes ahead and produces it. But when it

comes to the fifth dress, the marginal revenue ($2) is less than the marginal cost ($5), so the fifth dress is a mistake. Tailor stops at four.

The short form of Method II is: Find the quantity at which marginal cost equals marginal revenue and produce that quantity. Graphically, this amounts to looking for the point where the Marginal cost and Marginal revenue curves cross.

The validity of Method II is an application of the equimarginal principle. It reveals that:

Any firm produces that quantity at which marginal cost equals marginal revenue.

In Exhibit 5.1, the farmer chooses the quantity where marginal cost equals marginal *benefit*. In Exhibit 5.3, the firm chooses the quantity where marginal cost equals marginal *revenue*. The firm is doing the same thing as the farmer, because to a profit-maximizing firm, revenue *is* the benefit that is derived from supplying goods.

Dangerous
Curve

Changes in Fixed Costs

Suppose the rent at the Tailor factory goes up from $2 a week to $8 a week. Exhibit 5.4 shows the consequence. All the numbers in the total cost column are increased by $6. Therefore, the total cost curve is shifted upward a vertical distance of $6. But none of the marginal cost numbers are affected. When the total costs all rise by the same amount, the differences between them are left unchanged.

A change in fixed costs causes the Total cost curve to shift parallel to itself and leaves marginal cost unchanged.

The validity of Method II tells us that if nothing changes in the Marginal columns, the firm's behavior won't change either. In this case, Tailor continues to produce 4 dresses and sell them for $7 each.

You can verify this result by using Method I: Scan the Profit column and you'll find that the largest possible profit—in this case, $10—still occurs at a quantity of 4 dresses.

Predict what will happen if the rent goes up to $12 a week. Make a table to verify your prediction.

The most important point of this example is that we could have predicted in advance that the rent increase would affect neither price nor quantity, simply on the basis of the observation that the rent increase did not affect anything marginal and the fact that only marginal quantities matter. Therefore, we know that the same result would hold for any change in fixed costs.

A change in fixed costs will not affect the firm's behavior.

There is one exception to this rule: If fixed costs go so high that profits are guaranteed to be negative, the firm will want to go out of business entirely. (In Chapter 7, we'll discuss circumstances in which firms are or are not able to go out of business entirely; the answer depends on the time frame under discussion.)

To illustrate the exception, suppose that Tailor's landlord raises the weekly rent not to $8 but to $108. All of the total cost numbers in Exhibit 5.4 grow by an additional $100, and all of the profit numbers fall by $100. The highest possible profit is −$90, which occurs at a quantity of 4 and a price of $7. If the firm is unable to exit the industry, it will continue to choose that price and that quantity. But it will exit if it can.

Sunk Costs Are Sunk

Before the rent increase in Exhibit 5.4, Tailor earned a profit of $16. After the rent increase, the profit is reduced to $10. The rent increase leaves Mr. Tailor, the owner, poorer by the amount of $6 per week. You might wonder why Tailor does not attempt to compensate for this loss by changing his price. The answer to this question can be found in Exhibit 5.4: There *is* no price that brings Tailor a profit of more than $10 per week. No change in pricing policy can benefit Mr. Tailor; he can only make himself worse off if he tries.

If this seems counterintuitive, ask yourself the following question: If Tailor could make greater profits by producing some quantity other than 4, or by charging some price other than $7, then why wasn't he already doing so before the rent was increased? If he has been profit-maximizing all along, why would a rent increase cause him to alter his strategy?

If you still aren't convinced, ask yourself these questions: If Tailor had accidentally lost a dollar bill down a sewer, would he change his business practices as a result? If he *did* change his business practices because of this bad luck, wouldn't you wonder whether those practices had been especially well thought out in the first place? Now, is the rent increase any different from losing a dollar bill in a sewer?[2]

Economists sum up the moral of this fable in this slogan:

Sunk costs are sunk.

Sunk cost

A cost that can no longer be avoided.

The rent increase is a **sunk cost** from the moment that the Tailor Dress Company decides to continue producing dresses at all; from that moment it is irretrievable. Once a cost has been sunk, it becomes irrelevant to any future decision making.

However, before you learn too well the lesson that a rent increase does not affect a company's behavior, note one exception: A sufficiently large rent increase might simply drive the firm out of business altogether. Only after the firm is committed to staying in business does the rent become a sunk cost.

Here is another example of the principle that sunk costs are sunk: Suppose the video you've spent $5 to rent turns out to be lousy; you're thinking about turning it off in the middle and watching a TV show instead. How should you decide what to do? Would your decision be any different if you'd gotten the video for free? Would it be any different if the video had cost you $10 instead of $5?

The answer is that the cost of the video is sunk and should therefore be irrelevant to your decision. If you expect the second half of the video to be better than the TV show, you should stick with the video. If you expect the TV show to be better, you should switch to the TV show.

It's true that if you switch to the TV show, you'll lose $5. But it's equally true that if you stick with the video, you'll lose $5. The $5 (or $10, or whatever you paid for the video) is lost no matter what you do; that's exactly what it means to say that this cost is sunk. Once a cost is sunk, it can be a cause for regret, but it should not affect your future behavior.

Changes in Variable Costs

Of course, variable costs can also change. Suppose, for example, that the price of fabric goes up. In this case, the cost of making a dress will certainly rise. The Tailor

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[2] There is one way in which the lost dollar is different from the rent increase. Mr. Tailor might be able to avoid the rent increase by going out of business entirely, but there is no way for him to recover his dollar. However, once Tailor decides to remain in business, either dollar is lost irretrievably.

Dress Company's *total* costs will rise and its *marginal* costs will rise as well. This example is very different from the example of the rent increase, where marginal costs remained fixed.

For a concrete example, suppose it takes a yard of fabric to make a dress, and the cost of fabric goes up by a dollar a yard. That adds $1 to the variable cost of making 1 dress, it adds $2 to the variable cost of making 2 dresses, and so forth. All the numbers in the Total Costs column increase, but they all increase by different amounts. Therefore, the Total cost curve not only rises; it changes shape. You can see the new total cost numbers and the new Total cost curve in Exhibit 5.5.

EXHIBIT 5.5   **A Change in Variable Costs**
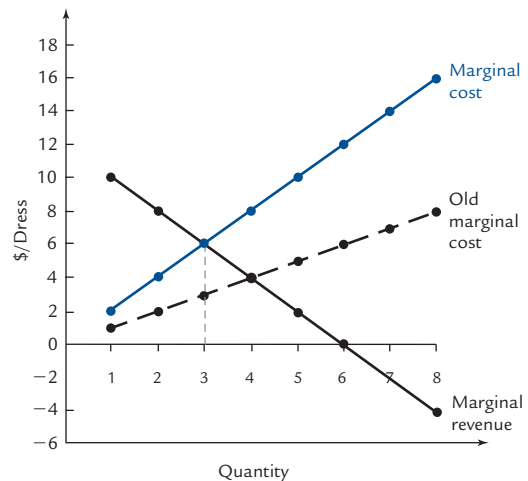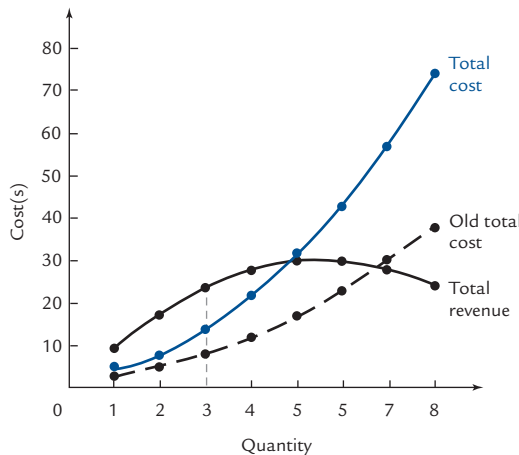
Demand Curve								
Quantity of Dresses	Price	Total Revenue	Marginal Revenue	Total Cost		Marginal Cost		Profit
0				$2	$2			
1	$10/dress	$10	$10/dress	~~3~~	4	~~$1dress~~	$2	~~$7~~	$6
2	9	18	8	~~5~~	8	~~2~~	4	~~13~~	10
3	8	24	6	~~8~~	14	~~3~~	6	~~16~~	10
4	7	28	4	~~12~~	22	~~4~~	8	~~16~~	6
5	6	30	2	~~17~~	32	~~5~~	10	~~3~~	−2
6	5	30	0	~~23~~	44	~~6~~	12	~~7~~	−14
7	4	28	−2	~~30~~	58	~~7~~	14	~~2~~	−30
8	3	24	−4	~~38~~	74	~~8~~	16	~~14~~	−50

When the price of fabric rises, Tailor's total cost numbers rise by different amounts at different quantities. Therefore, the total cost curve shifts upward and also changes shape. The marginal cost numbers change, so the marginal cost curve shifts. The point of maximum profit changes—in this case, from 4 dresses at $7 apiece to 3 dresses at $8 apiece.

Because the total cost numbers all increase by different amounts, the differences between them—that is, the marginal cost numbers—also change. The new marginal cost numbers, and the new Marginal cost curve, are also shown in Exhibit 5.5.

A change in variable costs causes the Total cost curve to shift by different amounts at different quantities and affects marginal costs.

Because the Marginal cost curve has shifted, it now crosses the Marginal revenue curve at a different quantity—3 instead of 4. That is the new profit- maximizing quantity (as you can verify by checking the Profit column). Tailor reduces its output from 4 dresses to 3, and consequently the price (which Tailor takes from the demand curve) rises from $7 to $8.

So a change in variable costs does affect the firm's behavior, even though a change in fixed costs does not.

Changes in the Revenue Schedule

We now understand a great deal about how and when changes in a firm's schedule of costs will affect its economic behavior. However, it is important to realize that this is not the whole story: Changes in the firm's marginal revenue schedule can affect its behavior as well. This is because both marginal revenue and marginal cost are used in the Method II calculations for maximizing profits. Therefore, it is important to understand the circumstances under which a firm's marginal revenue schedule might change.

Referring to Exhibit 5.3, you will see that when we computed marginal revenue, it was determined completely by the demand curve for Tailor dresses. We used the demand curve to determine the right price to charge for any given quantity, then calculated total revenue by multiplying price times quantity, then calculated marginal value revenue from that. What can affect marginal revenue? The answer is: Anything that affects the demand curve.

Our question then becomes: What can affect the demand curve for the Tailor Dress Company? First, anything that affects the demand curve for dresses in general—changes in income, changes in the prices of related goods, and so on. But there are other factors as well. Suppose the Seamstress Dress Company down the street closes up shop for good and its customers have to look elsewhere for dresses. In that case, the demand for Tailor's product will probably rise and so will its marginal revenue curve. It is likely to produce a different number of dresses at a different price.

We can continue this line of inquiry one step further back and ask what might have driven the Seamstress Dress Company out of business. One possibility is a very large increase in rent at the Seamstress building. So we have the remarkable conclusion that although a rise in the Tailor Dress Company's rent will not lead to a change in Tailor's prices, a rise in someone *else's* rent very well *could* have that effect—provided that the "someone else" is a competitor who is driven out of business by the rent increase.

Summary

We assume that firms act to maximize profits. This implies that they will act in accordance with the equimarginal principle; that is, they will engage in any activity up to the point where marginal cost equals marginal benefit.

When the firm sells goods in the marketplace, it chooses the profit- maximizing quantity. In accordance with the equimarginal principle, this is the quantity at which marginal cost equals marginal revenue. The firm sells this quantity at a price determined by the demand curve for its product.

The total revenue derived from selling a given quantity is given by the formula Revenue = Price × Quantity, where the price is read off the demand curve. Thus, the total revenue curve, and consequently the marginal revenue curve, are determined by the demand curve for the firm's product.

A change in the firm's fixed costs, because it affects nothing marginal, will not affect the quantity or price of the firm's output. There is one exception: A sufficiently large increase in fixed costs will cause the firm to shut down or leave the industry entirely.

A change in marginal costs can lead to a change in the firm's behavior. So can a change in marginal revenue. Any change in the demand curve facing the firm can lead to a change in marginal revenue. For example, a change in the availability of competing products can affect demand and, consequently, marginal revenue and, consequently, the behavior of the firm.

Author Commentary   www.cengage.com/economics/landsburg

AC1. In the simple profit model presented in this chapter, firms produce a given good of a given quality. But in the real world, can firms increase profits by withholding high-quality goods from the market?

Review Questions

R1. Suppose a farmer is deciding how many acres to spray. The crop duster charges $7 per acre. The total benefit of spraying is given by the following chart:

No. of Acres Sprayed	Total Benefit	Marginal Benefit	Total Cost	Marginal Cost	Net Gain
0	$0				
1	12				
2	22				
3	30				
4	37				
5	42				

a. Fill in the remaining columns of the chart.

b. Use Method I to determine how many acres the farmer should spray.

    c. Use Method II to determine how many acres the farmer should spray.

    d. If the crop duster adds a fixed fee of $5 to come out to the farm, how many acres should the farmer spray? Predict the answer without creating a new chart. Then create a new chart to verify your prediction.

    e. If the crop duster raises his fee to $10 per acre, how many acres should the farmer spray?

R2. The chart below shows the demand curve for dog food at Charlie's dog food factory and the total cost of producing various quantities:

Quantity	Price	Total Revenue	Marginal Revenue	Total Cost	Marginal Cost	Profit
1	$15/lb		$3			
2	13		8			
3	11		15			
4	9		24			
5	7		35			
6	5		48			

    a. Fill in the rest of the chart.

    b. How much dog food should Charlie sell, and what price should he charge? Answer first using Method I and then using Method II.

    c. If Charlie is required to pay a $5 annual license fee to operate his dog food factory, what happens to his total cost numbers? What happens to his marginal cost numbers? What happens to the amount of dog food he sells and the price he charges?

    d. If Charlie is required to pay an excise tax of $6 per pound of dog food, what happens to his total cost numbers? What happens to his marginal cost numbers? What happens to the amount of dog food he sells and the price he charges?

R3. What is the equimarginal principle?

R4. What is the formula for profit in terms of revenue and cost? What is the formula for revenue in terms of price and quantity?

R5. Which of the following can affect a firm's behavior, and in what way?

    a. A change in variable costs.

    b. A change in fixed costs.

    c. A change in the demand for the firm's product.

    d. A competitor leaving the industry.

Numerical Exercises

In the following exercises suppose that x liters of orange juice can be produced for a total cost of $\$x^2$.

N1. Write down a formula for the marginal cost of production when x liters of orange juice are produced. Simplify your formula algebraically.

N2. Suppose now that orange juice is measured in centiliters (there are 100 centiliters in a liter). Write a formula for the total cost of producing y centiliters of

orange juice. (*Hint:* When you produce *y* centiliters, how many liters are you producing? What is the associated cost?)

N3. Write a formula for the marginal cost of production when *y* centiliters are produced. Your formula gives the marginal cost in dollars per centiliter. Express the same formula in terms of dollars per liter.

N4. On the basis of your answer to Exercise N3, would you be willing to say that the marginal cost when *x* liters are produced is about $2*x* per liter? Why or why not?

N5. Now measure orange juice in milliliters (there are 1,000 milliliters in a liter). Write formulas for total cost and marginal cost when orange juice is measured in milliliters. Convert your marginal cost formula from dollars per milliliter to dollars per liter. Are you now more confident of your answer to Exercise N4? What do you think will happen if you measure orange juice in even smaller units?

Problem Set

1. The government has undertaken a highway project that was originally projected to cost $1 billion and provide benefits of $1.5 billion. Unfortunately, the costs have been much higher than anticipated. The government has spent $1.2 billion so far and now expects that it will cost an additional $1.2 billion to finish the project. Should the project be abandoned or completed?

2. The ABC company has a problem with vandals, who throw bricks through its windows at random times. The XYZ company has a problem with pilferage: Of everything it produces, about 10% is stolen. **True or False:** Although the vandalism problem will not affect prices at ABC, the pilferage problem might cause XYZ's prices to rise.

3. The RH Snippet company has one president and 1000 assembly line workers. Which of the following events would have a bigger impact on the price of RH Snippets and why?

    a. The president gets a raise of $1,000,000 a year.

    b. A new union contract raises each worker's wages by $1000 a year, but allows the firm to fire as many workers as it wants to.

4. There is only one doctor in the town of Erewhon. Every time she treats a patient, she must use a pair of disposable rubber gloves, which costs her $1. She also finds it necessary to keep an X-ray machine in her office, which she rents for $500 a year. The town council has decided to help the doctor meet expenses and is undecided between two plans. Under Plan A, they will provide the doctor with unlimited free rubber gloves; under Plan B they will provide her with a free X-ray machine. Which plan is better for the doctor's *patients* and why?

5. In the town of Smallville, there are many dentists but just one eye doctor. Suppose the town institutes a new rule requiring every doctor and every dentist to take an expensive retraining course once a year. Which is more likely to increase: the price of a dental exam or the price of an eye exam?

6. Suppose that a new law requires every department store in Springfield to carry $10 million worth of fire insurance. **True or False:** If there is only one department store in Springfield, then none of the insurance costs will be passed on to consumers, but if there are many stores, then some of the costs might be passed on.

7.   Suppose that Pat and Sandy's restaurant has just installed fancy new decor costing $10,000. Suppose also that in a distant solar system, there is a planet identical to earth in every way except that at this planet's Pat and Sandy's, the same redecoration cost $20,000. **True or False:** Pat and Sandy's hamburgers will be more expensive in the distant solar system than on earth.

8.   Which of the following might affect the price of a hamburger at Waldo's Lunch Counter and why?

   a.   The price of meat goes up.

   b.   A new restaurant tax of 50¢ per hamburger is imposed.

   c.   Waldo's is discovered to be in violation of a safety code, and the violation is one that would be prohibitively expensive to correct. As a result, Waldo is certain to incur a fine of $500 per year from now on.

   d.   A new restaurant tax of $500 per year is imposed.

   e.   Waldo recalculates and realizes that the redecoration he did last month cost him 15% more than he thought it had.

   f.   Word gets around that a lot of Waldo's customers have been having stomach problems lately.

9.   Suppose you own a river that many people want to cross by car. You've recently bought a fleet of ferry boats, and you've been charging people to take their cars across the river. It's just occurred to you that if you built a toll bridge, the trip would be faster and people would be willing to pay more per crossing. Unfortunately, if you build the toll bridge, the ferry boats must all be scrapped; they have no alternative uses. Which of the following numbers are relevant to the decision of whether to build the bridge:

   a.   The cost of building the bridge.

   b.   The revenue you could earn from a bridge.

   c.   The cost of the ferry boats.

   d.   The revenue you earn from the ferry boats.

10. a.   Suppose that a famous Chicago Cubs baseball player threatens to quit unless his salary is doubled, and the management accedes to his demand. **True or False:** The fans will have to pay for this through higher ticket prices.

   b.   Now suppose that the Cubs hire a famous and popular player away from the Philadelphia Phillies. Explain what will happen to ticket prices now.

11. A firm faces the following demand and total cost schedules:

Demand		Total Cost	
P	Q	Q	TC
$20	1	1	$2
18	2	2	6
16	3	3	11
14	4	4	18
12	5	5	26

Suppose that the firm is required to produce a whole number of items each month. How much does it produce and at what price? How do you know?

12. A firm faces the following demand and total cost schedules, with all quantities listed on a per-month basis. Suppose that it is required to produce a whole number of items each month.

Demand		Total Cost	
P	Q	Q	TC
$20	1	1	$5
18	2	2	15
15	3	3	30
12	4	4	50
8	5	5	75

a. How much does the firm produce, and at what price? How do you know?

b. Suppose that the firm is subject to an excise tax of $5 per item sold. How much does it produce, and at what price? How do you know?

c. Suppose, instead, that the firm is subject to a tax of $20 per month, regardless of how much it produces. How much does it produce, and at what price? How do you know?

d. Suppose, instead, that the firm is subject to a tax of $25 per month, regardless of how much it produces. How much does it produce, and at what price? How do you know?

13. Fred and Wilma have noticed that prices tend to be higher in stores that are located in high-rent districts. Fred thinks that the high rents cause the high prices, whereas Wilma thinks that the high prices cause the high rents. Under what circumstances is Fred correct? Under what circumstances is Wilma correct?