CHAPTER

3

RATIONAL CONSUMER CHOICE

You have just cashed your monthly allowance check and are on your way to the local music store to buy an Eric Clapton CD you've been wanting. The price of the disc is $10. In scenario 1 you lose $10 on your way to the store. In scenario 2 you buy the disc and then trip and fall on your way out of the store; the disc shatters as it hits the sidewalk. Try to imagine your frame of mind in each scenario.

a. Would you proceed to buy the disc in scenario 1?

b. Would you return to buy the disc in scenario 2?

These questions[1] were recently put to a large class of undergraduates who had never taken an economics course. In response to the first question, 54 percent answered yes, saying they would buy the disc after losing the $10 bill. But only 32 percent answered yes to the second question—68 percent said they would *not* buy the disc after having broken the first one. There is, of course, no "correct" answer to either question. The events described will have more of an impact, for example, on a poor consumer than on a rich one. Yet a moment's reflection reveals that your behavior in one scenario logically should be exactly the same as in the other. After all, in both scenarios, the only economically relevant change is that you now have $10 less to spend than before. This might well mean that you will want to give up having the disc; or it could mean saving less or giving up some other good that you would have bought. But your choice should not be

[1]These questions are patterned after similar questions posed by decision theorists Daniel Kahneman and Amos Tversky (see Chapter 8).

affected by the particular way you happened to become $10 poorer. In both scenarios, the cost of the disc is $10, and the benefit you will receive from listening to it is also the same. You should either buy the disc in both scenarios or not buy it in both. And yet, as noted, many people would choose differently in the two scenarios.

CHAPTER PREVIEW

Our task in this chapter is to set forth the economist's basic model for answering questions such as the ones posed above. This model is known as the theory of *rational consumer choice*. It underlies all individual purchase decisions, which in turn add up to the demand curves we worked with in the preceding chapter.

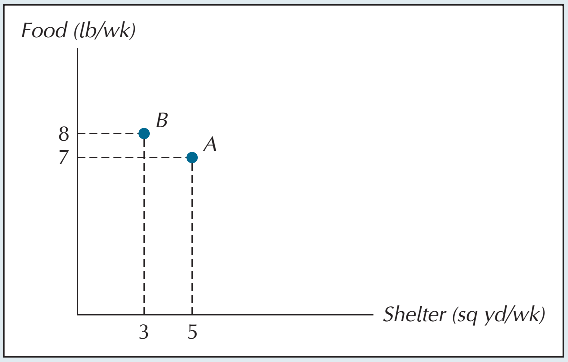
Rational choice theory begins with the assumption that consumers enter the marketplace with well-defined preferences. Taking prices as given, their task is to allocate their incomes to best serve these preferences. Two steps are required to carry out this task. Step 1 is to describe the various combinations of goods the consumer is *able* to buy. These combinations depend on both her income level and the prices of the goods. Step 2 then is to select from among the feasible combinations the particular one that she *prefers* to all others. Analysis of step 2 requires some means of describing her preferences, in particular, a summary of her ranking of the desirability of all feasible combinations. Formal development of these two elements of the theory will occupy our attention throughout this chapter. Because the first element—describing the set of possibilities—is much less abstract than the second, let us begin with it.

THE OPPORTUNITY SET OR BUDGET CONSTRAINT

bundle a particular combination of two or more goods.

For simplicity, we start by considering a world with only two goods,[2] shelter and food. A **bundle** of goods is the term used to describe a particular combination of shelter, measured in square yards per week, and food, measured in pounds per week. Thus, in Figure 3.1, one bundle (bundle *A*) might consist of 5 sq yd/wk of shelter and 7 lb/wk of food, while another (bundle *B*) consists of 3 sq yd/wk of shelter and 8 lb/wk of food. For brevity, we use (5, 7) to denote bundle *A* and (3, 8) to denote bundle *B*. More generally, (S_0, F_0) will denote the bundle with S_0 sq yd/wk of shelter and F_0 lb/wk of food. By convention, the first number of the pair in any bundle represents the good measured along the horizontal axis.

FIGURE 3.1
Two Bundles of Goods
A bundle is a specific combination of goods. Bundle *A* has 5 units of shelter and 7 units of food. Bundle *B* has 3 units of shelter and 8 units of food.



[2]As economists use the term, a "good" may refer to either a product or a service.

Note that the units on both axes are *flows,* which means physical quantities per unit of time—pounds per week, square yards per week. Consumption is always measured as a flow. It is important to keep track of the time dimension because without it there would be no way to evaluate whether a given quantity of consumption was large or small. (Suppose all you know is that your food consumption is 4 lb. If that's how much you eat each day, it's a lot. But if that's all you eat in a month, you're not likely to survive for long.)[3]

Suppose the consumer's income is M = \$100/wk, all of which she spends on some combination of food and shelter. (Note that income is also a flow.) Suppose further that the prices of shelter and food are P_S = \$5/sq yd and P_F = \$10/lb, respectively. If the consumer spent all her income on shelter, she could buy M/P_S = (\$100/wk) ÷ (\$5/sq yd) = 20 sq yd/wk. That is, she could buy the bundle consisting of 20 sq yd/wk of shelter and 0 lb/wk of food, denoted (20, 0). Alternatively, suppose the consumer spent all her income on food. She would then get the bundle consisting of M/P_F = (\$100/wk) ÷ (\$10/lb), which is 10 lb/wk of food and 0 sq yd/wk of shelter, denoted (0, 10).

Note that the units in which consumption goods are measured are subject to the standard rules of arithmetic. For example, when we simplify the expression on the right-hand side of the equation M/P_S = (\$100/wk) ÷ (\$5/sq yd), we are essentially dividing one fraction by another, so we follow the standard rule of inverting the fraction in the denominator and multiplying it by the fraction in the numerator: (sq yd/\$5) × (\$100/wk) = (\$100 × sq yd)/(\$5 × wk). After dividing both the numerator and denominator of the fraction on the right-hand side of this last equation by \$5, we have 20 sq yd/wk, which is the maximum amount of shelter the consumer can buy with an income of \$100/wk. Similarly, M/P_F = (\$100/wk) ÷ (\$10/lb) simplifies to 10 lb/wk, the maximum amount of food the consumer can purchase with an income of \$100/wk.

In Figure 3.2 these polar cases are labeled K and L, respectively. The consumer is also able to purchase any other bundle that lies along the straight line that joins points K and L. [Verify, for example, that the bundle (12, 4) lies on this same line.] This line is called the **budget constraint** and is labeled B in the diagram.

budget constraint the set of all bundles that exactly exhaust the consumer's income at given prices. Also called the *budget line*.

Recall the maxim from high school algebra that the slope of a straight line is its "rise" over its "run" (the change in its vertical position divided by the corresponding change in its horizontal position). Here, note that the slope of the budget constraint

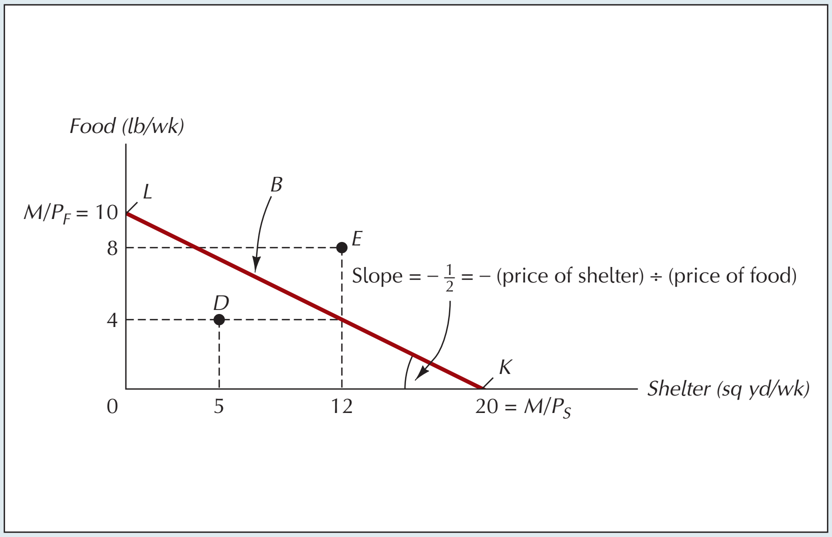


FIGURE 3.2
The Budget Constraint, or Budget Line
Line B describes the set of all bundles the consumer can purchase for given values of income and prices. Its slope is the negative of the price of shelter divided by the price of food. In absolute value, this slope is the opportunity cost of an additional unit of shelter—the number of units of food that must be sacrificed in order to purchase one additional unit of shelter at market prices.

[3]The flow aspect of consumption also helps us alleviate any concern about goods not being divisible. If you consume 1.5 lb/mo, then you consume 18 lb/yr, which is a whole number.

is its vertical intercept (the rise) divided by its horizontal intercept (the corresponding run): $-(10 \text{ lb/wk})/(20 \text{ sq yd/wk}) = -\frac{1}{2}$ lb/sq yd. (Note again how the units obey the standard rules of arithmetic.) The minus sign signifies that the budget line falls as it moves to the right—that it has a negative slope. More generally, if M denotes the consumer's weekly income, and P_S and P_F denote the prices of shelter and food, respectively, the horizontal and vertical intercepts will be given by (M/P_S) and (M/P_F), respectively. Thus the general formula for the slope of the budget constraint is given by $-(M/P_F)/(M/P_S) = -P_S/P_F$, which is simply the negative of the price ratio of the two goods. Given their respective prices, it is the rate at which food can be exchanged for shelter. Thus, in Figure 3.2, 1 lb of food can be exchanged for 2 sq yd of shelter. In the language of opportunity cost from Chapter 1, we would say that the opportunity cost of an additional square yard of shelter is $P_S/P_F = \frac{1}{2}$ lb of food.

In addition to being able to buy any of the bundles along her budget constraint, the consumer is also able to purchase any bundle that lies within the *budget triangle* bounded by it and the two axes. D is one such bundle in Figure 3.2. Bundle D costs \$65/wk, which is well below the consumer's income of \$100/wk. The bundles on or within the budget triangle are also referred to as the *feasible set,* or **affordable set.** Bundles like E that lie outside the budget triangle are said to be *infeasible,* or *unaffordable.* At a cost of \$140/wk, E is simply beyond the consumer's reach.

affordable set bundles on or below the budget constraint; bundles for which the required expenditure at given prices is less than or equal to the income available.

If S and F denote the quantities of shelter and food, respectively, the budget constraint must satisfy the following equation:

$$P_S S + P_F F = M, \tag{3.1}$$

which says simply that the consumer's weekly expenditure on shelter ($P_S S$) plus her weekly expenditure on food ($P_F F$) must add up to her weekly income (M). To express the budget constraint in the manner conventionally used to represent the formula for a straight line, we solve Equation 3.1 for F in terms of S, which yields

$$F = \frac{M}{P_F} - \frac{P_S}{P_F} S \tag{3.2}$$

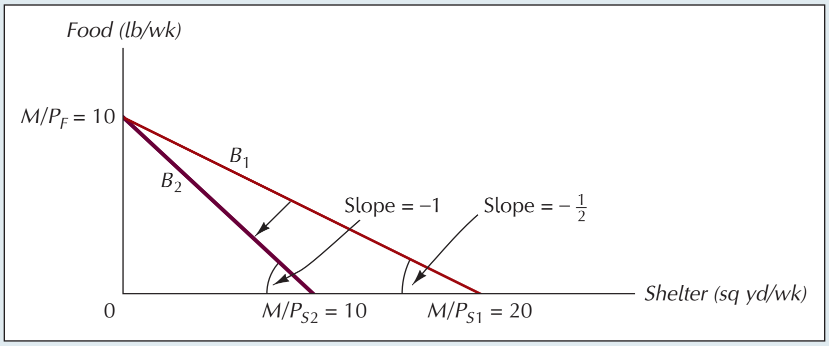
Equation 3.2 is another way of seeing that the vertical intercept of the budget constraint is given by M/P_F and its slope by $-(P_S/P_F)$. The equation for the budget constraint in Figure 3.2 is $F = 10 - \frac{1}{2} S$.

BUDGET SHIFTS DUE TO PRICE OR INCOME CHANGES

Price Changes

The slope and position of the budget constraint are fully determined by the consumer's income and the prices of the respective goods. Change any one of these factors and we have a new budget constraint. Figure 3.3 shows the effect of an increase

FIGURE 3.3
The Effect of a Rise in the Price of Shelter
When shelter goes up in price, the vertical intercept of the budget constraint remains the same. The original budget constraint rotates inward about this intercept.



in the price of shelter from P_{S1} = \$5/sq yd to P_{S2} = \$10. Since both weekly income and the price of food are unchanged, the vertical intercept of the consumer's budget constraint stays the same. The rise in the price of shelter rotates the budget constraint inward about this intercept, as shown in the diagram.

Note in Figure 3.3 that even though the price of food has not changed, the new budget constraint, B_2, curtails not only the amount of shelter the consumer can buy but also the amount of food.[4]

EXERCISE 3.1

Show the effect on the budget constraint B_1 in Figure 3.3 of a fall in the price of shelter from \$5/sq yd to \$4/sq yd.

In Exercise 3.1, you saw that a fall in the price of shelter again leaves the vertical intercept of the budget constraint unchanged. This time the budget constraint rotates outward. Note also in Exercise 3.1 that although the price of food remains unchanged, the new budget constraint enables the consumer to buy bundles that contain not only more shelter but also more food than she could afford on the original budget constraint.

The following exercise illustrates how changing the price of the good on the vertical axis affects the budget constraint.

EXERCISE 3.2

Show the effect on the budget constraint B_1 in Figure 3.3 of a rise in the price of food from \$10/lb to \$20/lb.

When we change the price of only one good, we necessarily change the slope of the budget constraint, $-P_S/P_F$. The same is true if we change both prices by different proportions. But as Exercise 3.3 will illustrate, changing both prices by exactly the same proportion gives rise to a new budget constraint with the same slope as before.

EXERCISE 3.3

Show the effect on the budget constraint B_3 in Figure 3.3 of a rise in the price of food from \$10/lb to \$20/lb and a rise in the price of shelter from \$5/sq yd to \$10/sq yd.

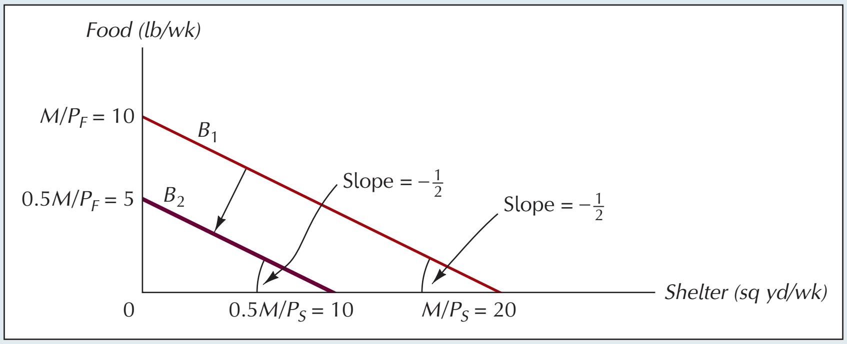
Note from Exercise 3.3 that the effect of doubling the prices of both food and shelter is to shift the budget constraint inward and parallel to the original budget constraint. The important lesson of this exercise is that the slope of a budget constraint tells us only about *relative prices,* nothing about prices in absolute terms. When the prices of food and shelter change in the same proportion, the opportunity cost of shelter in terms of food remains the same as before.

Income Changes

The effect of a change in income is much like the effect of an equal proportional change in all prices. Suppose, for example, that our hypothetical consumer's income is cut by half, from \$100/wk to \$50/wk. The horizontal intercept of the consumer's budget constraint then falls from 20 sq yd/wk to 10 sq yd/wk, and the vertical intercept falls from 10 lb/wk to 5 lb/wk, as shown in Figure 3.4. Thus the new budget, B_2, is parallel to the old, B_1, each with a slope of $-\frac{1}{2}$. In terms of its effect on what the consumer can buy, cutting income by one-half is thus no different from doubling each price. Precisely the same budget constraint results from both changes.

[4]The single exception to this statement involves the vertical intercept (0, 10), which lies on both the original and the new budget constraints.

FIGURE 3.4
The Effect of Cutting Income by Half
Both horizontal and vertical intercepts fall by half. The new budget constraint has the same slope as the old but is closer to the origin.



EXERCISE 3.4

Show the effect on the budget constraint B_1 in Figure 3.4 of an increase in income from \$100/wk to \$120/wk.

Exercise 3.4 illustrates that an increase in income shifts the budget constraint parallel outward. As in the case of an income reduction, the slope of the budget constraint remains the same.

BUDGETS INVOLVING MORE THAN TWO GOODS

In the examples discussed so far, the consumer could buy only two different goods. No consumer faces such narrow options. In its most general form, the consumer budgeting problem can be posed as a choice between not two but N different goods, where N can be an indefinitely large number. With only two goods ($N = 2$), the budget constraint is a straight line, as we just saw. With three goods ($N = 3$), it is a plane. When we have more than three goods, the budget constraint becomes what mathematicians call a *hyperplane,* or *multidimensional plane*. It is difficult to represent this multidimensional case geometrically. We are just not very good at visualizing surfaces that have more than three dimensions.

The nineteenth-century economist Alfred Marshall proposed a disarmingly simple solution to this problem. It is to view the consumer's choice as being one between a particular good—call it X—and an amalgam of other goods, denoted Y. This amalgam is generally called the **composite good.** By convention, the units of the composite good are defined so that its price is \$1 per unit. This convention enables us to think of the composite good as the amount of income the consumer has left over after buying the good X. Equivalently, it is the amount the consumer spends on goods other than X. For the moment, all the examples we consider will be ones in which consumers spend all their incomes. In Chapter 5 we will use the rational choice model to analyze the decision to save.

composite good in a choice between a good X and numerous other goods, the amount of money the consumer spends on those other goods.

To illustrate how the composite good concept is used, suppose the consumer has an income of \$$M$/wk, and the price of X is P_X. The consumer's budget constraint may then be represented as a straight line in the X, Y plane, as shown in Figure 3.5. Because the price of a unit of the composite good is \$1, a consumer who devotes all his income to it will be able to buy M units. All this means is that he will have \$$M$ available to spend on other goods if he buys no X. Alternatively, if he spends his entire income on X, he will be able to purchase the bundle $(M/P_X, 0)$. Since the price of Y is assumed to be \$1/unit, the slope of the budget constraint is simply $-P_X$.

As before, the budget constraint summarizes the various combinations of bundles that exhaust the consumer's income. Thus, the consumer can have X_1 units of X and Y_1 units of the composite good in Figure 3.5, or X_2 and Y_2, or any other combination that lies on the budget constraint.

~~discovers his loss will shift inward to B_2. If he does not take the trip, he will have $M - \$60$ available to spend on other goods in both cases. And if he does take the trip, he will have to purchase the required gasoline at \$3/gal in both cases. No matter what the source of the loss, the remaining opportunities are exactly the same. If Gowdy's budget is tight, he may decide to cancel his trip. Otherwise, he may go despite the loss. But because his budget constraint and tastes are the same in the lost-cash case as in the stolen-gas case, it would not be rational for him to take the trip in one instance but not in the other.~~

~~Note that the situation described in Example 3.2 has the same structure as the one described in the broken-disc example with which we began this chapter. It too is one in which the decision should be the same in both instances because the budget constraint and preferences are the same in each.~~

~~Although the rational choice model makes clear that the decisions *should* be the same if the budget constraints and preferences are the same, people sometimes choose differently. The difficulty is often that the way the different situations are described sometimes causes people to overlook the essential similarities between them. For instance, in Example 3.2, many people erroneously conclude that the cost of taking the trip is higher in the stolen-gas case than in the lost-money case, and so they are less likely to take the trip in the former instance. Similarly, many people were less inclined to buy the disc after having broken the first one than after having lost \$10 because they thought, incorrectly, that the disc would cost more under the broken-disc scenario. As we have seen, however, the amount that will be saved by not buying the disc, or by not taking the trip, is exactly the same under each scenario.~~

~~To recapitulate briefly, the budget constraint or budget line summarizes the combinations of bundles that the consumer is able to buy. Its position is determined jointly by income and prices. From the set of feasible bundles, the consumer's task is to pick the particular one she likes best. To identify this bundle, we need some means of summarizing the consumer's preferences over all possible bundles she might consume. We now turn to this task.~~

CONSUMER PREFERENCES

For simplicity, let us again begin by considering a world with only two goods: shelter and food. A **preference ordering** enables the consumer to rank different bundles of goods in terms of their desirability, or order of preference. Consider two bundles, *A* and *B*. For concreteness, suppose that *A* contains 4 sq yd/wk of shelter and 2 lb/wk of food, while *B* has 3 sq yd/wk of shelter and 3 lb/wk of food. Knowing nothing about a consumer's preferences, we can say nothing about which of these bundles he will prefer. *A* has more shelter but less food than *B*. Someone who spends a lot of time at home would probably choose *A*, while someone with a rapid metabolism might be more likely to choose *B*.

preference ordering a ranking of all possible consumption bundles in order of preference.

In general, we assume that for any two such bundles, the consumer is able to make one of three possible statements: (1) *A* is preferred to *B*, (2) *B* is preferred to *A*, or (3) *A* and *B* are equally attractive. The preference ordering enables the consumer to rank different bundles but not to make more precise quantitative statements about their relative desirability. Thus, the consumer might be able to say that he prefers *A* to *B* but not that *A* provides twice as much satisfaction as *B*.

Preference orderings often differ widely among consumers. One person will like Rachmaninoff, another the Red Hot Chili Peppers. Despite these differences, however, most preference orderings share several important features. More specifically, economists generally assume four simple properties of preference orderings. These properties allow us to construct the concise analytical representation of preferences we need for the budget allocation problem.

1. Completeness

A preference ordering is *complete* if it enables the consumer to rank all possible combinations of goods and services. Taken literally, the completeness assumption is never satisfied, for there are many goods we know too little about to be able to evaluate. It is nonetheless a useful simplifying assumption for the analysis of choices among bundles of goods with which consumers are familiar. Its real intent is to rule out instances like the one portrayed in the fable of Buridan's ass. The hungry animal was unable to choose between two bales of hay in front of him and starved to death as a result.

2. More-Is-Better

The more-is-better property means simply that, other things equal, more of a good is preferred to less. We can, of course, think of examples of more of something making us worse off rather than better (as with someone who has overeaten). But these examples usually contemplate some sort of practical difficulty, such as having a self-control problem or being unable to store a good for future use. As long as people can freely store or dispose of goods they don't want, having more of something can't make them worse off.

As an example of the application of the more-is-better assumption, consider two bundles: *A,* which has 12 sq yd/wk of shelter and 10 lb/wk of food, and *B,* which has 12 sq yd/wk of shelter and 11 lb/wk of food. The assumption tells us that *B* is preferred to *A,* because it has more food and no less shelter.

3. Transitivity

If you like steak better than hamburger and hamburger better than hot dogs, you are probably someone who likes steak better than hot dogs. To say that a consumer's preference ordering is *transitive* means that, for any three bundles *A, B,* and *C,* if he prefers *A* to *B* and prefers *B* to *C,* then he always prefers *A* to *C.* For example, suppose *A* is (4, 2), *B* is (3, 3), and *C* is (2, 4). If you prefer (4, 2) over (3, 3) and you prefer (3, 3) over (2, 4), then you must prefer (4, 2) over (2, 4). The preference relationship is thus assumed to be like the relationship used to compare heights of people. If O'Neal is taller than Nowitzki and Nowitzki is taller than Bryant, we know that O'Neal must be taller than Bryant.

Not all comparative relationships are transitive. The relationship "half sibling," for example, is not. I have a half sister who, in turn, has three half sisters of her own. But her half sisters are not my half sisters. A similar nontransitivity is shown by the relationship "defeats in football." Some seasons, Ohio State defeats Michigan, and Michigan defeats Michigan State, but that doesn't tell us that Ohio State will necessarily defeat Michigan State.

Transitivity is a simple consistency property and applies as well to the relation "equally attractive as" and to any combination of it and the "preferred to" relation. For example, if *A* is equally attractive as *B* and *B* is equally attractive as *C,* it follows that *A* is equally attractive as *C.* Similarly, if *A* is preferred to *B* and *B* is equally attractive as *C,* it follows that *A* is preferred to *C.*

The transitivity assumption can be justified as eliminating the potential for a "money pump" problem. To illustrate, suppose you prefer *A* to *B* and *B* to *C,* but you also prefer *C* over *A,* so that your preferences are intransitive. If you start with *C,* you would trade *C* for *B,* trade *B* for *A,* and then trade *A* for *C.* This cycle could continue forever. If in each stage you were charged a tiny fee for the trade, you would eventually transfer all your money to the other trader. Clearly, such preferences are problematic.

As reasonable as the transitivity property sounds, we will see examples in later chapters of behavior that seems inconsistent with it. But it is an accurate description of preferences in most instances. Unless otherwise stated, we will adopt it.

4. Convexity

Mixtures of goods are preferable to extremes. If you are indifferent between two bundles *A* and *B,* your preferences are convex if you prefer a bundle that contains half of *A* and half of *B* (or any other mixture) to either of the original bundles. For example, suppose you are indifferent between $A = (4, 0)$ and $B = (0, 4)$. If your preferences are convex, you will prefer the bundle (2, 2) to each of the more extreme bundles. This property conveys the sense that we like balance in our mix of consumption goods.

INDIFFERENCE CURVES

Let us consider some implications of these assumptions about preference orderings. Most important, they enable us to generate a graphical description of the consumer's preferences. To see how, consider first the bundle *A* in Figure 3.8, which has 12 sq yd/wk of shelter and 10 lb/wk of food. The more-is-better assumption tells us that all bundles to the northeast of *A* are preferred to *A*, and that *A*, in turn, is preferred to all those to the southwest of *A*. Thus, the more-is-better assumption tells us that *Z*, which has 28 sq yd/wk of shelter and 12 lb/wk of food, is preferred to *A* and that *A*, in turn, is preferred to *W*, which has only 6 sq yd/wk of shelter and 4 lb/wk of food.

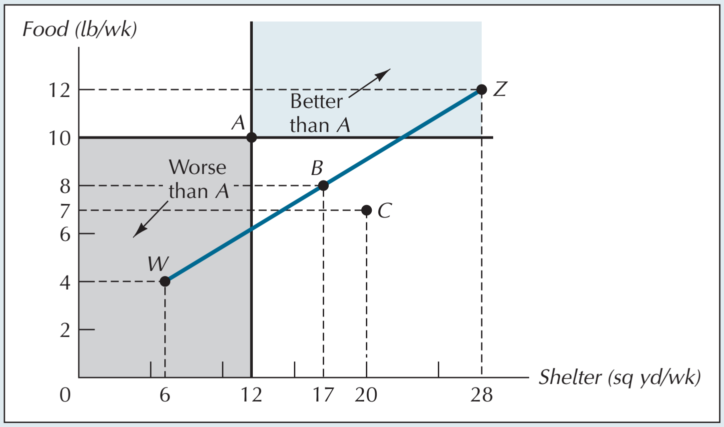


FIGURE 3.8
Generating Equally Preferred Bundles
Z is preferred to *A* because it has more of each good than *A* has. For the same reason, *A* is preferred to *W*. It follows that on the line joining *W* and *Z* there must be a bundle *B* that is equally attractive as *A*. In similar fashion, we can find a bundle *C* that is equally attractive as *B*.

Now consider the set of bundles that lie along the line joining *W* and *Z*. Because *Z* is preferred to *A* and *A* is preferred to *W*, it follows that as we move from *Z* to *W* we must encounter a bundle that is equally attractive as *A*. (The intuition behind this claim is the same as the intuition that tells us that if we climb on any continuous path on a mountainside from one point at 1000 feet above sea level to another at 2000 feet, we must pass through every intermediate altitude along the way.) Let *B* denote the bundle that is equally attractive as *A*, and suppose it contains 17 sq yd/wk of shelter and 8 lb/wk of food. (The exact amounts of each good in *B* will of course depend on the specific consumer whose preferences we are talking about.) The more-is-better assumption also tells us that there will be only one such bundle on the straight line between *W* and *Z*. Points on that line to the northeast of *B* are all better than *B;* those to the southwest of *B* are all worse.

In precisely the same fashion, we can find another point—call it *C*—that is equally attractive as *B*. *C* is shown as the bundle (20, 7), where the specific quantities in *C* again depend on the preferences of the consumer under consideration. By the transitivity assumption, we know that *C* is also equally attractive as *A* (since *C* is equally attractive as *B*, which is equally attractive as *A*).

We can repeat this process as often as we like, and the end result will be an **indifference curve,** a set of bundles all of which are equally attractive as the original bundle *A*, and hence also equally attractive as one another. This set is shown as the curve labeled *I* in Figure 3.9. It is called an indifference curve because the consumer is indifferent among all the bundles that lie along it.

indifference curve a set of bundles among which the consumer is indifferent.

An indifference curve also permits us to compare the satisfaction implicit in bundles that lie along it with those that lie either above or below it. It permits us, for example, to compare bundle *C* (20, 7) to bundle *K* (23, 4), which has less food and more shelter than *C* has. We know that *C* is equally attractive as *D* (25, 6)

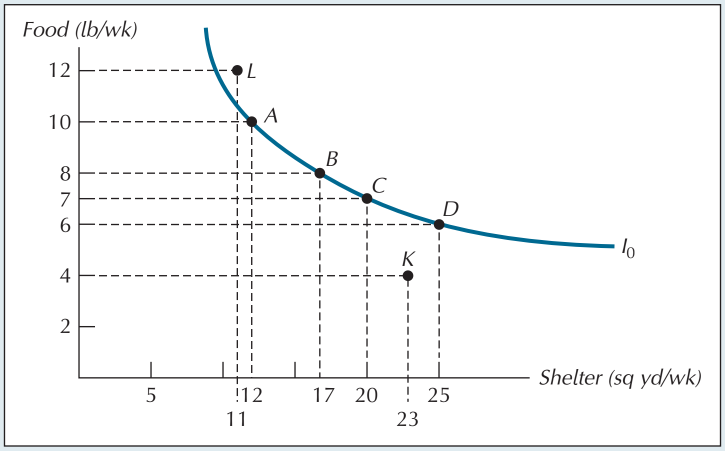


FIGURE 3.9
An Indifference Curve
An indifference curve is a set of bundles that the consumer considers equally attractive. Any bundle, such as *L*, that lies above an indifference curve is preferred to any bundle on the indifference curve. Any bundle on the indifference curve, in turn, is preferred to any bundle, such as *K*, that lies below the indifference curve.

because both bundles lie along the same indifference curve. *D*, in turn, is preferred to *K* because of the more-is-better assumption: It has 2 sq yd/wk more shelter and 2 lb/wk more food than *K* has. Transitivity, finally, tells us that since *C* is equally attractive as *D* and *D* is preferred to *K*, *C* must be preferred to *K*.

By analogous reasoning, we can say that bundle *L* is preferred to *A*. *In general, bundles that lie above an indifference curve are all preferred to the bundles that lie on it. Similarly, bundles that lie on an indifference curve are all preferred to those that lie below it.*

The completeness property of preferences implies that there is an indifference curve that passes through every possible bundle. That being so, we can represent a consumer's preferences with an **indifference map,** an example of which is shown in Figure 3.10. This indifference map shows just four of the infinitely many indifference curves that, taken together, yield a complete description of the consumer's preferences.

indifference map a representative sample of the set of a consumer's indifference curves, used as a graphical summary of her preference ordering.

The numbers $I_1, \ldots, I_4$ in Figure 3.10 are index values used to denote the order of preference that corresponds to the respective indifference curves. Any index numbers would do equally well provided they satisfied the property $I_1 < I_2 < I_3 < I_4$. In representing the consumer's preferences, what really counts is the *ranking* of the indifference curves, not the particular numerical values we assign to them.[5]

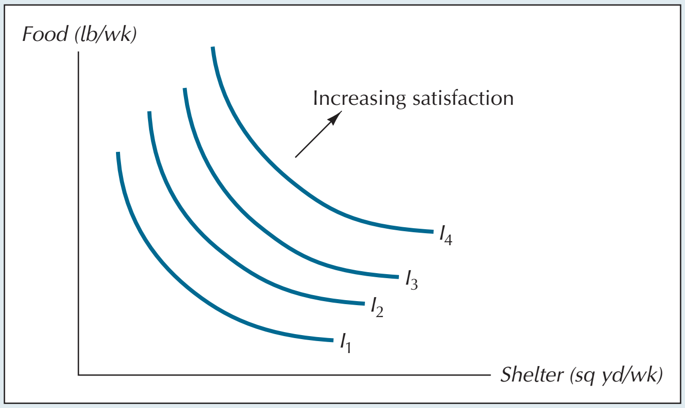


FIGURE 3.10
Part of an Indifference Map
The entire set of a consumer's indifference curves is called the consumer's indifference map. Bundles on any indifference curve are less preferred than bundles on a higher indifference curve, and more preferred than bundles on a lower indifference curve.

[5]For a more complete discussion of this issue, see pp. 87–89 of the appendix to this chapter.

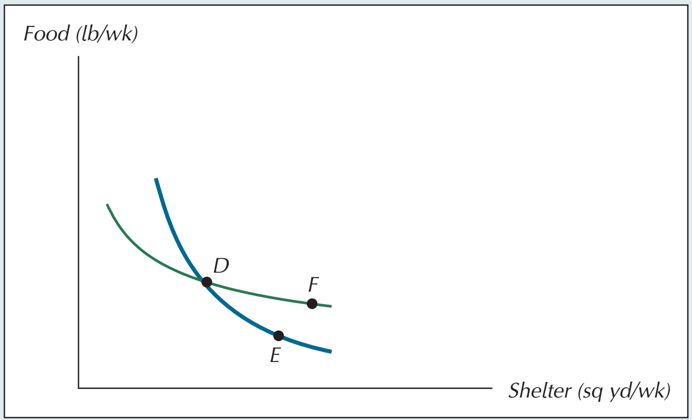


FIGURE 3.11
Why Two Indifference Curves Do Not Cross
If indifference curves were to cross, they would have to violate at least one of the assumed properties of preference orderings.

The four properties of preference orderings imply four important properties of indifference curves and indifference maps:

1. Indifference curves are ubiquitous. Any bundle has an indifference curve passing through it. This property is assured by the completeness property of preferences.
2. Indifference curves are downward-sloping. An upward-sloping indifference curve would violate the more-is-better property by saying a bundle with more of both goods is equivalent to a bundle with less of both.
3. Indifference curves (from the same indifference map) cannot cross. To see why, suppose that two indifference curves did, in fact, cross as in Figure 3.11. The following statements would then have to be true:
   E is equally attractive as *D* (because they each lie on the same indifference curve).
   D is equally attractive as *F* (because they each lie on the same indifference curve).
   E is equally attractive as *F* (by the transitivity assumption).
   But we also know that
   F is preferred to *E* (because more is better).
   Because it is not possible for the statements *E is equally attractive as F* and *F is preferred to E* to be true simultaneously, the assumption that two indifference curves cross thus implies a contradiction. The conclusion is that the original proposition must be true, namely, two indifference curves cannot cross.
4. Indifference curves become less steep as we move downward and to the right along them. As discussed below, this property is implied by the convexity property of preferences.

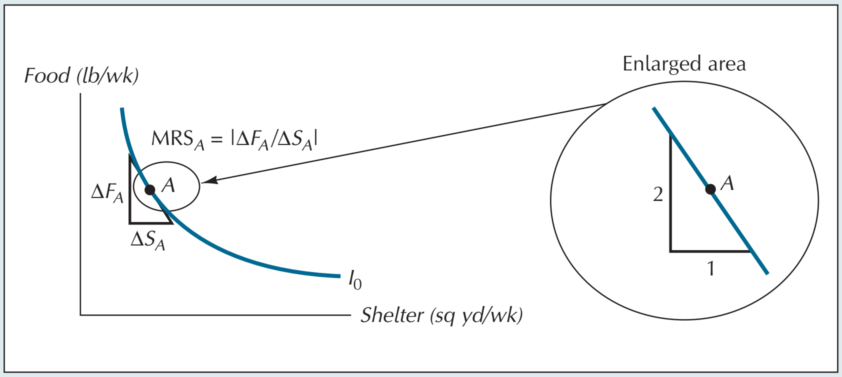
TRADE-OFFS BETWEEN GOODS

An important property of a consumer's preferences is the rate at which he is willing to exchange, or "trade off," one good for another. This rate is represented at any point on an indifference curve by the **marginal rate of substitution (MRS),** which is defined as the absolute value of the slope of the indifference curve at that point. In the left panel of Figure 3.12, for example, the marginal rate of substitution at point *A* is given by the absolute value of the slope of the tangent to the indifference curve at *A*, which is the ratio $\Delta F_A/\Delta S_A$.[6] (The notation ΔF_A means "small change in food from the amount at point *A*.") If we take ΔF_A units of food away from the consumer at point *A*, we have to give him ΔS_A additional units of shelter to make him

marginal rate of substitution (MRS) at any point on an indifference curve, the rate at which the consumer is willing to exchange the good measured along the vertical axis for the good measured along the horizontal axis; equal to the absolute value of the slope of the indifference curve.

[6]More formally, the indifference curve may be expressed as a function $Y = Y(X)$ and the MRS at point *A* is defined as the absolute value of the derivative of the indifference curve at that point: $MRS = |dY(X)/dX|$.

FIGURE 3.12
The Marginal Rate of Substitution
MRS at any point along an indifference curve is defined as the absolute value of the slope of the indifference curve at that point. It is the amount of food the consumer must be given to compensate for the loss of 1 unit of shelter.



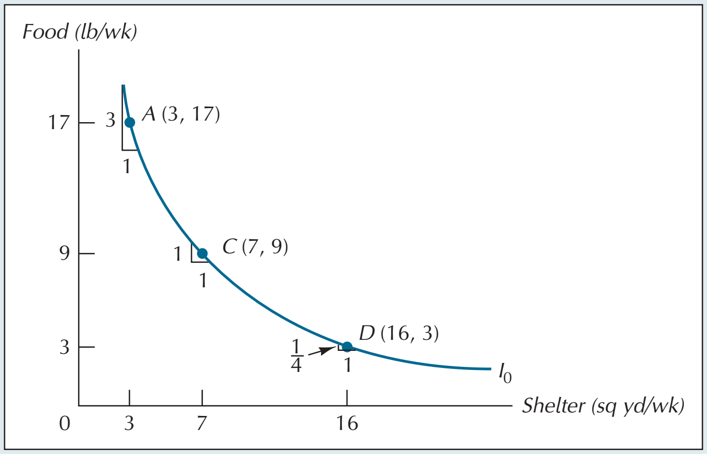
just as well off as before. The right panel of the figure shows an enlargement of the region surrounding bundle *A*. If the marginal rate of substitution at *A* is 2, this means that the consumer must be given 2 lb/wk of food to make up for the loss of 1 sq yd/wk of shelter.

Whereas the slope of the budget constraint tells us the rate at which we can substitute food for shelter without changing total expenditure, the MRS tells us the rate at which we can substitute food for shelter without changing total satisfaction. Put another way, the slope of the budget constraint is the marginal cost of shelter in terms of food, and the MRS is the marginal benefit of shelter in terms of food.

The convexity property of preferences tells us that along any indifference curve, the more a consumer has of one good, the more she must be given of that good before she will be willing to give up a unit of the other good. Stated differently, MRS declines as we move downward to the right along an indifference curve. Indifference curves with diminishing rates of marginal substitution are thus convex—or bowed outward—when viewed from the origin. The indifference curves shown in Figures 3.9, 3.10, and 3.12 have this property, as does the curve shown in Figure 3.13.

In Figure 3.13, note that at bundle *A* food is relatively plentiful and the consumer would be willing to sacrifice 3 lb/wk of it in order to obtain an additional square yard of shelter. Her MRS at *A* is 3. At *C*, the quantities of food and shelter are more balanced, and there she would be willing to give up only 1 lb/wk to obtain an additional square yard of shelter. Her MRS at *C* is 1. Finally, note that food is

FIGURE 3.13
Diminishing Marginal Rate of Substitution
The more food the consumer has, the more she is willing to give up to obtain an additional unit of shelter. The marginal rates of substitution at bundles *A, C,* and *D* are 3, 1, and 1/4, respectively.



relatively scarce at *D*, and there she would be willing to give up only $\frac{1}{4}$ lb/wk of food to obtain an additional unit of shelter. Her MRS at *D* is $\frac{1}{4}$.

Intuitively, diminishing MRS means that consumers like variety. We are usually willing to give up goods we already have a lot of to obtain more of those goods we now have only a little of.

USING INDIFFERENCE CURVES TO DESCRIBE PREFERENCES

To get a feel for how indifference maps describe a consumer's preferences, let us see how indifference maps can be used to portray differences in preferences between two consumers. Suppose, for example, that both Tex and Mohan like potatoes but that Mohan likes rice much more than Tex does. This difference in their tastes is captured by the differing slopes of their indifference curves in Figure 3.14. Note in Figure 3.14*a*, which shows Tex's indifference map, that Tex would be willing to exchange 1 lb of potatoes for 1 lb of rice at bundle *A*. But at the corresponding bundle in Figure 3.14*b*, which shows Mohan's indifference map, we see that Mohan would trade 2 lb of potatoes for 1 lb of rice. Their difference in preferences shows up clearly in this difference in their marginal rates of substitution of potatoes for rice.

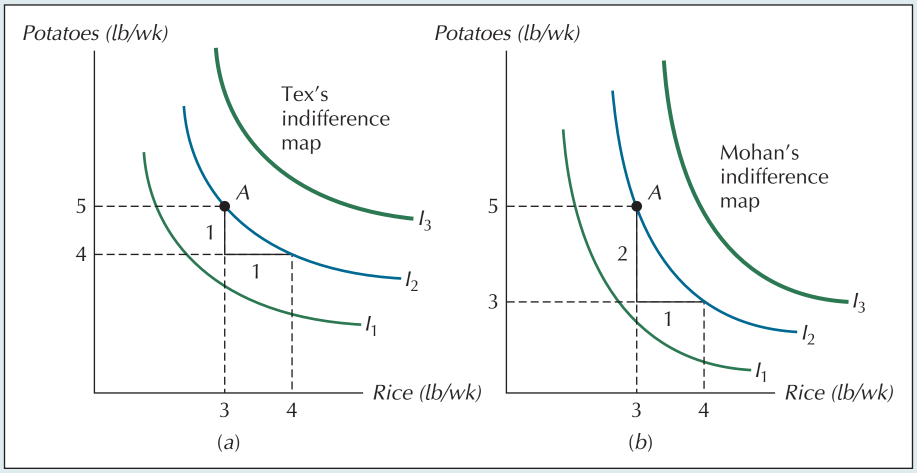


FIGURE 3.14
People with Different Tastes
Relatively speaking, Tex is a potato lover; Mohan, a rice lover. This difference shows up in the fact that at any given bundle Tex's marginal rate of substitution of potatoes for rice is smaller than Mohan's.

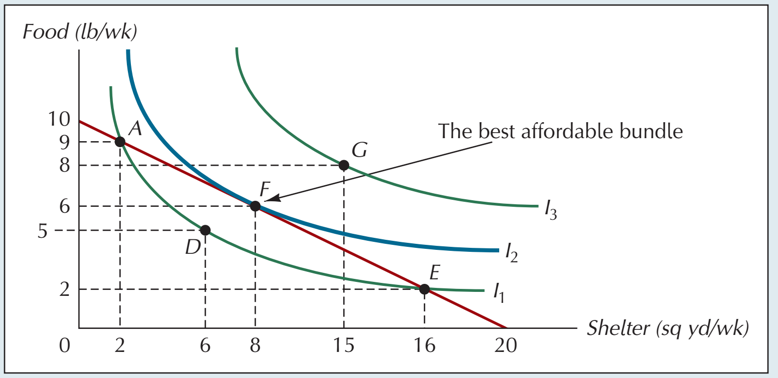
THE BEST FEASIBLE BUNDLE

We now have the tools we need to determine how the consumer should allocate his income between two goods. The indifference map tells us how the various bundles are ranked in order of preference. The budget constraint, in turn, tells us which bundles are affordable. The consumer's task is to put the two together and to choose the most preferred or **best affordable bundle.** (Recall from Chapter 1 that we need not suppose that consumers think explicitly about budget constraints and indifference maps when deciding what to buy. It is sufficient to assume that people make decisions *as if* they were thinking in these terms, just as expert pool players choose between shots as if they knew all the relevant laws of Newtonian physics.)

best affordable bundle the most preferred bundle of those that are affordable.

Let us again consider the choice between food and shelter that confronts a consumer with an income of M = \$100/wk facing prices of P_F = \$10/lb and P_S = \$5/sq yd. Figure 3.15 shows this consumer's budget constraint and part of his indifference map. Of the five labeled bundles—*A*, *D*, *E*, *F*, and *G*—in the diagram, *G* is the most preferred because it lies on the highest indifference curve. *G*, however, is not affordable, nor is any other bundle that lies beyond the budget constraint. The

FIGURE 3.15
The Best Affordable Bundle
The best the consumer can do is to choose the bundle on the budget constraint that lies on the highest attainable indifference curve. Here, that is bundle *F*, which lies at a tangency between the indifference curve and the budget constraint.



more-is-better assumption implies that the best affordable bundle must lie *on* the budget constraint, not inside it. (Any bundle inside the budget constraint would be less preferred than one just slightly to the northeast, which would also be affordable.)

Where exactly is the best affordable bundle located along the budget constraint? We know that it cannot be on an indifference curve that lies partly inside the budget constraint. On the indifference curve I_1, for example, the only points that are even candidates for the best affordable bundle are the two that lie on the budget constraint, namely, *A* and *E*. But *A* cannot be the best affordable bundle because it is equally attractive as *D*, which in turn is less desirable than *F* by the more-is-better assumption. So by transitivity, *A* is less desirable than *F*. For the same reason, *E* cannot be the best affordable bundle.

Since the best affordable bundle cannot lie on an indifference curve that lies partly inside the budget constraint, and since it must lie on the budget constraint itself, we know it has to lie on an indifference curve that intersects the budget constraint only once. In Figure 3.15, that indifference curve is the one labeled I_2, and the best affordable bundle is *F*, which lies at the point of tangency between I_2 and the budget constraint. With an income of \$100/wk and facing prices of \$5/sq yd for shelter and \$10/lb for food, the best this consumer can do is to buy 6 lb/wk of food and 8 sq yd/wk of shelter.

The choice of bundle *F* makes perfect sense on intuitive grounds. The consumer's goal, after all, is to reach the highest indifference curve he can, given his budget constraint. His strategy is to keep moving to higher and higher indifference curves until he reaches the highest one that is still affordable. For indifference maps for which a tangency point exists, as in Figure 3.15, the best bundle will always lie at the point of tangency.

In Figure 3.15, note that the marginal rate of substitution at *F* is exactly the same as the absolute value of the slope of the budget constraint. This will always be so when the best affordable bundle occurs at a point of tangency. The condition that must be satisfied in such cases is therefore

$$MRS = \frac{P_S}{P_F}. \tag{3.3}$$

The right-hand side of Equation 3.3 represents the opportunity cost of shelter in terms of food. Thus, with P_S = \$5/sq yd and P_F = \$10/lb, the opportunity cost of an additional square yard of shelter is $\frac{1}{2}$ lb of food. The left-hand side of Equation 3.3 is $|\Delta F/\Delta S|$, the absolute value of the slope of the indifference curve at the point of tangency. It is the amount of additional food the consumer must be given in order to compensate him fully for the loss of 1 sq yd of shelter. In the language of cost-benefit analysis discussed in Chapter 1, the slope of the budget constraint represents the opportunity cost of shelter in terms of food, while the slope of the indifference curve represents the benefits of consuming shelter as compared with consuming food. Since the slope of the budget constraint is $-\frac{1}{2}$ in this example, the tangency condition tells us that $\frac{1}{2}$ lb of food would be required to compensate for the benefits given up with the loss of 1 sq yd of shelter.

If the consumer were at some bundle on the budget line for which the two slopes are not the same, then it would always be possible for him to purchase a better bundle. To see why, suppose he were at a point where the slope of the indifference curve (in absolute value) is less than the slope of the budget constraint (also in absolute value), as at point E in Figure 3.15. Suppose, for instance, that the MRS at E is only $\frac{1}{4}$. This tells us that the consumer can be compensated for the loss of 1 sq yd of shelter by being given an additional $\frac{1}{4}$ lb of food. But the slope of the budget constraint tells us that by giving up 1 sq yd of shelter, he can purchase an additional $\frac{1}{2}$ lb of food. Since this is $\frac{1}{4}$ lb more than he needs to remain equally satisfied, he will clearly be better off if he purchases more food and less shelter than at point E. The opportunity cost of an additional pound of food is less than the benefit it confers.

EXERCISE 3.6

Suppose that the marginal rate of substitution at point *A* in Figure 3.15 is 1.0. Show that this means the consumer will be better off if he purchases less food and more shelter than at *A*.

CORNER SOLUTIONS

The best affordable bundle need not always occur at a point of tangency. In some cases, there may simply *be* no point of tangency—the MRS may be everywhere greater, or less, than the slope of the budget constraint. In this case we get a **corner solution,** like the one shown in Figure 3.16, where M, P_F, and P_S are again given by \$100/wk, \$10/lb and \$5/sq yd, respectively. The best affordable bundle is the one labeled A, and it lies at the upper end of the budget constraint. At A the MRS is less than the absolute value of the slope of the budget constraint. For the sake of illustration, suppose the MRS at $A = 0.25$, which means that this consumer would be willing to give up 0.25 lb of food to get an additional square yard of shelter. But at market prices the opportunity cost of an additional square yard of shelter is 0.5 lb of food. He increases his satisfaction by continuing to give up shelter for more food until it is no longer possible to do so. Even though this consumer regards shelter as a desirable commodity, the best he can do is to spend all his income on food. Market prices are such that he would have to give up too much food to make the purchase of even a single unit of shelter worthwhile.

corner solution in a choice between two goods, a case in which the consumer does not consume one of the goods.

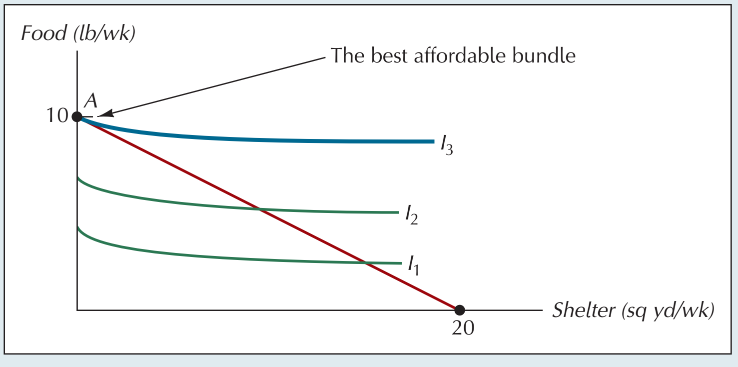


FIGURE 3.16
A Corner Solution
When the MRS of food for shelter is always less than the slope of the budget constraint, the best the consumer can do is to spend all his income on food.

The indifference map in Figure 3.16 satisfies the property of diminishing marginal rate of substitution—moving to the right along any indifference curve, the slope becomes smaller in absolute terms. But because the slopes of the indifference curves start out smaller than the slope of the budget constraint here, the two never reach equality.

Indifference curves that are not strongly convex are characteristic of goods that are easily substituted for one another. Corner solutions are more likely to occur for such goods, and indeed are almost certain to occur when goods are perfect substitutes. (See Example 3.3.) For such goods, the MRS does not diminish at all; rather, it is everywhere the same. With perfect substitutes, indifference curves are straight lines. If they happen to be steeper than the budget constraint, we get a corner solution on the horizontal axis; if less steep, we get a corner solution on the vertical axis.

EXAMPLE 3.3

Mattingly is a caffeinated-cola drinker who spends his entire soft drink budget on Coca-Cola and Jolt cola and cares only about total caffeine content. If Jolt has twice the caffeine of Coke, and if Jolt costs $1/pint and Coke costs $0.75/pint, how will Mattingly spend his soft drink budget of $15/wk?

For Mattingly, Jolt and Coke are *perfect substitutes,* which means that his indifference curves will be linear. The top line in Figure 3.17 is the set of all possible Coke-Jolt combinations that provide the same satisfaction as the bundle consisting of 0 pints of Jolt per day and 30 pints of Coke per day. Since each pint of Jolt has twice the caffeine of a pint of Coke, all bundles along this line contain precisely the same amount of caffeine. The first green line down is the indifference curve for bundles equivalent to bundle (0, 20); and the second green line down is the indifference curve corresponding to (0, 10). Along each of these indifference curves, the marginal rate of substitution of Coke for Jolt is always $\frac{2}{1}$, that is, 2 pints of Coke for every pint of Jolt.

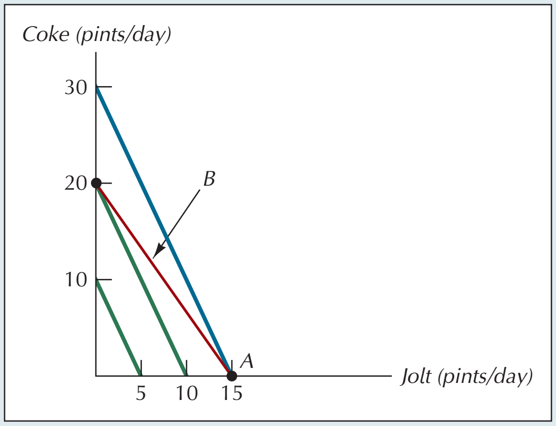


FIGURE 3.17
Equilibrium with Perfect Substitutes
Here, the MRS of Coke for Jolt is 2 at every point. Whenever the price ratio P_J/P_C is less than 2, a corner solution results in which the consumer buys only Jolt. On the budget constraint *B,* the consumer does best to buy bundle *A.*

In the same diagram, Mattingly's budget constraint is shown as *B*. The slope of his indifference curves is -2; of his budget constraint, $-\frac{4}{3}$. The best affordable bundle is the one labeled *A,* a corner solution in which he spends his entire budget on Jolt. This makes intuitive sense in light of Mattingly's peculiar preferences: he cares only about total caffeine content, and Jolt provides more caffeine per dollar than Coke does. If the Jolt-Coke price ratio, P_J/P_C had been $\frac{3}{1}$ (or any other amount greater than $\frac{2}{1}$), Mattingly would have spent all his income on Coke. That is, we would again have had a corner solution, only this time on the vertical axis. Only if the price ratio had been exactly $\frac{2}{1}$ might we have seen Mattingly spend part of his income on each good. In that case, any combination of Coke and Jolt on his budget constraint would have served equally well.

APPENDIX

3

THE UTILITY FUNCTION APPROACH TO THE CONSUMER BUDGETING PROBLEM

THE UTILITY FUNCTION APPROACH TO CONSUMER CHOICE

Finding the highest attainable indifference curve on a budget constraint is just one way that economists have analyzed the consumer choice problem. For many applications, a second approach is also useful. In this approach we represent the consumer's preferences not with an indifference map but with a *utility function*.

For each possible bundle of goods, a utility function yields a number that represents the amount of satisfaction provided by that bundle. Suppose, for example, that Tom consumes only food and shelter and that his utility function is given by $U(F, S) = FS$, where F denotes the number of pounds of food, S the number of square yards of shelter he consumes per week, and U his satisfaction, measured in "utils" per week.[1] If $F = 4$ lb/wk and $S = 3$ sq yd/wk, Tom will receive 12 utils/wk of utility, just as he would if he consumed 3 lb/wk of food and 4 sq yd/wk of shelter. By contrast, if he consumed 8 lb/wk of food and 6 sq yd/wk of shelter, he would receive 48 utils/wk.

The utility function is analogous to an indifference map in that both provide a complete description of the consumer's preferences. In the indifference curve framework, we can rank any two bundles by seeing which one lies on a higher indifference curve. In the utility-function framework, we can compare any two bundles by seeing which one yields a greater number of utils. Indeed, as the following example illustrates, it is straightforward to use the utility function to construct an indifference map.

EXAMPLE A.3.1

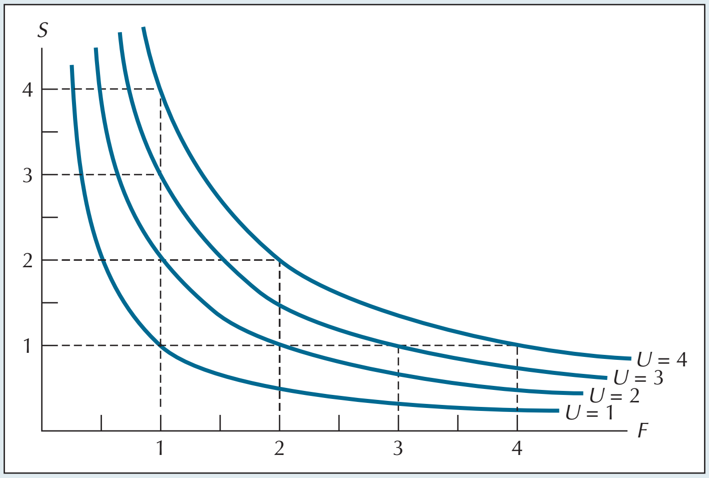
If Tom's utility function is given by $U(F, S) = FS$ graph the indifference curves that correspond to 1, 2, 3, and 4 utils, respectively.

In the language of utility functions, an indifference curve is all combinations of F and S that yield the same level of utility—the same number of utils. Suppose we look at the indifference curve that corresponds to 1 unit of utility—that is, the combinations of bundles for which $FS = 1$. Solving this equation for S, we have

$$S = \frac{1}{F}, \tag{A.3.1}$$

which is the indifference curve labeled $U = 1$ in Figure A.3.1. The indifference curve that corresponds to 2 units of utility is generated by solving $FS = 2$ to get $S = 2/F$, and it is shown by the curve labeled $U = 2$ in Figure A.3.1. In similar fashion, we generate the indifference curves to $U = 3$ and $U = 4$, which are correspondingly labeled in the diagram. More generally, we get the indifference curve corresponding to a utility level of U_0 by solving $FS = U_0$ to get $S = U_0/F$.

FIGURE A.3.1
Indifference Curves for the Utility Function $U = FS$
To get the indifference curve that corresponds to all bundles that yield a utility level of U_0, set $FS = U_0$ and solve for S to get $S = U_0/F$.



In the indifference curve framework, the best attainable bundle is the bundle on the budget constraint that lies on the highest indifference curve. Analogously, the best attainable bundle in the utility-function framework is the bundle on the budget constraint that provides the highest level of utility. In the indifference curve framework, the best attainable bundle occurs at a point of tangency between an indifference

[1]The term "utils" represents an arbitrary unit. As we will see, what is important for consumer choice is not the actual number of utils various bundles provide, but the rankings of the bundles based on their associated utilities.

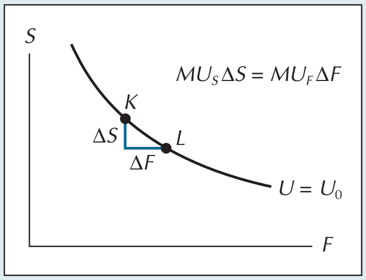


FIGURE A.3.2
Utility Along an Indifference Curve Remains Constant
In moving from *K* to *L*, the loss in utility from having less shelter, $MU_s\Delta S$, is exactly offset by the gain in utility from having more food, $MU_F\Delta_F$.

curve and the budget constraint. At the optimal bundle, the slope of the indifference curve, or MRS, equals the slope of the budget constraint. Suppose food and shelter are again our two goods, and P_F and P_S are their respective prices. If $\Delta S/\Delta F$ denotes the slope of the highest attainable indifference curve at the optimal bundle, the tangency condition says that $\Delta S/\Delta F = P_F/P_S$. What is the analogous condition in the utility-function framework?

To answer this question, we must introduce the concept of *marginal utility* (the marginal utility of a good is the rate at which total utility changes with consumption of the good), which is the rate at which total utility changes as the quantities of food and shelter change. More specifically, let MU_F denote the number of additional utils we get for each additional unit of food and MU_S denote the number of additional utils we get for each additional unit of shelter. In Figure A.3.2, note that bundle *K* has ΔF fewer units of food and ΔS more units of shelter than bundle *L*. Thus, if we move from bundle *K* to bundle *L*, we gain $MU_F\Delta F$ utils from having more food, but we lose $MU_S\Delta S$ utils from having less shelter.

Because *K* and *L* both lie on the same indifference curve, we know that both bundles provide the same level of utility. Thus the utility we lose from having less shelter must be exactly offset by the utility we gain from having more food. This tells us that

$$MU_F\Delta F = MU_S\Delta S. \tag{A.3.2}$$

Cross-multiplying terms in Equation A.3.2 gives

$$\frac{MU_F}{MU_S} = \frac{\Delta S}{\Delta F}. \tag{A.3.3}$$

Suppose that the optimal bundle lies between *K* and *L*, which are very close together, so that ΔF and ΔS are both very small. As *K* and *L* move closer to the optimal bundle, the ratio $\Delta S/\Delta F$ becomes equal to the slope of the indifference curve at that bundle, which Equation A.3.3 tells us is equal to the ratio of the marginal utilities of the two goods. And since the slope of the indifference curve at the optimal bundle is the same as that of the budget constraint, the following condition must also hold for the optimal bundle:

$$\frac{MU_F}{MU_S} = \frac{P_F}{P_S}. \tag{A.3.4}$$

Equation A.3.4 is the condition in the utility-function framework that is analogous to the $MRS = P_F/P_S$ condition in the indifference curve framework.

If we cross-multiply terms in Equation A.3.4, we get an equivalent condition that has a very straightforward intuitive interpretation:

$$\frac{MU_F}{P_F} = \frac{MU_S}{P_S}. \tag{A.3.5}$$

CHAPTER

4

INDIVIDUAL AND MARKET DEMAND

A pound of salt costs 30 cents at the grocery store where I shop. My family and I use the same amount of salt at that price as we would if it instead sold for 5 cents/lb or even $10/lb. I also consume about the same amount of salt now as I did as a graduate student, when my income was less than one-tenth as large as it is today.

Salt is an unusual case. The amounts we buy of many other goods are much more sensitive to prices and incomes. Sometimes, for example, my family and I consider spending a sabbatical year in New York City, where housing prices are more than four times what they are in Ithaca. If we ever do go there, we will probably live in an apartment that is less than half the size of our current house.

CHAPTER PREVIEW

Viewed within the framework of the rational choice model, my behavior with respect to salt and housing purchases is perfectly intelligible. Our focus in this chapter is to use the tools from Chapter 3 to shed additional light on why, exactly, the responses of various purchase decisions to changes in income and price differ so widely. In Chapter 3, we saw how changes in prices and incomes affect the budget constraint. Here we will see how changes in the budget constraint affect actual purchase decisions. More specifically, we will use the rational choice model to generate an individual consumer's demand curve for a product and employ our model to construct a relationship that summarizes how individual demands vary with income.

We will see how the total effect of a price change can be decomposed into two separate effects: (1) the substitution effect, which denotes the change in the quantity demanded that results because the price change alters the attractiveness of substitute goods, and (2) the income effect, which denotes the change in quantity demanded that results from the change in purchasing power caused by the price change.

Next we will show how individual demand curves can be added to yield the demand curve for the market as a whole. A central analytical concept we will develop in this chapter is the price elasticity of demand, a measure of the responsiveness of purchase decisions to small changes in price. We will also consider the income elasticity of demand, a measure of the responsiveness of purchase decisions to small changes in income. And we will see that, for some goods, the distribution of income, not just its average value, is an important determinant of market demand.

A final elasticity concept in this chapter is the cross-price elasticity of demand, which is a measure of the responsiveness of the quantity demanded of one good to small changes in the prices of another good. Cross-price elasticity is the criterion by which pairs of goods are classified as being either substitutes or complements.

These analytical constructs provide a deeper understanding of a variety of market behaviors as well as a stronger foundation for intelligent decision and policy analysis.

THE EFFECTS OF CHANGES IN PRICE

THE PRICE-CONSUMPTION CURVE

Recall from Chapter 2 that a market demand curve tells how much of a good the market as a whole wants to purchase at various prices. Suppose we want to generate a demand schedule for a good—say, shelter—not for the market as a whole but for only a single consumer. Holding income, preferences, and the prices of all other goods constant, how will a change in the price of shelter affect the amount of shelter the consumer buys? To answer this question, we begin with this consumer's indifference map, plotting shelter on the horizontal axis and the composite good Y on the vertical axis. Suppose the consumer's income is \$120/wk, and the price of the composite good is again \$1 per unit. The vertical intercept of her budget constraint will then be 120. The horizontal intercept will be $120/P_S$, where P_S denotes the price of shelter. Figure 4.1 shows four budget constraints that correspond to four different prices of shelter, namely, \$24/sq yd, \$12/sq yd, \$6/sq yd, and \$4/sq yd. The corresponding best affordable bundles contain 2.5, 7, 15, and 20 sq yd/wk of shelter, respectively. If we were to repeat this procedure for indefinitely many prices, the resulting points of tangency would trace out the line labeled PCC in Figure 4.1. This line is called the **price-consumption curve**, or **PCC.**

price-consumption curve (PCC) holding income and the price of Y constant, the PCC for a good X is the set of optimal bundles traced on an indifference map as the price of X varies.

For the particular consumer whose indifference map is shown in Figure 4.1, note that each time the price of shelter falls, the budget constraint rotates outward, enabling the consumer to purchase not only more shelter but more of the composite good as well. And each time the price of shelter falls, this consumer chooses a bundle that contains more shelter than in the bundle chosen previously. Note, however, that the amount of money spent on the composite good may either rise or fall when the price of shelter falls. Thus, the amount spent on other goods falls when

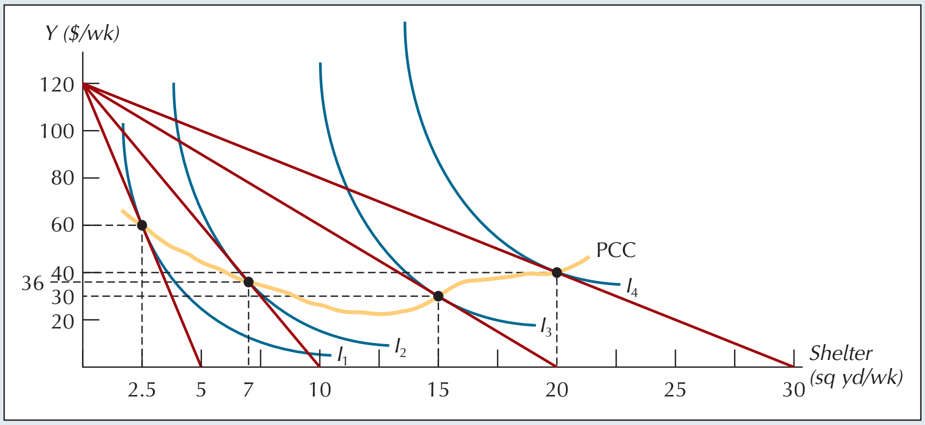


FIGURE 4.1
The Price-Consumption Curve
Holding income and the price of Y fixed, we vary the price of shelter. The set of optimal bundles traced out by the various budget lines is called the price-consumption curve, or PCC.

the price of shelter falls from $24/sq yd to $12/sq yd but rises when the price of shelter falls from $6/sq yd to $4/sq yd. Below, we will see why this is a relatively common purchase pattern.

THE INDIVIDUAL CONSUMER'S DEMAND CURVE

An individual consumer's demand curve is like the market demand curve in that it tells the quantities the consumer will buy at various prices. All the information we need to construct the individual demand curve is contained in the price-consumption curve. The first step in going from the PCC to the individual demand curve is to record the relevant price-quantity combinations from the PCC in Figure 4.1, as in Table 4.1. (Recall from Chapter 3 that the price of shelter along any budget constraint is given by income divided by the horizontal intercept of that budget constraint.)

TABLE 4.1
A Demand Schedule

Price of shelter ($/sq yd)	Quantity of shelter demanded (sq yd/wk)
24	2.5
12	7
6	15
4	20

To derive the individual's demand curve for shelter from the PCC in Figure 4.1, begin by recording the quantities of shelter that correspond to the shelter prices on each budget constraint.

The next step is to plot the price-quantity pairs from Table 4.1, with the price of shelter on the vertical axis and the quantity of shelter on the horizontal. With sufficiently many price-quantity pairs, we generate the individual's demand curve, shown as *DD* in Figure 4.2. Note carefully that in moving from the PCC to the individual demand curve, we are moving from a graph in which both axes measure quantities to one in which price is plotted against quantity.

MARKET DEMAND: AGGREGATING INDIVIDUAL DEMAND CURVES

Having seen where individual demand curves come from, we are now in a position to see how individual demand curves may be aggregated to form the market demand curve. Consider a market for a good—for the sake of concreteness, again shelter—with only two potential consumers. Given the demand curves for these consumers, how do we generate the market demand curve? In Figure 4.16, D_1 and D_2 represent the individual demand curves for consumers 1 and 2, respectively. To get the market demand curve, we begin by calling out a price—say, \$4/sq yd—and adding the quantities demanded by each consumer at that price. This sum, 6 sq yd/wk + 2 sq yd/wk = 8 sq yd/wk, is the total quantity of shelter demanded at the price \$4/sq yd. We then plot the point (4, 8) as one of the quantity-price pairs on the market demand curve D in the right panel of Figure 4.16. To generate additional points on the market demand curve, we simply repeat this process for other prices. Thus, the price \$8/sq yd corresponds to a quantity of 4 + 0 = 4 sq yd/wk on the market demand curve for shelter. Proceeding in like fashion for additional prices, we trace out the entire market demand curve. Note that for prices above \$8/sq yd, consumer 2 demands no shelter at all, and so the market demand curve for prices above \$8 is identical to the demand curve for consumer 1.

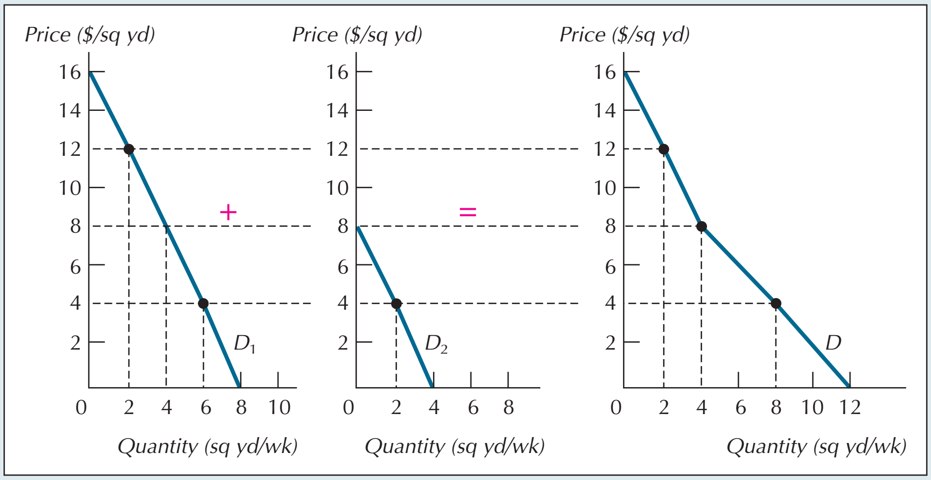


FIGURE 4.16
Generating Market Demand from Individual Demands
The market demand curve (D in the right panel) is the horizontal sum of the individual demand curves, D_1 (left panel) and D_2 (center panel).

The procedure of announcing a price and adding the individual quantities demanded at that price is called *horizontal summation*. It is carried out the same way whether there are only two consumers in the market or many millions. In both large and small markets, the market demand curve is the horizontal summation of the individual demand curves.

In Chapter 2 we saw that it is often easier to generate numerical solutions when demand and supply curves are expressed algebraically rather than geometrically. Similarly, it will often be convenient to aggregate individual demand curves algebraically rather than graphically. When using the algebraic approach, a common error is to add individual demand curves vertically instead of horizontally. A simple example makes this danger clear.

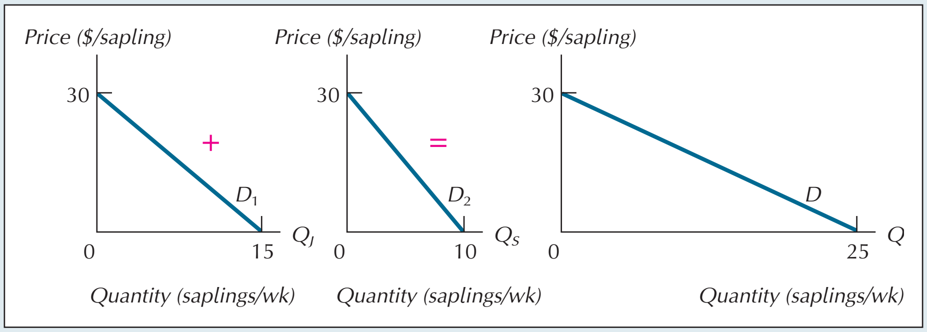
EXAMPLE 4.4

Smith and Jones are the only consumers in the market for beech saplings in a small town in Vermont. Their demand curves are given by $P = 30 - 2Q_J$ and $P = 30 - 3Q_S$ where Q_J and Q_S are the quantities demanded by Jones

and Smith, respectively. What is the market demand curve for beech saplings in their town?

When we add demand curves horizontally, we are adding quantities, not prices. Thus it is necessary first to solve the individual demand equations for the respective quantities in terms of price. This yields $Q_J = 15 - (P/2)$ for Jones, and $Q_S = 10 - (P/3)$ for Smith. If the quantity demanded in the market is denoted by Q, we have $Q = Q_J + Q_S = 15 - (P/2) + 10 - (P/3) = 25 - (5P/6)$. Solving back for P, we get the equation for the market demand curve: $P = 30 - (6Q/5)$. We can easily verify that this is the correct market demand curve by adding the individual demand curves graphically, as in Figure 4.17.

FIGURE 4.17
The Market Demand Curve for Beech Saplings
When adding individual demand curves algebraically, be sure to solve for quantity first before adding.



The common pitfall is to add the demand functions as originally stated and then solve for P in terms of Q. Here, this would yield $P = 30 - (5Q/2)$, which is obviously not the market demand curve we are looking for.

EXERCISE 4.3

Write the individual demand curves for shelter in Figure 4.16 in algebraic form, then add them algebraically to generate the market demand curve for shelter. (*Caution:* Note that the formula for quantity along D_2 is valid only for prices between 0 and 8.)

The horizontal summation of individual consumers' demands into market demand has a simple form when the consumers in the market are all identical. Suppose n consumers each have the demand curve $P = a - bQ_i$. To add up the quantities for the n consumers into market demand, we rearrange the consumer demand curve $P = a - bQ_i$ to express quantity alone on one side $Q_i = a/b - (1/b)\,P$. Then market demand is the sum of the quantities demanded Q_i by each of the n consumers.

$$Q = nQ_i = n\left(\frac{a}{b} - \frac{1}{b}P\right) = \frac{na}{b} - \frac{n}{b}P.$$

We can then rearrange market demand $Q = na/b - n(P/b)$ to get back in the form of price alone on one side $P = a - (b/n)\,Q$. The intuition is that each one unit demanded by the market is $1/n$ unit for each consumer. These calculations suggest a general rule for constructing the market demand curve when consumers are identical. If we have n individual consumer demand curves $P = a - bQ_i$, then the market demand curve is $P = a - (b/n)Q$.

EXAMPLE 4.5

Suppose a market has 10 consumers, each with demand curve $P = 10 - 5Q_i$, where P is the price in dollars per unit and Q_i is the number of units demanded per week by the *i*th consumer (Figure 4.18). Find the market demand curve.

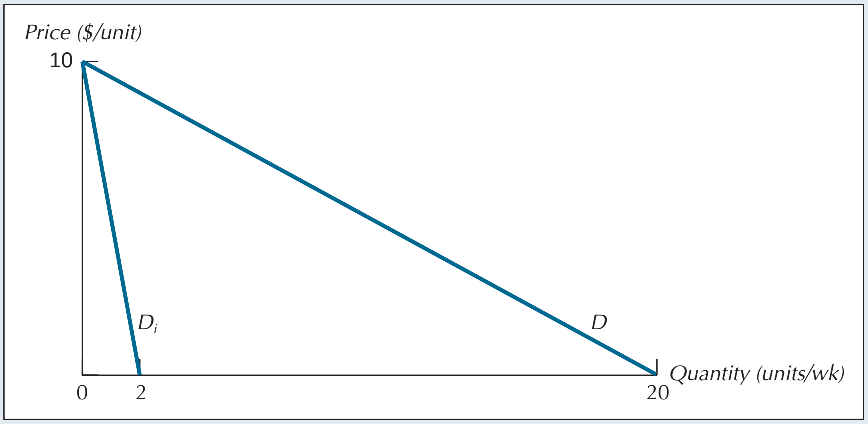


FIGURE 4.18
Market Demand with Identical Consumers
When 10 consumers each have demand curve $P = 10 - 5Q_i$ the market demand curve is the horizontal summation $P = 10 - (\frac{1}{2})Q$, with the same price intercept and $\frac{1}{10}$ the slope.

First, we need to rearrange the representative consumer demand curve $P = 10 - 5Q_i$ to have quantity alone on one side:

$$Q_i = 2 - \tfrac{1}{5}P.$$

Then we multiply by the number of consumers, $n = 10$:

$$Q = nQ_i = 10Q_i = 10(2 - \tfrac{1}{5}P) = 20 - 2P.$$

Finally, we rearrange the market demand curve $Q = 20 - 2P$ to have price alone on one side, $P = 10 - (\frac{1}{2})Q$, to return to the slope-intercept form.

EXERCISE 4.4

Suppose a market has 30 consumers, each with demand curve $P = 120 - 60Q_i$, where P is price in dollars per unit and Q_i is the number of units demanded per week by the *i*th consumer. Find the market demand curve.

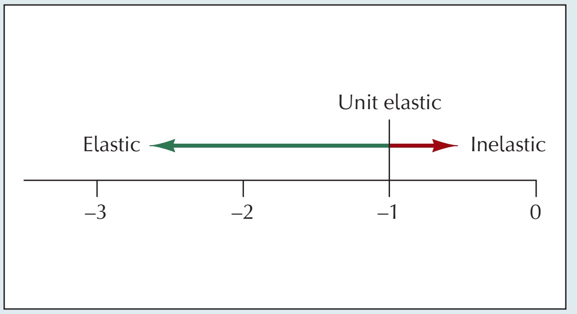
PRICE ELASTICITY OF DEMAND

price elasticity of demand the percentage change in the quantity of a good demanded that results from a 1 percent change in its price.

An analytical tool of central importance is the **price elasticity of demand.** It is a quantitative measure of the responsiveness of purchase decisions to variations in price, and as we will see in both this and later chapters, it is useful for a variety of practical problems. *Price elasticity of demand is defined as the percentage change in the quantity of a good demanded that results from a 1 percent change in price.* For example, if a 1 percent rise in the price of shelter caused a 2 percent reduction in the quantity of shelter demanded, then the price elasticity of demand for shelter would be -2. The price elasticity of demand will always be negative (or zero) because price changes always move in the opposite direction from changes in quantity demanded.

The demand for a good is said to be *elastic* with respect to price if its price elasticity is less than -1. The good shelter mentioned in the preceding paragraph would thus be one for which demand is elastic with respect to price. The demand for a good is *inelastic* with respect to price if its price elasticity is greater than -1 and

FIGURE 4.19
Three Categories of Price Elasticity
With respect to price, the demand for a good is elastic if its price elasticity is less than −1, inelastic if its price elasticity exceeds −1, and unit elastic if its price elasticity is equal to −1.



unit elastic with respect to price if its price elasticity is equal to −1. These definitions are portrayed graphically in Figure 4.19.

When interpreting actual demand data, it is often useful to have a more general definition of price elasticity that can accommodate cases in which the observed change in price does not happen to be 1 percent. Let P be the current price of a good and let Q be the quantity demanded at that price. And let ΔQ be the change in the quantity demanded that occurs in response to a very small change in price, ΔP. The price elasticity of demand at the current price and quantity will then be given by

$$\epsilon = \frac{\Delta Q/P}{\Delta P/P}. \tag{4.1}$$

The numerator on the right side of Equation 4.1 is the proportional change in quantity. The denominator is the proportional change in price. Equation 4.1 is exactly the same as our earlier definition when ΔP happens to be a 1 percent change in current price. The advantage is that the more general definition also works when ΔP is any other small percentage change in current price.

A GEOMETRIC INTERPRETATION OF PRICE ELASTICITY

Another way to interpret Equation 4.1 is to rewrite it as

$$\epsilon = \frac{\Delta Q}{\Delta P}\frac{P}{Q}. \tag{4.2}$$

Equation 4.2 suggests a simple interpretation in terms of the geometry of the market demand curve. When ΔP is small, the ratio $\Delta P/\Delta Q$ is the slope of the demand curve, which means that the ratio $\Delta Q/\Delta P$ is the reciprocal of that slope. Thus the price elasticity of demand may be interpreted as the product of the ratio of price to quantity and the reciprocal of the slope of the demand curve:[2]

$$\epsilon = \frac{P}{Q}\frac{1}{\text{slope}}. \tag{4.3}$$

Equation 4.3 is called the *point-slope method* of calculating price elasticity of demand. By way of illustration, consider the demand curve for shelter shown in Figure 4.20. Because this demand curve is linear, its slope is the same at every point, namely, −2. The reciprocal of this slope is $-\frac{1}{2}$. The price elasticity of demand at point A is therefore given by the ratio of price to quantity at A $(\frac{12}{2})$ multiplied by the reciprocal of the slope at A $(-\frac{1}{2})$, so we have $\epsilon_A = (\frac{12}{2})(-\frac{1}{2}) = -3$.

[2]In calculus terms, price elasticity is defined as $\epsilon = (P/Q)[dQ(P)/dP]$.

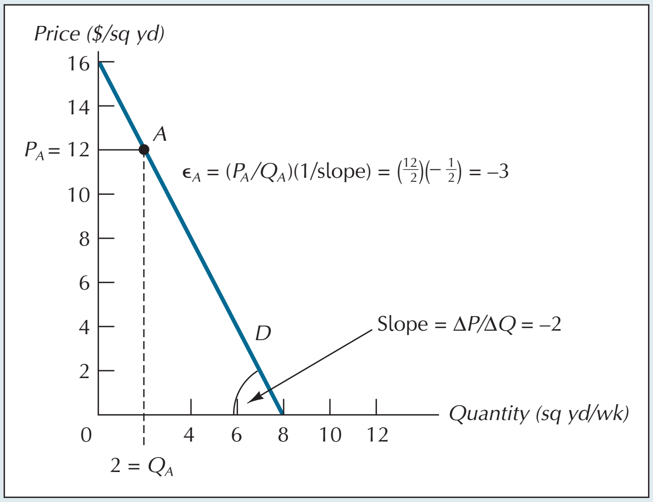


FIGURE 4.20
The Point-Slope Method
The price elasticity of demand at any point is the product of the price-quantity ratio at that point and the reciprocal of the slope of the demand curve at that point. The price elasticity at *A* is thus $(\frac{12}{2})(-\frac{1}{2}) = -3$.

When the market demand curve is linear, as in Figure 4.20, several properties of price elasticity quickly become apparent from this interpretation. The first is that the price elasticity is different at every point along the demand curve. More specifically, we know that the slope of a linear demand curve is constant throughout, which means that the reciprocal of its slope is also constant. The ratio of price to quantity, by contrast, takes a different value at every point along the demand curve. As we approach the vertical intercept, it approaches infinity. It declines steadily as we move downward along the demand curve, finally reaching a value of zero at the horizontal intercept.

A second property of demand elasticity is that it is never positive. As noted earlier, because the slope of the demand curve is always negative, its reciprocal must also be negative; and because the ratio *P*/*Q* is always positve, it follows that the price elasticity of demand—which is the product of these two—must always be a negative number (except at the horizontal intercept of the demand curve, where *P*/*Q*, and hence elasticity, is zero). For the sake of convenience, however, economists often ignore the negative sign of price elasticity and refer simply to its absolute value. When a good is said to have a "high" price elasticity of demand, this will always mean that its price elasticity is large in absolute value, indicating that the quantity demanded is highly responsive to changes in price. Similarly, a good whose price elasticity is said to be "low" is one for which the absolute value of elasticity is small, indicating that the quantity demanded is relatively unresponsive to changes in price.

A third property of price elasticity at any point along a straight-line demand curve is that it will be inversely related to the slope of the demand curve. The steeper the demand curve, the less elastic is demand at any point along it. This follows from the fact that the reciprocal of the slope of the demand curve is one of the factors used to compute price elasticity.

EXERCISE 4.5

Use the point-slope method (Equation 4.3) to determine the elasticity of the demand curve $P = 32 - Q$ at the point where $P = 24$.

Two polar cases of demand elasticity are shown in Figure 4.21. In Figure 4.21*a*, the horizontal demand curve, with its slope of zero, has an infinitely high price elasticity at every point. Such demand curves are often called *perfectly elastic* and, as we will see, are especially important in the study of competitive firm

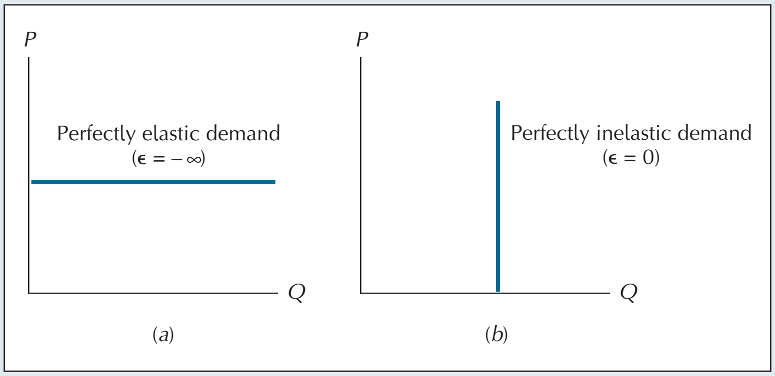


FIGURE 4.21
Two Important Polar Cases
(*a*) The price elasticity of the demand curve is equal to $-\infty$ at every point. Such demand curves are said to be perfectly elastic. (*b*) The price elasticity of the demand curve is equal to 0 at every point. Such demand curves are said to be perfectly inelastic.

behavior. In Figure 4.21*b*, the vertical demand curve has a price elasticity everywhere equal to zero. Such curves are called *perfectly inelastic*.

As a practical matter, it would be impossible for any demand curve to be perfectly inelastic at all prices. Beyond some sufficiently high price, income effects must curtail consumption, even for seemingly essential goods with no substitutes, such as surgery for malignant tumors. Even so, the demand curve for many such goods and services will be perfectly inelastic over an extremely broad range of prices (recall the salt example discussed earlier in this chapter).

THE UNIT-FREE PROPERTY OF ELASTICITY

Another way of measuring responsiveness to changes in price is to use the slope of the demand curve. Other things equal, for example, we know that the quantity demanded of a good with a steep demand curve will be less responsive to changes in price than will one with a less steep demand curve.

Since the slope of a demand curve is much simpler to calculate than its elasticity, it may seem natural to ask, "Why bother with elasticity at all?" One reason is that the slope of the demand curve is sensitive to the units we use to measure price and quantity, while elasticity is not. By way of illustration, notice in Figure 4.22*a* that when the price of gasoline is measured in \$/gal, the slope of the demand curve at point C is -0.02. By contrast, in Figure 4.22*b*, where price is measured in \$/oz, the slope at C is -0.00015625. In both cases, however, note that the price elasticity of demand at C is -3. This will be true no matter how we measure price and quantity.

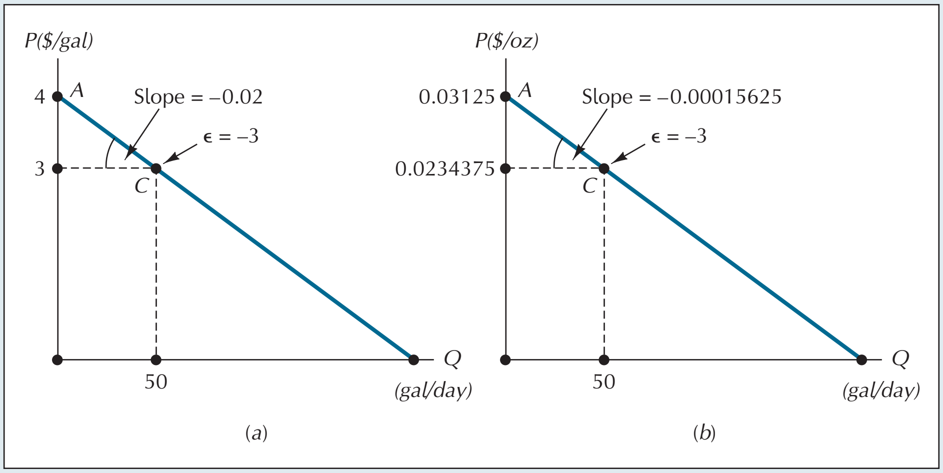


FIGURE 4.22
Elasticity Is Unit-Free
The slope of the demand curve at any point depends on the units in which we measure price and quantity. The slope at point *C* when we measure the price of gasoline in dollars per gallon (*a*) is much larger than when we measure the price in dollars per ounce (*b*). The price elasticity at any point, by contrast, is completely independent of units of measure.

And most people find it much more informative to know that a 1 percent cut in price will lead to a 3 percent increase in the quantity demanded than to know that the slope of the demand curve is −0.00015625.

SOME REPRESENTATIVE ELASTICITY ESTIMATES

As the entries in Table 4.4 show, the price elasticities of demand for different products often differ substantially. The low elasticity for theater and opera performances probably reflects the fact that buyers in this market have much larger than average incomes, so that income effects of price variations are likely to be small. Income effects for green peas are also likely to be small even for low-income consumers, yet the price elasticity of demand for green peas is more than 14 times larger than for theater and opera performances. The difference is that there are many more close substitutes for green peas than for theater and opera performances. Later in this chapter we investigate in greater detail the factors that affect the price elasticity of demand for a product.

TABLE 4.4
Price Elasticity Estimates for Selected Products*

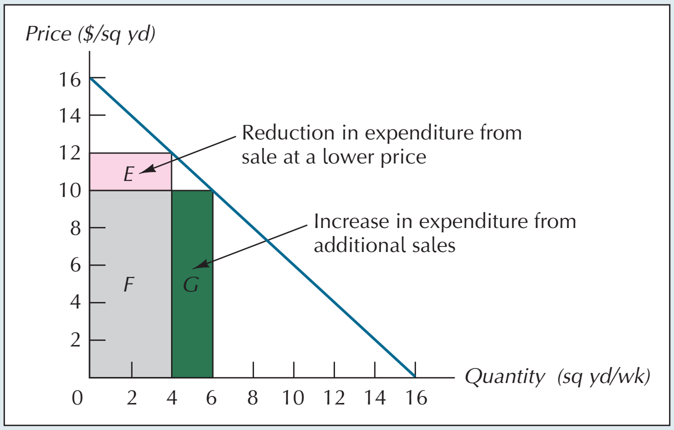
Good or service	Price elasticity
Green peas	−2.8
Air travel (vacation)	−1.9
Frying chickens	−1.8
Beer	−1.2
Marijuana	−1.0
Movies	−0.9
Air travel (nonvacation)	−0.8
Shoes	−0.7
cigarettes	−0.3
Theater, opera	−0.2
Local telephone calls	−0.1

Some of these short-run elasticity estimates represent the midpoint of the corresponding range of estimates. Sources: Fred Nordhauser and Paul L. Farris, "An Estimate of the Short-Run Price Elasticity of Demand for Fryers," *Journal of Farm Economics,* November 1959; H. S. Houthakker and Lester Taylor, *Consumer Demand in the United States: Analyses and Projections,* 2d ed., Cambridge, MA: Harvard University Press, 1970; Charles T. Nisbet and Firouz Vakil, "Some Estimates of Price and Expenditure Elasticities of Demand for Marijuana among UCLA Students," *Review of Economics and Statistics,* November 1972; L. Taylor, "The Demand for Electricity: A Survey," *Bell Journal of Economics,* Spring 1975; K. Elzinga, "The Beer Industry," in Walter Adams (ed.), *The Structure of American Industry,* New York: Macmillan, 1977; Rolla Edward Park, Bruce M. Wetzel, and Bridger Mitchell, *Charging for Local Telephone Calls: Price Elasticity Estimates from the GTE Illinois Experiment,* Santa Monica, CA: Rand Corporation, 1983; Tae H. Oum, W. G. Waters II, and Jong Say Yong, "A Survey of Recent Estimates of Price Elasticities of Demand for Transport," World Bank Infrastructure and Urban Development Department Working Paper 359, January 1990; M. C. Farrelly and J. W. Bray, "Response to Increases in Cigarette Prices by Race/Ethnicity, Income, and Age Groups—United States, 1976–1993," *Journal of the American Medical Association,* 280, 1998.

ELASTICITY AND TOTAL EXPENDITURE

Suppose you are the administrator in charge of setting tolls for the Golden Gate Bridge, which links San Francisco to Marin County. Suppose that with the toll at \$3/trip, 100,000 trips per hour are taken across the bridge. If the price elasticity of demand for trips is −2.0, what will happen to the number of trips taken per

FIGURE 4.23
The Effect on Total Expenditure of a Reduction in Price
When price falls, people spend less on existing units (*E*). But they also buy more units (*G*). Here, *G* is larger than *E,* which means that total expenditure rises.



hour if you raise the toll by 10 percent? With an elasticity of −2.0, a 10 percent increase in price will produce a 20 percent reduction in quantity. Thus the number of trips will fall to 80,000/hr. Total expenditure at the higher toll will be (80,000 trips/hr)($3.30/trip) = $264,000/hr. Note that this is smaller than the total expenditure of $300,000/hr that occurred under the $3 toll.

Now suppose that the price elasticity had been not −2.0 but −0.5. How would the number of trips and total expenditure then be affected by a 10 percent increase in the toll? This time the number of trips will fall by 5 percent to 95,000/hr, which means that total expenditure will rise to (95,000 trips/hr) ($3.30/trip) = $313,500/hr. If your goal as an administrator is to increase the total revenue collected from the bridge toll, you need to know something about the price elasticity of demand before deciding whether to raise the toll or lower it.

This example illustrates the important relationships between price elasticity and total expenditure. The questions we want to be able to answer are of the form, "If the price of a product changes, how will total spending on the product be affected?" and "Will more be spent if we sell more units at a lower price or fewer units at a higher price?" In Figure 4.23, for example, we might want to know how total expenditures for shelter are affected when the price falls from $12/sq yd to $10/sq yd.

The total expenditure, R, at any quantity-price pair (Q, P) is given by the product

$$R = PQ. \tag{4.4}$$

In Figure 4.23, the total expenditure at the original quantity-price pair is thus ($12/sq yd)(4 sq yd/wk) = $48/wk. Geometrically, it is the sum of the two shaded areas E and F. Following the price reduction, the new total expenditure is ($10/sq yd)(6 sq yd/wk) = $60/wk, which is the sum of the shaded areas F and G. These two total expenditures have in common the shaded area F. The change in total expenditure is thus the difference in the two shaded areas E and G. The area E, which is ($2/sq yd)(4 sq yd/wk) = $8/wk, may be interpreted as the reduction in expenditure caused by selling the original 4 sq yd/wk at the new, lower price. G, in turn, is the increase in expenditure caused by the additional 2 sq yd/wk of sales. This area is given by ($10/sq yd)(2 sq yd/wk) = $20/wk. Whether total expenditure rises or falls thus boils down to whether the gain from additional sales exceeds the loss from lower prices. Here, the gain exceeds the loss by $12, so total expenditure rises by that amount following the price reduction.

If the change in price is small, we can say how total expenditure will move if we know the initial price elasticity of demand. Recall that one way of expressing price elasticity is the percentage change in quantity divided by the corresponding percentage change in price. If the absolute value of that quotient exceeds 1, we know that the percentage change in quantity is larger than the percentage change in price. And when that happens, the increase in expenditure from additional sales will always exceed the reduction from sales of existing units at the lower price. In Figure 4.23, note that the elasticity at the original price of $12 is 3.0, which confirms our earlier observation that the price reduction led to an increase in total expenditure. Suppose, on the contrary, that price elasticity is less than unity. Then the percentage change in quantity will be smaller than the corresponding percentage change in price, and the additional sales will not compensate for the reduction in expenditure from sales at a lower price. Here, a price reduction will lead to a reduction in total expenditure.

EXERCISE 4.6

For the demand curve in Figure 4.23, what is the price elasticity of demand when *P* = \$4/sq yd? What will happen to total expenditure on shelter when price falls from \$4/sq yd to \$3/sq yd?

The general rule for small price reductions, then, is this: *A price reduction will increase total revenue if and only if the absolute value of the price elasticity of demand is greater than 1.* Parallel reasoning leads to an analogous rule for small price increases: *An increase in price will increase total revenue if and only if the absolute value of the price elasticity is less than 1.* These rules are summarized in the top panel of Figure 4.24, where the point *M* is the midpoint of the demand curve.

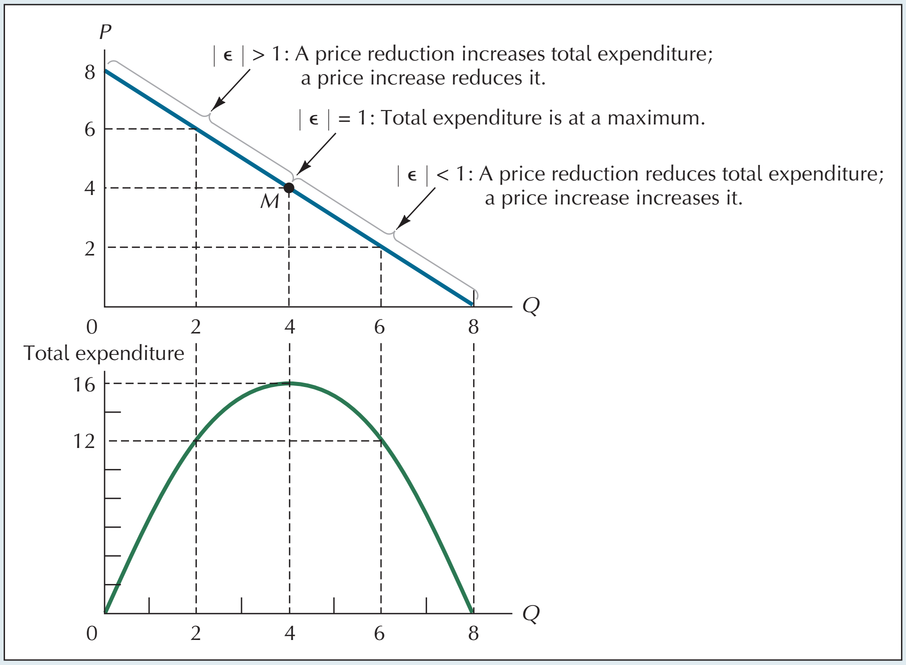


FIGURE 4.24
Demand and Total Expenditure
When demand is elastic, total expenditure changes in the opposite direction from a change in price. When demand is inelastic, total expenditure and price both move in the same direction. At the midpoint of the demand curve (*M*), total expenditure is at a maximum.

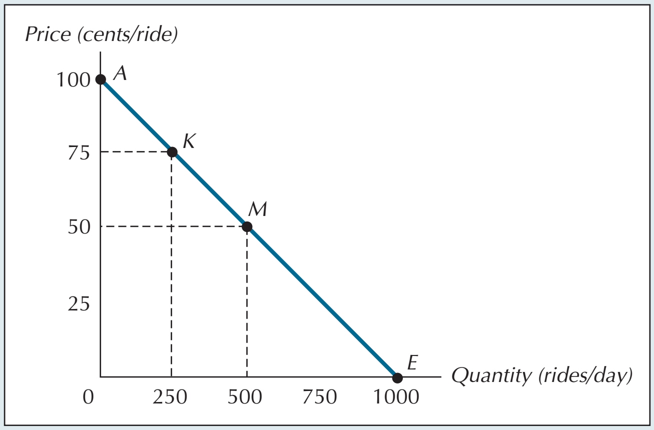
The relationship between elasticity and total expenditure is spelled out in greater detail in the relationship between the top and bottom panels of Figure 4.24. The top panel shows a straight-line demand curve. For each quantity, the bottom panel shows the corresponding total expenditure. As indicated in the bottom panel, total expenditure starts at zero when *Q* is zero and increases to its maximum value at the quantity corresponding to the midpoint of the demand curve (point *M* in the top panel). At that quantity, price elasticity is unity. Beyond that quantity, total expenditure declines with output, reaching zero at the horizontal intercept of the demand curve.

EXAMPLE 4.6 **The market demand curve for bus rides in a small community is given by $P = 100 - (Q/10)$, where P is the fare per ride in cents and Q is the number of rides each day. If the price is 50 cents/ride, how much revenue will the transit system collect each day? What is the price elasticity of demand for rides? If the system needs more revenue, should it raise or lower price? How would your answers have differed if the initial price had been not 50 cents/ride but 75?**

Total revenue for the bus system is equal to total expenditure by riders, which is the product PQ. First we solve for Q from the demand curve and get $Q = 1000 - 10P$. When P is 50 cents/ride, Q will be 500 rides/day and the resulting total revenue will be \$250/day. To compute the price elasticity of demand, we can use the formula $\epsilon = (P/Q)(1/slope)$. Here the slope is $-\frac{1}{10}$, so $1/\text{slope} = -10$ (see footnote 3). P/Q takes the value $50/500 = \frac{1}{10}$. Price elasticity is thus the product $(-\frac{1}{10})(10) = -1$. With a price elasticity of unity, total revenue attains its maximum value. If the bus company either raises or lowers its price, it will earn less than it does at the current price.

At a price of 50 cents, the company was operating at the midpoint of its demand curve. If the price had instead been 75 cents, it would be operating above the midpoint. More precisely, it would be halfway between the midpoint and the vertical intercept (point K in Figure 4.25). Quantity would be only 250 rides/day, and price elasticity would have been -3 (computed, for example, by multiplying the price-quantity ratio at K, $\frac{3}{10}$, by the reciprocal of the demand curve slope, $-\frac{1}{10}$). Operating at an elastic point on its demand curve, the company could increase total revenue by cutting its price.

FIGURE 4.25
The Demand for Bus Rides
At a price of 50 cents/ride, the bus company is maximizing its total revenues. At a price of 75 cents/ride, demand is elastic with respect to price, and so the company can increase its total revenues by cutting its price.



DETERMINANTS OF PRICE ELASTICITY OF DEMAND

What factors influence the price elasticity of demand for a product? Our earlier discussion of substitution and income effects suggests primary roles for the following factors:

- **Substitution possibilities.** The substitution effect of a price change tends to be small for goods with no close substitutes. Consider, for example, the vaccine against rabies. People who have been bitten by rabid animals have no substitute for this vaccine, so demand for it is highly inelastic. We saw that the same was true for a good such as salt. But consider now the demand for a particular brand of salt, say, Morton's. Despite the advertising claims of salt manufacturers, one brand of salt is a more-or-less perfect substitute for any other.

[3]The slope here is from the formula $P = 100 - (Q/10)$.

Because the substitution effect between specific brands is large, a rise in the price of one brand should sharply curtail the quantity of it demanded. In general, the absolute value of price elasticity will rise with the availability of attractive substitutes.

- **Budget share.** The larger the share of total expenditures accounted for by the product, the more important will be the income effect of a price change. Goods such as salt, rubber bands, cellophane wrap, and a host of others account for such small shares of total expenditures that the income effects of a price change are likely to be negligible. For goods like housing and higher education, by contrast, the income effect of a price increase is likely to be large. In general, the smaller the share of total expenditure accounted for by a good, the less elastic demand will be.
- **Direction of income effect.** A factor closely related to the budget share is the direction—positive or negative—of its income effect. While the budget share tells us whether the income effect of a price change is likely to be large or small, the direction of the income effect tells us whether it will offset or reinforce the substitution effect. Thus, a normal good will have a higher price elasticity than an inferior good, other things equal, because the income effect reinforces the substitution effect for a normal good but offsets it for an inferior good.
- **Time.** Our analysis of individual demand did not focus explicitly on the role of time. But it too has an important effect on responses to changes in prices. Consider the oil price increases of recent years. One possible response is simply to drive less. But many auto trips cannot be abandoned, or even altered, very quickly. A person cannot simply stop going to work, for example. He can cut down on his daily commute by joining a car pool or by purchasing a house closer to where he works. He can also curtail his gasoline consumption by trading in his current car for one that gets better mileage. But all these steps take time, and as a result, the demand for gasoline will be much more elastic in the long run than in the short run.

The short- and long-run effects of a supply shift in the market for gasoline are contrasted in Figure 4.26. The initial equilibrium at *A* is disturbed by a supply reduction from *S* to *S′*. In the short run, the effect is for price to rise to P_{SR} = \$2.80/gal and for quantity to fall to Q_{SR} = 5 million gal/day. The long-run demand curve is more elastic than the short-run demand curve. As consumers have more time to adjust, therefore, price effects tend to moderate while quantity effects tend to become

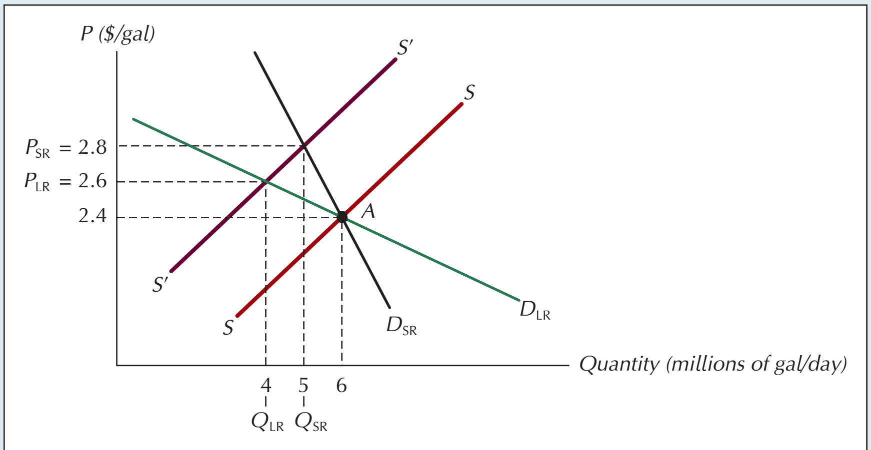


FIGURE 4.26
Price Elasticity Is Greater in the Long Run Than in the Short Run
The more time people have, the more easily they can switch to substitute products. The price effects of supply alterations are therefore always more extreme in the short run than in the long run.

more pronounced. Thus the new long-run equilibrium in Figure 4.26 occurs at a price of P_{LR} = \$2.60/gal and a quantity of Q_{LR} = 4 million gal/day.

We see an extreme illustration of the difference between short- and long-run price elasticity values in the case of natural gas used in households. The price elasticity for this product is only −0.1 in the short run but a whopping −10.7 in the long run![4] This difference reflects the fact that once a consumers have chosen appliances to heat and cook with, they are virtually locked in for the short run. People aren't going to cook their rice for only 10 minutes just because the price of natural gas has gone up. In the long run, however, consumers can and do switch between fuels when there are significant changes in relative prices.

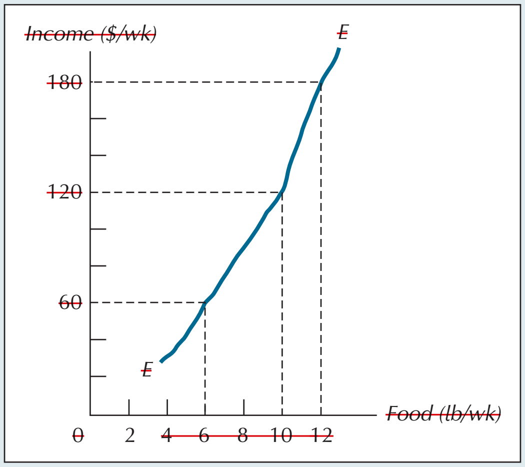
~~THE DEPENDENCE OF MARKET DEMAND ON INCOME~~

~~As we have seen, the quantity of a good demanded by any person depends not only on its price but also on the person's income. Since the market demand curve is the horizontal sum of individual demand curves, it too will be influenced by consumer incomes. In some cases, the effect of income on market demand can be accounted for completely if we know only the average income level in the market. This would be the case, for example, if all consumers in the market were alike in terms of preference and all had the same incomes.~~

~~In practice, however, a given level of average income in a market will sometimes give rise to different market demands depending on how income is distributed. A simple example helps make this point clear.~~

~~EXAMPLE 4.7~~

~~Two consumers, *A* and *B*, are in a market for food. Their tastes are identical, and each has the same initial income level, \$120/wk. If their individual Engel curves for food are as given by *EE* in Figure 4.27, how will the market demand curve for food be affected if *A*'s income goes down by 50 percent while *B*'s goes up by 50 percent?~~



~~FIGURE 4.27~~
~~The Engel Curve for Food of *A* and *B*~~
~~When individual Engel curves take the nonlinear form shown, the increase in food consumption that results from a given increase in income will be smaller than the reduction in food consumption that results from an income reduction of the same amount.~~

~~The nonlinear shape of the Engel curve pictured in Figure 4.27 is plausible considering that a consumer can eat only so much food. Beyond some point, increases in income should have no appreciable effect on the amount of food consumed. The implication is that *B*'s new income (\$180/wk) will produce an increase in his~~

~~[4]H. S. Houthakker and Lester Taylor, *Consumer Demand in the United States: Analyses and Projections*, 2d ed., Cambridge, MA: Harvard University Press, 1970.~~