CHAPTER 4

Individual and Market Demand

How do individuals' consumption choices respond to price changes and how is the market demand curve derived from individual consumers' demand curves?

Chapter Outline

Learning Objectives

- Understand how price changes affect consumption choices.
- Differentiate between the income and substitution effects associated with a price change on the consumption of a particular good.
- Explain the relation between income and substitution effects in the case of inferior goods.
- Show how individual demand curves are aggregated to obtain the market demand curve.
- Demonstrate how consumer surplus represents the net benefit, or gain, served by an individual from consuming one market basket instead of another.
- Investigate the relationship between own-price elasticity of demand and the price-consumption curve.
- Examine network effects: the extent to which an individual consumer's demand for a good is influenced by other individuals' purchases.
- Overview the basics of demand estimation.

In Chapter 3, we developed a model using indifference curves and budget lines to explain consumer behavior and used it to examine how changes in income affect consumer choices. In this chapter we use the consumer choice model to analyze the effects of price changes and show how a consumer's demand curve can be derived using the model. We also discuss how individual demand curves are aggregated to obtain the market demand curve. In addition, we explain the concept of consumer surplus, which relates to how areas under the demand curve can be used to measure the net benefits or costs to consumers from changes in consumption. And finally, we cover demand estimation to show how individuals' or market demand curves can be estimated from real-world data.

This chapter completes our discussion of the basic elements of the *theory* of consumer choice. Chapter 5, however, will illustrate the wide range of *applications* of this theory to such diverse problems as pricing garbage collection, deciding how much to save and borrow, and determining how much to invest in various financial assets.

4.1 PRICE CHANGES AND CONSUMPTION CHOICES[1]

Let's examine the way a change in a good's price affects the market basket chosen by a consumer. Because we wish to isolate the effect of a price change on consumption, we hold constant other factors such as income, preferences, and the prices of other goods.

Figure 4.1a depicts a consumer deciding how to allocate a given amount of annual income between college education (C) and all other goods. The per-credit-hour price of college education, $250, is indicated by the slope of the budget line since the per-dollar price of outlays on all other goods can be taken to be unity. With an initial budget line of AZ, the consumer's optimal consumption point is *W*. The consumption of college education is C_1, and outlays on other goods are A_1.

If the price of college education falls from $250 to $200, the budget line rotates around point A and becomes flatter. With a price of $200, the budget line becomes *AZ′*, where *Z′* equals the consumer's constant income divided by the lower price of college education. Confronted with this new budget line, the consumer selects the most preferred market basket from among those available on *AZ′*. For the particular preferences shown, the preferred basket is point *W′*, where the slope of U_2 (the marginal rate of substitution) equals the slope of the flatter budget line *AZ′*. Consumption of college education has increased to C_2 in response to the reduction in its price. If the price of college education falls still further to $150, then the budget line becomes *AZ″*, and the consumer will choose point *W″*, with the amount of credit hours of college education consumed equal to C_3.

PRICE-CONSUMPTION CURVE
a curve that identifies the optimal market basket associated with each possible price of a good, holding constant all other determinants of demand

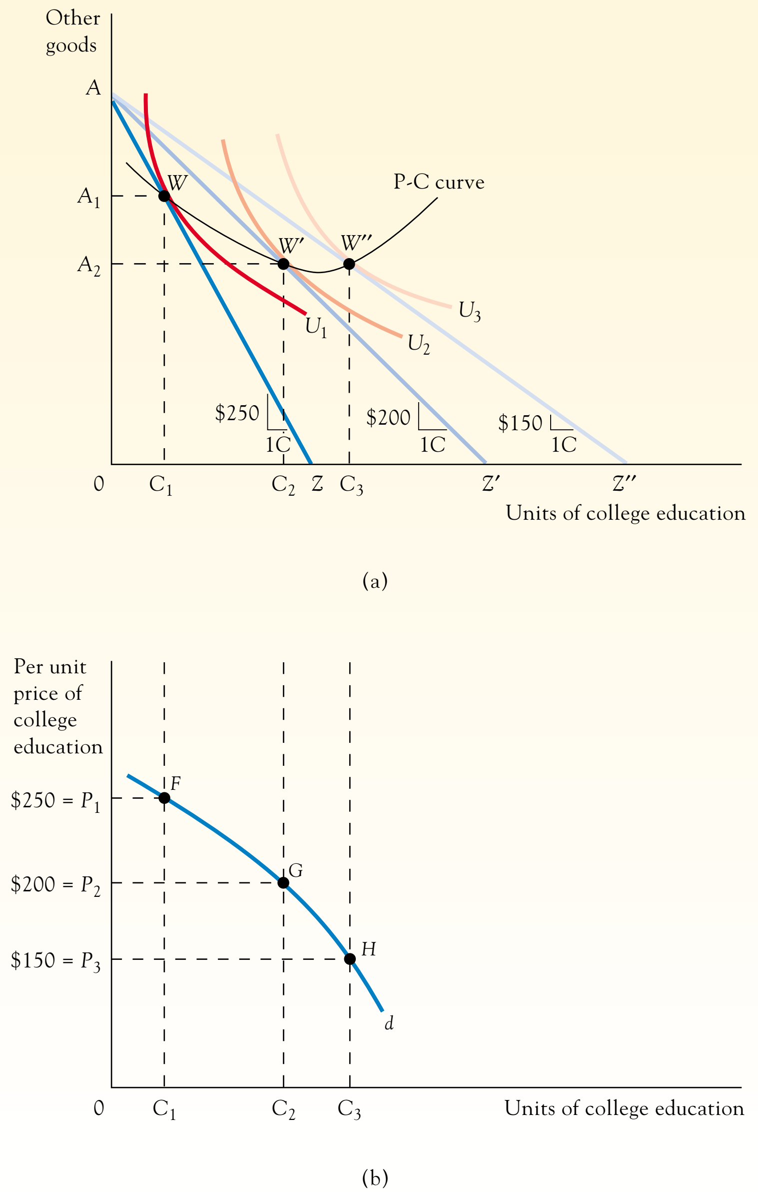
Proceeding in this way, we can vary the price of college education and observe the market basket chosen by the consumer. For every possible price, a different budget line results and the consumer selects the market basket that permits attainment of the highest possible indifference curve. Points *W*, *W′*, and *W″* represent three market baskets associated with prices of $250, $200, and $150, respectively. If we connect these optimal consumption points, and those associated with other prices (not drawn in explicitly), we obtain the **price-consumption curve**, shown as the *P-C* curve in the diagram. The price-consumption curve identifies the optimal market basket associated with each possible price of college education, holding constant all other determinants of demand.

[1]A mathematical treatment of some of the material in this section is given in the appendix at the back of the book (page xxx).

FIGURE 4.1

Derivation of the Consumer's Demand Curve

A reduction in the price of college education, with income, preferences, and the prices of other goods remaining fixed, leads the consumer to purchase more units of college education. (a) The optimal market baskets associated with alternative prices for college education are connected to form the price-consumption curve. (b) The same information is plotted as the consumer's demand curve for college education.



The Consumer's Demand Curve

Using the procedure just described, we can determine the consumer's demand curve for college education. The demand curve relates consumption of college education to its price, holding constant such factors as income, the prices of related goods, and preferences. The price-consumption curve does the same thing although it is not itself the demand curve. To convert the price-consumption curve to a demand curve, we simply plot the price-quantity relationship identified by the price-consumption curve in the appropriate graph.

Figure 4.1b shows the consumer's demand curve *d* (as before, we use lowercase letters to indicate the individual consumer's demand curve); it indicates the quantity of college education the consumer will buy at alternative prices, other factors held constant. The demand curve is determined by plotting the price-quantity combinations identified by the price-consumption curve in Figure 4.1a. For example, when the price of college education is $250 (the slope of *AZ*), consumption of college education is C_1 at point *W* in Figure 4.1a. Figure 4.1b shows the price of college education explicitly on the vertical axis. When the price is $250, consumption is C_1, so point *F* locates one point on the demand curve. When the price is $200 (the slope of *AZ′*), consumption is C_2, which identifies a second point, G, on the demand curve. Other points are obtained in the same manner to plot the entire demand curve *d*.

Some Remarks About the Demand Curve

We have just derived a consumer's demand curve from the individual's underlying preferences (with a given income and fixed prices of other goods). This approach clarifies several points about the demand curve:

1. The consumer's level of well-being varies along the demand curve. This point is clear from Figure 4.1a, where the consumer reaches a higher indifference curve when the price of college education falls. The diagram specifies why the consumer benefits from a lower price: the consumer can now purchase market baskets that were previously unattainable.

2. The prices of other goods are held constant along a demand curve, but the quantities purchased of these other goods can vary. For example, in Figure 4.1a, consumption of all other goods falls from A_1 to A_2 when the price of college education falls from $250 to $200. Because all other goods are lumped together and treated as a composite good, the way in which consumption of any other specific good may change is not shown explicitly.

3. At each point on the demand curve, the consumer's optimality condition $MRS_{CO} = P_C/P_O$ is satisfied. (The subscript O refers to *other goods*, the composite good measured on the vertical axis.) As the price of college education falls, the value of P_C/P_O becomes smaller, and the consumer chooses a market basket for which MRS_{CO}, the slope of the indifference curve, is also smaller.

4. The demand curve identifies the marginal benefit associated with various levels of consumption. The height of the demand curve from the horizontal axis, at each level of consumption, indicates the marginal benefit of the good. For example, when consumption is C_2 at point G on the demand curve (Figure 4.1b), the distance GC_2 (or $200) is a measure of how much the marginal unit of college education consumed is worth to the consumer. Why? Refer to Figure 4.1a; for a market basket selected by a consumer to be optimal, such as *W′* when the price of college education is $200, MRS_{CO} equals P_C/P_O. Since P_O can be taken to equal unity, this implies that $MRS_{CO} = P_C$. Thus, at point *W′* in Figure 4.1a, MRS_{CO} is equal to $200 per unit of college education. Because the *MRS* is a measure of what the consumer is willing to give up for an additional credit hour of college education, it is a measure of the marginal benefit. *Note that at every point on the demand curve the height of the demand curve equals the* MRS, *thereby indicating the marginal benefit of the good to the consumer*. For this reason economists refer to the price at which people purchase a given good as revealing the relative importance of the good to them.

APPLICATION 4.1 USING PRICE TO DETER YOUTH ALCOHOL ABUSE, TRAFFIC FATALITIES, AND CAMPUS VIOLENCE

Although economists ascribe an important role to price in determining the quantity demanded of a product, policymakers often do not. A case in point is the campaign waged by policymakers since the mid-1970s to discourage alcohol abuse and thereby decrease the number of traffic-related deaths. One of the main campaign objectives has been to raise the legal age for alcohol consumption to 21 years. The reason behind this is that while people under the age of 25 represent 20 percent of all licensed drivers, they account for 35 percent of all drivers involved in fatal accidents. Alcohol is involved in more than half the driving fatalities accounted for by young drivers.

By raising the legal age for alcohol consumption to 21, policymakers hope to shift the demand curve for alcohol to the left (diminishing the portion of the population with access to alcohol) and thereby reduce both alcohol abuse and driving fatalities.

Shifting the demand curve for alcohol to the left is one way to reduce alcohol abuse and traffic fatalities. However, economic research suggests that a more effective method, even among teenagers, would be to raise the price of alcohol through higher taxes, thereby producing a movement along the demand curve for alcohol.

The federal tax on alcohol was constant in nominal dollar terms between 1951 and 1991 ($9 per barrel of beer, $10.50 per proof gallon of distilled spirits such as vodka, and so on) and has only been increased modestly since then. In real terms, consequently, the federal tax on alcohol has decreased since 1951. For examples, the real federal tax on beer has declined by 70 percent since 1951 while the real tax on distilled spirits has decreased by 81 percent. The decline, in real terms, of the federal tax on alcohol is a major factor behind the substantial decrease in the real price of alcohol since 1951—40 percent in the case of beer and 70 percent for hard liquor.

A national survey of teenagers finds that, holding constant other factors such as a state's minimum drinking age, religious affiliation, and proximity to bordering states with lower minimum drinking ages, the amount of alcohol consumed by the average teenager in a state is significantly influenced by the price of alcohol there.[2]

[2]According to Douglas Coate and Michael Grossman, "Effects of Alcoholic Beverage Prices and Legal Drinking Ages on Youth Alcohol Use," *Journal of Law and Economics*, 31 No. 1 (April 1988), pp. 145–172, the estimated price elasticity of demand for teenage drinking ranges from 0.5 to 1.2.

The survey findings suggest that raising taxes on alcohol offers a potent mechanism for deterring alcohol abuse and traffic fatalities among teenagers. Specifically, based on the survey's results, had federal taxes on alcohol remained constant since 1951 in real purchasing power terms rather than in dollar terms, teenage drinking would have fallen more than if the minimum drinking age had been raised to 21 in all states. Raising the price of drinking and moving along the demand curve for alcohol thus promises to be more effective at reducing teenage drinking than the policy pursued by most policymakers—shifting the demand curve for alcohol to the left by imposing age restrictions.

According to another study, the decline in the real price of alcohol also appears to have resulted in an increase in campus violence over the last decade.[3] Currently, a third of the college student population of 14.5 million in the United States is expected to be involved, in any given year, in same kind of campus violence (arguments, fights, run-ins with police or college authorities, sexual misconduct, and so on). Because alcoholic consumption is positively correlated with violence, the study examined the relationship between prices of six-packs of beer and levels of violence at colleges around the country. The study found that a 10 percent increase in the price of beer would be sufficient to decrease campus violence by 4 percent, other factors held constant. However, since the real price of beer has actually fallen by 10 percent since 1991—largely due to the decline, in real items, of the federal tax on alcohol—the converse result has occurred. Namely, the study concludes that campus violence has increased by 4 percent (200,000 incidents) since 1991 on account of the decline in the real price of beer.

[3]"How to Calm the Campus," *Business Week*, November 1, 1999, p. 32.

Application 4.2 Sales Tax Avoidance and Online Commerce

An important factor driving online commerce appears to be the fact that local sales taxes generally are not applied to purchases made on the Internet. Using data on the buying decisions of 25,000 online users, Austan Goolsbee of the University of Chicago finds that, holding all other factors constant, individuals living in places with higher local sales tax rates are significantly more likely to buy goods over the Internet.[4] In other words, the lower relative price for goods made possible through the Internet results in increased consumption along the lines of the downward-sloping demand curve depicted in Figure 4.1. Moreover, the likelihood of shopping online increases only for goods where buying online avoids sales tax (books, computers, software, clothing, and so on). The probability of online shopping doesn't increase for goods where the buyer is unlikely to avoid sales taxes either because such taxes are not applied to local purchases (airline and movie tickets) or because a sales tax is associated with online purchases through the need for local deliveries (cars, flowers, and groceries). Finally, Goolsbee's research suggests that if existing sales taxes were applied to Internet commerce, the adverse impact on online purchases would be sizable (24 percent fewer online buyers).

[4]Austan Goolsbee, "In a World without Borders: The Impact of Taxes on Internet Commerce," *Quarterly Journal of Economics*, 115, No. 2 (May 2000), pp. 561–576.

Do Demand Curves Always Slope Downward?

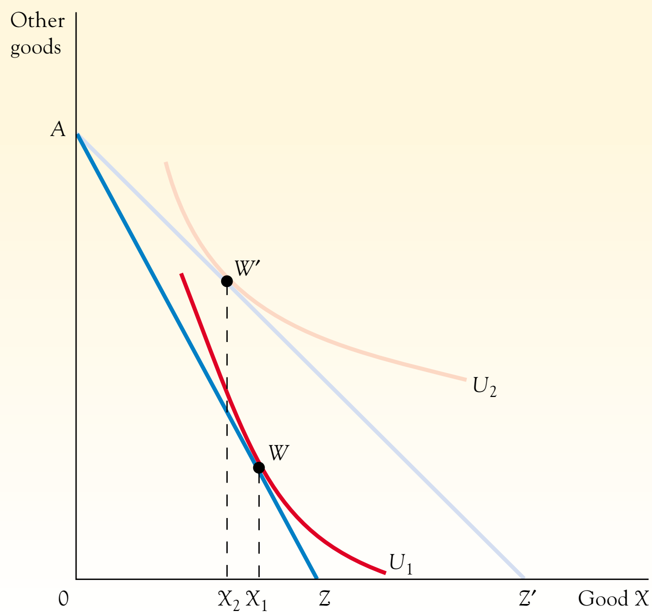
For the specific indifference curves shown in Figure 4.1, we derived a downward-sloping demand curve. But does the demand curve always slope downward? Is it possible for a consumer to have indifference curves so that the law of demand does not hold for some goods?

Figure 4.2 suggests such a possibility. When the budget line is AZ, consumption of good X is X_1 units. If the price of X falls so that the budget line becomes AZ', consumption of X falls to X_2, an apparent violation of the law of demand. Note that the indifference curves that produce this result are downward-sloping, nonintersecting, and convex; that is, they do not contradict any of our basic assumptions about preferences.

Just because we can draw a diagram that shows reduced consumption at a lower price does not mean such an outcome will ever be observed in reality. It does suggest, however, the importance of carefully considering exactly why consumption of a good varies in response to a change in its price. We illustrate this idea in the following sections.

FIGURE 4.2

A Lower Price Leading to Less Consumption
A consumer purchases less of good *X* when its price falls, an apparent violation of the law of demand. In this case the demand curve will be upward-sloping.



4.2 INCOME AND SUBSTITUTION EFFECTS OF A PRICE CHANGE

When the price of a good changes, the change affects consumption in two different ways. Normally, we cannot observe these two effects separately. Instead, when the consumer alters consumption in response to a price change, all we see is the combined effect of both factors. Nevertheless, it is useful to analytically break down the effects of a price change into these two components.

INCOME EFFECT
a change in a consumer's real purchasing power brought about by a change in the price of a good

SUBSTITUTION EFFECT
an incentive to increase consumption of a good whose price falls, at the expense of other, now relatively more expensive, goods

The first way a price change affects consumption is the **income effect**. When the price of a good falls, a consumer's real purchasing power increases, which affects consumption of the good. A price reduction increases *real* income—that is, makes it possible for the consumer to attain a higher indifference curve.

The second way a price reduction affects consumption is the **substitution effect**. When the price of one good falls, the consumer has an incentive to increase consumption of that good at the expense of other, now *relatively* more expensive, goods. The individual's consumption pattern will change in favor of the now less costly good and away from other goods. In short, the consumer will substitute the less expensive good for other goods—hence the name *substitution effect*.

To see intuitively that two different factors are at work when a price changes, compare Figure 3.14 from Chapter 3 and Figure 4.1. In Figure 4.1, a price reduction results in the consumer reaching a higher indifference curve. In Figure 3.14, an increase in income, with no change in prices, also results in consumers reaching a higher indifference curve. Apparently, a common factor is at work: both a reduction in price and an increase in income raise the consumer's real income, in the sense of permitting attainment of greater well-being. In both cases the budget line moves outward, allowing consumption of market baskets that were not previously attainable. This points to one of the two ways a price reduction affects consumption: it augments real income (by increasing the purchasing power of a given nominal income), which obviously affects consumption. This is the income effect.

Although a price reduction and an income increase both have an income effect on consumption, there is a significant difference between them. With a price reduction the consumer moves to a point on a higher indifference curve where the slope is lower than it was at the original optimal consumption point (see Figure 4.1). In effect, the consumer has moved down the indifference curve to consume more of the lower-priced good. This result illustrates the substitution in favor of the less costly good. When income increases, however, the consumer moves to a point on a higher indifference curve where the slope (the *MRS*) is the same as it was prior to the income increase. This is so because if only income changes, the slope of the consumer's budget line does not change. The precise distinction between these two effects and the way they help us understand why the demand curve has the shape it does are clarified next with a graphical treatment.

Income and Substitution Effects Illustrated: The Normal-Good Case

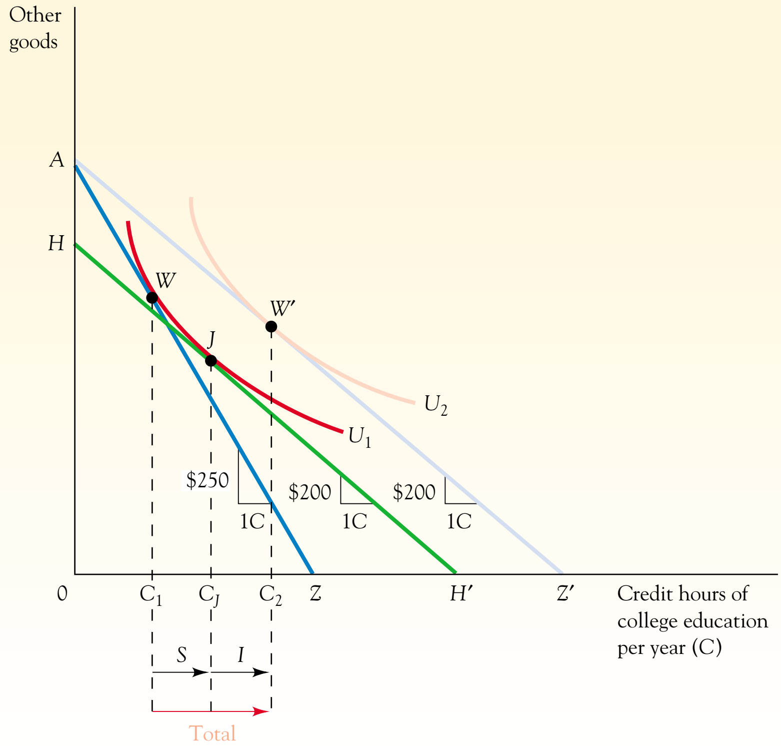
In Figure 4.3, the consumer's original budget line *AZ* relates annual credit hours of college education and outlays on all other goods. At a per-credit-hour price of \$250, the optimal market basket is *W*, with C_1 credit hours bought by the consumer. If the price of college education falls to \$200, the budget line becomes *AZ*′, and the consumer buys C_2 units. The increase in consumption of college education (from C_1 to C_2) in response to the lower price is the *total effect* of the price reduction on purchases of college education. The demand curve shows the total effect. Now we wish to show how this total effect can be decomposed conceptually into its two component parts—the income effect and the substitution effect.

The substitution effect illustrates how the change in relative prices *alone* affects consumption, independent of any change in real income or well-being. To isolate the substitution effect, we must keep the consumer on the original indifference curve, U_1, while at the same

FIGURE 4.3

Income and Substitution Effects of a Price Reduction

The total effect (from C_1 to C_2) of a reduction in the price of college education can be separated into two components, the income effect and the substitution effect. A hypothetical budget line *HH′* is drawn parallel to the new (after-price-change) budget line but tangent to the initial indifference curve U_1 at point *J*. The substitution effect is then C_1 to C_J, and the income effect is C_J to C_2, which together give the total effect of the price decrease on the consumption of college education by the consumer.



time confronting the individual with a lower price of college education. We do so by drawing a new budget line with a smaller slope, reflecting the lower price, and then imagining that the consumer's income is reduced just enough (while holding the price of college education at \$200) so that the student can attain indifference curve U_1. In other words, we move the *AZ′* budget line toward the origin parallel to itself until it is tangent to U_1. The result is the *hypothetical* budget line *HH′*, paralleling *AZ′* (both reflect the \$200 price) and tangent to U_1 at point *J*. This new budget line shows that if, after the price decrease, the consumer's income is reduced by *AH*, the preferred market basket will be point *J* on U_1, the indifference curve attained by the consumer prior to the price decrease. (Remember from the last chapter that the height of the budget line's intercept on the vertical axis represents the consumer's income when dollar outlays on all other goods are measured on the vertical axis.)

This manipulation permits us to separate the income and substitution effects so that each can be identified independently. *The substitution effect is shown by the difference between the market baskets at points* W *and* J. The lower price of college education, looked at by itself, leads to an increased consumption of college education from C_1 to C_J and reduces consumption of other goods. In effect, the substitution effect involves sliding down the original indifference curve from point *W*, where its slope is \$250 per credit hour, to point *J*, where its slope is \$200 per credit hour. Consequently, the substitution effect of the lower price increases consumption from C_1 to C_J.

The income effect is shown by the change in consumption when the consumer moves from point J *on* U_1 *to point* W′ *on* U_2. This change involves a parallel movement in *HH′* out to the *AZ′* budget line. Recall that a parallel shift in the budget line indicates a change in income but no change in the price of college education. Thus, the income effect of the lower price causes consumption of college education to rise from C_J to C_2.

The sum of the substitution effect (C_1 to C_J) and the income effect (C_J to C_2) measures the total effect (C_1 to C_2) of the lower price on the consumption of college education. Any change in price can be separated into income and substitution effects in this manner.

Although this analysis may seem esoteric, it is highly significant. Ultimately, we are seeking a firm basis for believing that people will consume more at lower prices—that is, that the law of demand is valid. Separating the income and substitution effects allows us to look at the issue more deeply.

Note that the substitution effect of any price change always implies more consumption of a good at a lower price and less consumption at a higher price. This relationship follows directly from the convexity of indifference curves: with convex indifference curves, a lower price implies a substitution effect that involves sliding down the initial indifference curve to a point where consumption of the good is greater. Thus, the substitution effect conforms to the law of demand.

The income effect of a price change, however, implies greater consumption at a lower price only if the good is a normal good. In Figure 4.3, when the budget line shifts from HH' to AZ' (a parallel shift), consumption of college education will rise if college education is a normal good.

The demand curve for a normal good must therefore be downward-sloping. Both the substitution and income effect of a price change involve greater consumption of the good when its price is lower.[5] Because the total effect is the sum of the income and substitution effects, people will consume more of a normal good when its price is lower. This conclusion is a powerful one, because we know that most goods are normal goods. Some goods are inferior goods, however. In Section 4.3 we will explore whether the law of demand applies to them.

APPLICATION 4.3 INCOME AND SUBSTITUTION EFFECTS AND HOME OWNERSHIP

The likelihood of home ownership in the United States increases with income.[6] For example, 35 percent of families with an annual income of less than $10,000 own a home versus 68 percent of families with an annual income of between $25,000 and $49,999 and 93 percent of families with an annual income of $100,000 or more. This phenomenon is due partly to an income effect: home ownership is a normal good, and as income increases, so does the likelihood of home ownership. A substitution effect, however, is also at work. This is because mortgage interest payments on a home can be deducted from the personal income subject to federal taxation, and the tax rate increases with income. Since higher-income individuals can disproportionately reduce the amount they owe in taxes through the mortgage interest deduction, the relative price of home ownership is lower for them. The lower relative price, a substitution effect, thus also encourages a positive correlation between income and home ownership.

[6]Jeffrey M. Perloff, *Microeconomics*, 2nd ed. (Boston: Addison-Wesley Longman, 2001) and U.S. Census Bureau, *Statistical Abstract of the United States: 2001* (Washington, DC: U.S. Government Printing Office, 2001).

[5]Figure 4.3 shows the substitution and income effects for a price reduction. An increase is handled in a slightly different way. If we were considering an increase in the price of college education from $200 to $250 in the diagram, we would accomplish the separation into substitution and income effects by drawing a hypothetical budget line with a slope of $250 (the new price) tangent to the indifference curve, U_2, the consumer is on before the price increase.

The Income and Substitution Effects Associated with a Gasoline-Tax-Plus-Rebate Program

Ever since the Arab oil embargo in 1973 and the quadrupling of oil prices that resulted from it, there have been numerous proposals designed to encourage or force U.S. consumers to cut back on their use of gasoline. One such proposal involves the use of a large excise tax on gasoline (roughly 50 cents per gallon) to raise its price and thereby reduce consumption. An **excise tax** is a tax on a specific good such as gasoline that allows the consumer to purchase as many units of the good at the taxed price as desired.

EXCISE TAX
a tax on a specific good

Realizing that a large gasoline excise tax would place a heavy burden on many families, most proponents of the proposal recommend that the tax revenues be returned to consumers in the form of unrestricted cash transfers, or tax rebates. Alternatively, the tax revenues could be used to reduce the federal government's outstanding debt.

Although a sizable increase in gasoline taxes has not yet been enacted into law, it poses an interesting problem. One objection commonly raised to this plan questions whether it would really cause gasoline consumption to fall. If the revenues from the tax are simply distributed to the general public, why would gas consumption be curtailed? We can use consumer choice theory to show that gasoline consumption will, in fact, be reduced by a combination of an excise tax and a tax rebate.

The key to analyzing this policy package is realizing that the tax rebate would be a cash transfer to each family completely unrelated to its gasoline consumption. In other words, the proposal would not give a rebate of 50 cents for every gallon of gasoline purchased by a family, because that policy would leave the effective price of gasoline unchanged and completely negate the effect of the tax. Instead, a family would receive a check for $500 a year, for example, regardless of how much gasoline it purchased. On average for all families, the rebate would equal the total tax paid, but some families would be overcompensated for the tax while others would be undercompensated.

Now let's examine the gasoline tax and rebate plan for a representative consumer. Figure 4.4a focuses on the effects of such a plan on the representative consumer's budget line *AZ*. The excise tax by itself will increase the price from $1.00 to $1.50 per gallon and therefore rotate the budget line inward to AZ'. This is not the end of the analysis, however, because the budget line to which the consumer will adjust must reflect both the tax and the rebate. The rebate is shown as the outward parallel shift in AZ' to $A'Z''$, similar to an increase in income, while the price of gasoline remains constant at $1.50 per gallon.

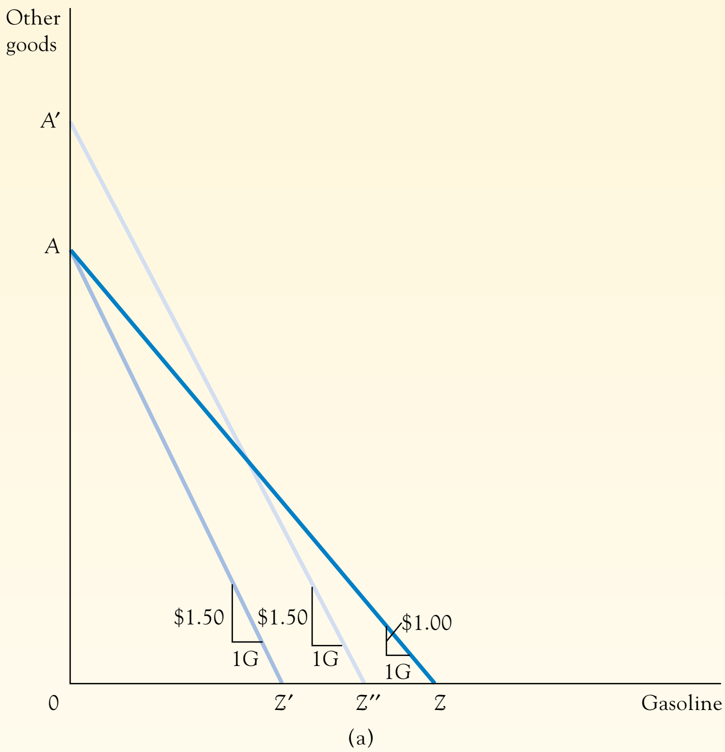
Figure 4.4b depicts what happens to the consumer's optimal consumption point under the tax and rebate plan. Initially, the consumer selects point *E*, along the original budget line *AZ*, with G_1 gallons being purchased. With the gasoline tax and rebate the consumer selects point E', where U_1 is tangent to the new budget line $A'Z''$. Gasoline consumption has fallen from G_1 to G_2, while consumption of other goods has increased.

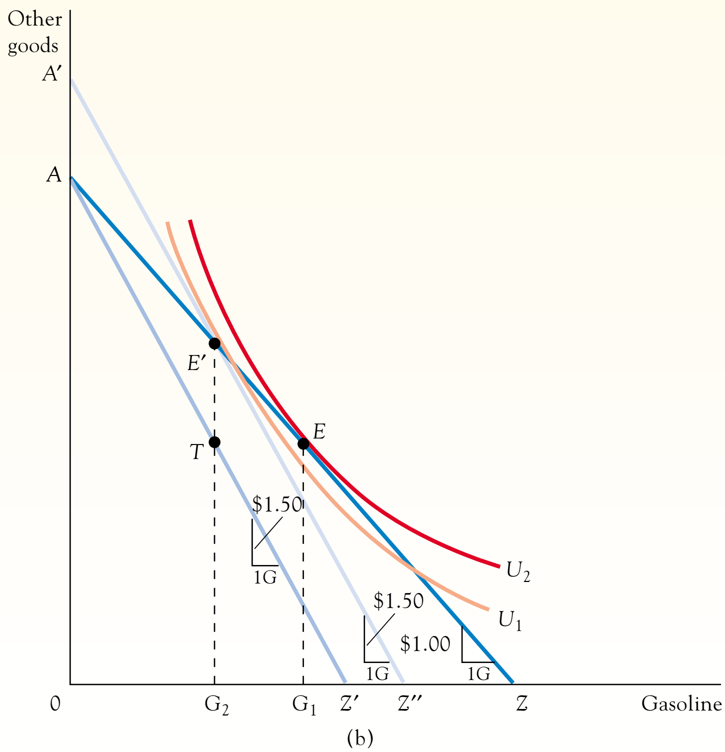
How far out will the tax rebate shift the after-tax budget line, AZ'? If everyone receives a rebate of the same size, and it is determined by dividing total tax revenue by the number of consumers, then the average consumer will receive a rebate equal to the tax he or she pays. Thus, it seems reasonable to focus the analysis on a consumer who receives a rebate equal to the tax paid, the situation shown in Figure 4.4b.

To see that the tax and rebate are equal when the consumer's optimal choice is point E', note that G_2 units of gasoline will be purchased at that point. Because the AZ' budget line shows the effect of the tax by itself, the total tax revenue is the vertical distance, $E'T$, between the original budget line, *AZ*, and the budget line, AZ', incorporating the tax. We can see that $E'T$ is the total tax bill by noting that if G_2 gallons were purchased when the market price was $1.00, outlays on other goods would have been vertical distance, $E'G_2$. Once the tax is levied, only TG_2 in income is left (before the rebate). The vertical difference, $E'T$, is thus the total tax. Because the rebate equals the tax, the budget line must shift up by

FIGURE 4.4

Tax-Plus-Rebate Program
An excise tax will reduce gasoline consumption even if the revenue is returned to taxpayers as lump-sum transfers. (a) The tax pivots the budget line to *AZ′* and the tax rebate shifts it to *A′Z″*. (b) The combined effect reduces gasoline consumption from G_1 to G_2.





an amount equal to $E'T$, and so it passes through point E'. Finally, we have already seen that point E' represents the consumer's optimal choice under the tax and rebate plan because the indifference curve is tangent to the final budget line at that point. By experimentation, you can determine that if the rebate were any larger, it would be greater than the amount of tax paid and, conversely, less than the tax paid if it were smaller.

The geometry of this case is slightly complicated, but the final outcome fits with common sense. The excise tax by itself (without a rebate) has an income effect and a substitution effect. Both effects reduce gas consumption—provided, of course, that gas is a normal good in the case of the income effect. The rebate thus offsets most of the income effect of the tax (but not quite all of it, because the consumer does not return all the way to the original indifference curve). Thus, the substitution effect determines the final result. Because a higher price leads the consumer to substitute away from gasoline, the final outcome is reduced gasoline consumption (G_2 versus G_1).

Finally, note that this combination of tax and rebate necessarily harms the consumer. This result is true, at least, for any consumer who receives a rebate exactly equal to the tax, because the final outcome will be a market basket on the original budget line inferior to the one selected in the absence of the tax and rebate. Why does anyone propose a policy that will make the average family worse off? A good question. Perhaps some consequences are not fully reflected in this analysis. For example, decreased gasoline purchases mean decreased Middle Eastern oil imports, and possibly decreased dependence on imported oil is beneficial in and of itself. In addition, reduced gasoline consumption means lower automobile emissions and possibly improved air quality. These benefits are not incorporated into the analysis, and if they were it is possible that consumers would be better off on balance.

4.3 INCOME AND SUBSTITUTION EFFECTS: INFERIOR GOODS

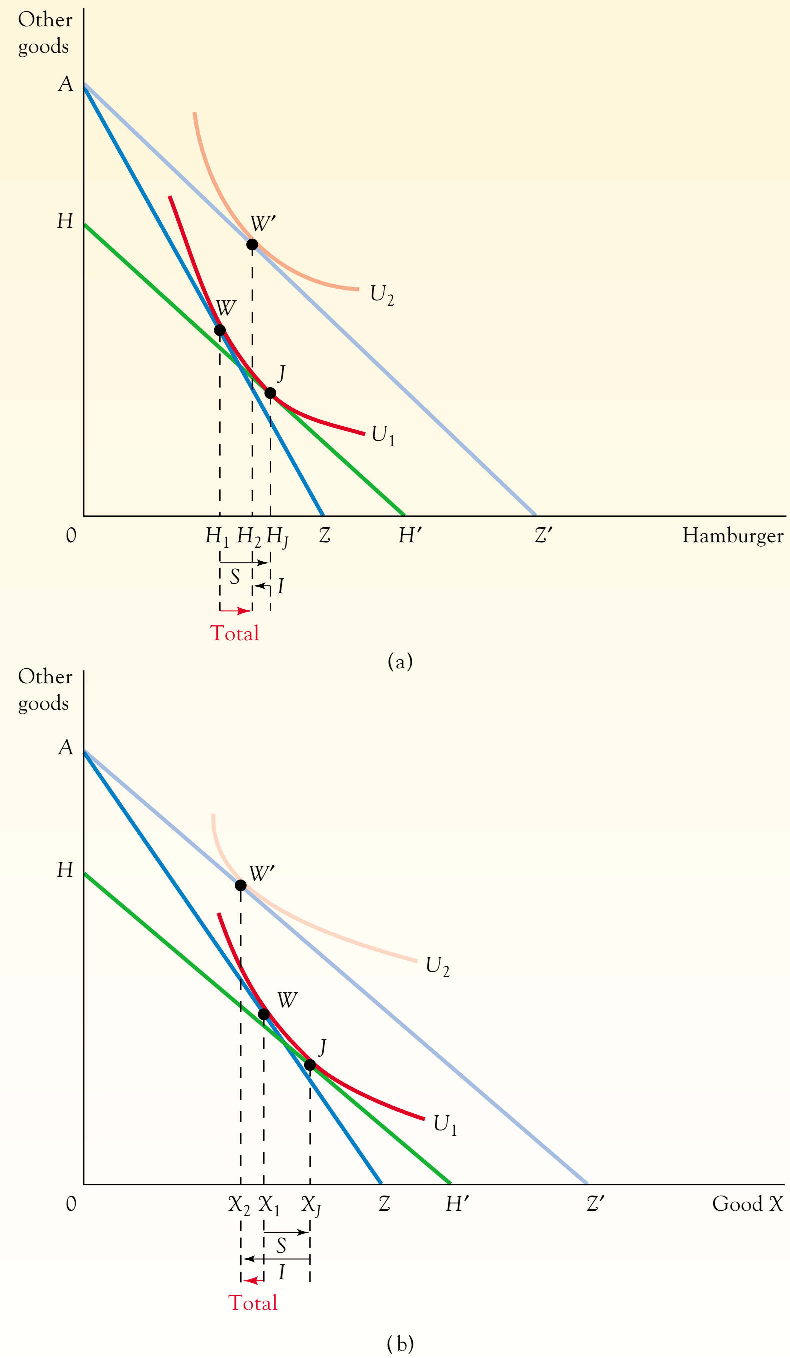
Mechanically, the separation of income and substitution effects for a change in the price of an inferior good is accomplished in the same way as for a normal good. The results, however, differ in one significant respect. With a price reduction, the substitution effect still encourages greater consumption, but the income effect works in the opposite direction. At a lower price the consumer's real income increases, and this by itself, implies less consumption of an inferior good. Thus, a price reduction for an inferior good involves a substitution effect that encourages *more* consumption but an opposing income effect that encourages *less* consumption. Apparently, the total effect—the sum of the income and substitution effects—could go either way.

Figure 4.5a shows one possibility. Initially, the budget line is AZ, with the price of hamburger at \$2 per pound and H_1 pounds purchased. When the price falls to \$1 per pound, the budget line pivots out to AZ', and hamburger consumption rises to H_2 pounds. Once again, the hypothetical budget line HH' that keeps the consumer on U_1, the original indifference curve, is drawn in. The substitution effect is the movement from point W to point J on U_1, implying an increase in consumption from H_1 to H_J. Now see what happens to hamburger consumption when we move out from budget line HH' to AZ', a movement reflecting the income effect of the lower price of hamburger. Because hamburger is an inferior good for this consumer, the income effect reduces hamburger consumption, from H_J to H_2. Overall, however, the total effect of the price reduction is increased consumption, because the substitution effect (greater consumption) is larger than the income effect (lower consumption). In this situation the consumer's demand curve for hamburger slopes downward.

For an inferior good there is another possibility, illustrated in Figure 4.5b. Good X is also an inferior good for some consumers, and a reduction in its price pivots the budget line from AZ to AZ'. Here, however, the total effect of the price decrease is a reduction in the consumption of X, from X_1 to X_2. When the income and substitution effects are shown sepa-

FIGURE 4.5

Income and Substitution Effects for an Inferior Good
(a) Hamburger is an inferior good with a normally shaped, downward-sloping demand curve, because the substitution effect is larger than the income effect.
(b) Good *X* is an inferior good with an upward-sloping demand curve, because the income effect is larger than the substitution effect. Good *X* is called a Giffen good.



rately, we see how this outcome occurs. The substitution effect (point *W* to point *J*, or increased consumption of *X*) still shows greater consumption at a lower price. However, the income effect for this inferior good not only works in the opposing direction (less consumption, from X_J to X_2), but also overwhelms the substitution effect. Because the income effect more than offsets the substitution effect, consumption falls. This consumer's demand curve for good *X*, at least for the prices shown in the diagram, will slope upward.

Thus, for inferior goods, there are two possibilities. If the substitution effect is larger than the income effect when the price of the good changes, then the demand curve will have its usual negative slope. If the income effect is larger than the substitution effect for an inferior good, then the demand curve will have a positive slope. This second case represents a theoretically possible (but rarely observed) exception to the law of demand. It can happen only with an inferior good and, moreover, only for a subset of inferior goods in which income effects are larger than substitution effects. We refer to a good in this class as a **Giffen good**, after the nineteenth-century English economist Robert Giffen, who believed that, during the years of famine, potatoes in Ireland had an upward-sloping demand curve. Giffen observed that as the blight diminished the supply of potatoes in Ireland and drove up their price, the quantity demanded of potatoes appeared to increase. (The evidence in support of Giffen's observation is a matter of debate among economists.)

GIFFEN GOOD
the result of an income effect being larger than the substitution effect for an inferior good, so that the demand curve will have a positive slope.

Finding an intuitively plausible example in which the demand curve slopes upward is difficult, but consider the following hypothetical situation.[7] The Smith family lives in Alaska and traditionally spends the month of January in Arizona. One year the price of home heating oil increases sharply. The Smiths cut back on their use of heating oil during the other winter months, but, nonetheless, their total heating costs rise to a point where they can no longer afford a vacation in Arizona. Because they stay at home in January, their use of heating oil for that month increases dramatically over the amount they would have used had they been in Arizona. On balance, annual heating oil purchases will rise if the increased use in January is greater than the reduction achieved during the remaining winter months. Consequently, an increase in the price of heating oil can conceivably lead to greater use of heating oil by the Smiths. (Conversely, a decrease in the price of heating oil can result in lower consumption of heating oil by the Smiths.)

This contrived scenario illustrates the type of situation shown in Figure 4.5b. Heating oil is an inferior good for the Smiths; a reduction in income will lead them to spend more time at home, which causes an increase in the use of heating oil. A price increase has an income effect that induces them to forgo their January vacation. If the expected consumption in January exceeds the reduced consumption of heating oil during the other winter months, a net increase in consumption of heating oil at a higher price results.

The Giffen Good Case: How Likely?

We might conceive of cases where the income effect for an inferior good exceeds the substitution effect, producing an upward-sloping demand curve. However, economists believe that most, if not all, real-world inferior goods have downward-sloping demand curves, as shown in Figure 4.5a. This belief stems from both theoretical considerations and empirical evidence.

At a theoretical level the question is whether the income effect or the substitution effect of a price change for an inferior good will be larger. If the substitution effect is larger, then the demand curve will slope downward, even for an inferior good. There are good reasons for believing that the substitution effect is larger. Consider first the income effect. Its size relates closely to the fraction of the consumer's budget devoted to the good. If the price of some good falls by 10 percent, the price reduction will benefit a consumer much more (have a larger income effect) if 25 percent of the consumer's income is spent on the good than if only 1 percent is spent on it. For example, a 10 percent reduction in the price of housing will probably influence housing consumption greatly by its income effect, but a 10 percent reduction in the price of computer diskettes will have a much smaller, almost im-

[7]This example is adapted from Edwin G. Dolan, *Basic Economics*, 4th ed. (Hinsdale, Ill.: Dryden Press, 1986).

perceptible income effect. Income effects from a change in price are quite small for most goods because they seldom account for as much as 10 percent of a consumer's budget. This observation is especially true of inferior goods, which are likely to be narrowly defined goods.

In contrast, there is reason to believe that substitution effects for inferior goods will be relatively large. Inferior goods usually belong to a general category that contains similar goods of differing qualities. Take hamburger: a reduction in its price can be expected to result in a rearrangement of a consumer's purchases away from chicken, pork, pot roast, and so on, in favor of hamburger, thus resulting in a large substitution effect. Consequently, price changes for inferior goods should involve relatively large substitution effects but small income effects. Therefore, the demand curve will slope downward, and the case shown in Figure 4.5a will be typical. The Giffen good remains an intriguing but remote theoretical possibility.

APPLICATION 4.4 DO RATS HAVE DOWNWARD-SLOPING DEMAND CURVES?

Logical reasoning and empirical evidence support the proposition that humans have downward-sloping demand curves. The inquiring reader may wonder whether the law of demand also applies to the behavior of animals. Experimental evidence suggests that it does. Consider the results of a study on rats done by researchers at Texas A&M University.[8] The rats were found to have downward-sloping demand curves for root beer and Tom Collins mix.

Researchers confronted each rat with a budget line relating root beer and Collins mix. They charged a "price" by requiring the rats to press a lever to receive 0.05 milliliter of each beverage. The "incomes" of the rats were determined by allocating each rat a certain number of lever presses per day. With an income of 300 lever presses and equal prices for root beer and Collins mix, rats expressed a decided preference for root beer and spent most of their incomes on it. Then, the price of Collins mix was cut in half (half as many lever presses required per unit of Collins mix) and the price of root beer doubled, with income set so that each rat could still consume its previously chosen market basket if it wished. Economic theory predicts that consumption of Collins mix will rise and root beer fall given the new "prices." The theory proved correct: the rats chose to consume more than four times as much Collins mix as before and less root beer.

In a more recent study, researchers attempted to create a situation in which the rats would consume less at a lower price (and, conversely, more at a higher price)—the Giffen good case.[9] Economic theory suggests that this can occur only when the good is strongly inferior and occupies a large portion of the budget (so the income effect is large). When consumption of fluids was restricted to root beer and quinine water, the researchers found that quinine water was an inferior good for the rats. They then lowered the rats' "incomes" to the point where most of their budget was devoted to quinine water; a change in the price of quinine water would then have a large income effect. Next came the crucial experiment: the price of quinine water was reduced. The rats consumed less quinine at the lower price and used their increased real income to increase their root beer consumption. A Giffen good case finally had been found. What is particularly interesting about the experimental results is that the Giffen good case was demonstrated in exactly the circumstances that theory emphasizes are necessary—a strongly inferior good, with most of the budget devoted to purchases of that good.

[8]John Kagel et al., "Experimental Studies of Consumer Demand Behavior Using Laboratory Animals," *Economic Inquiry*, 13 No. 1 (March 1975), pp. 22–38.

[9]Raymond C. Battalio, John H. Kagel, and Carl Kogut, "Experimental Confirmation of the Existence of a Giffen Good," *American Economic Review*, 81 No. 3 (September 1991), pp. 961–970.

4.4 FROM INDIVIDUAL TO MARKET DEMAND

We have seen how to derive an individual consumer's demand curve and why the concepts of income and substitution effects imply that it will typically slope downward. But most practical applications of economic theory require the use of the market demand curve. We begin with a discussion of individual demand because the individual demand curves of all the consumers in the market added together constitute the market demand curve. We will show that, if the typical consumer's demand curve has a negative slope, then the market demand curve must also have a negative slope.

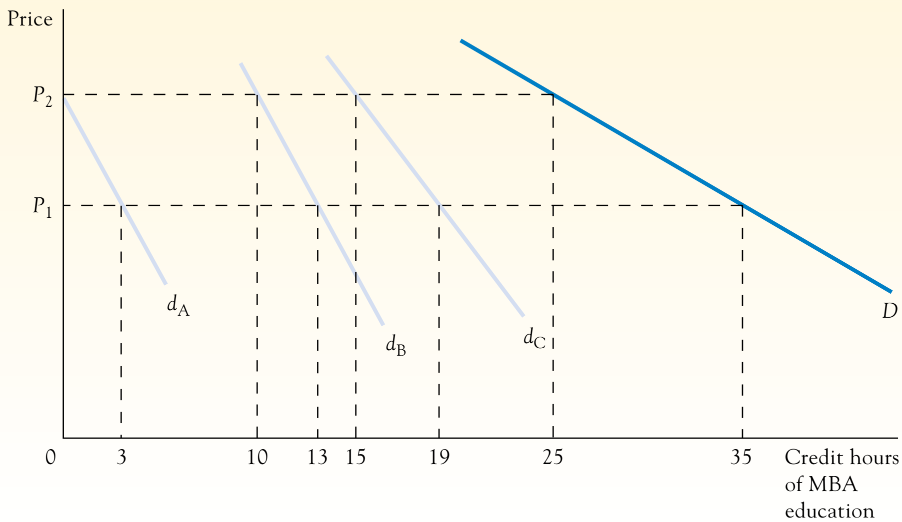
Figure 4.6 illustrates how individual demand curves are aggregated to obtain the market demand curve. Assume that there are only three consumers who purchase an MBA education, although the process will obviously apply to the more important case where there are a great many consumers. The individual demand curves are d_A, d_B, and d_C. To derive the market demand curve, we sum the quantities each consumer will buy at alternative prices. For example, at P_2 consumer B will buy 10 credit hours, consumer C will buy 15, and consumer A will buy none. (Note that when the price is P_2, consumer A will be at a corner optimum.) The combined purchases of all consumers total 25 credit hours when the price is P_2, and this combination identifies one point on the market demand curve D.

Other points on the market demand curve are derived in the same way. If the price is P_1, A will buy 3 credit hours, B will buy 13, and C will buy 19, so total quantity demanded at a price of P_1 is 35 credit hours. The process of adding up the individual demand curves to obtain the market demand curve is called *horizontal summation*, because the quantities (measured on the horizontal axis) bought at each price are added. Note that when the individual demand curves slope downward, the market demand curve also slopes downward. If all consumers buy more at a lower price, then total purchases will rise when the price falls.

FIGURE 4.6

Summing Individual Demands to Obtain Market Demand

The market demand curve *D* is derived from the individual consumers' demand curves by horizontally summing the individual demand curves. At each price we sum the quantities each consumer will buy to obtain the total quantity demanded at that price.



A market demand curve, however, can slope downward even if some consumers have upward-sloping individual demand curves. In a market with thousands of consumers, if a few happened to have upward-sloping demand curves, then their contribution to the market demand curve would be more than offset by the normal behavior of the other consumers. So we have yet another reason not to be overly concerned about the Giffen good case. It is possible to imagine that the Smith family in Alaska will buy more heating oil at a higher price, but it is difficult to believe that their behavior is typical.

APPLICATION 4.5 AGGREGATING DEMAND CURVES FOR A UCLA MBA

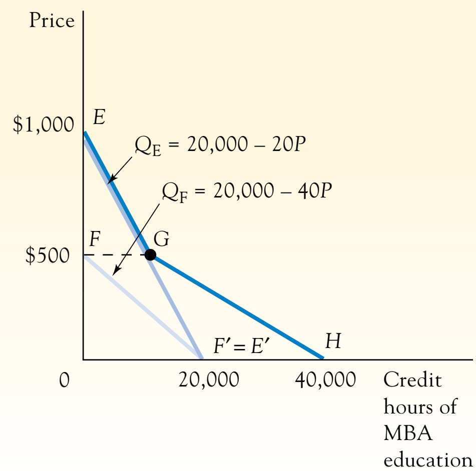
Many business schools offer both a full-time and an evening MBA program. The degrees are the same but the length of time it takes to obtain the degree often differs: a full-time program lasts two years, while earning an MBA at night (and retaining one's job during the day) requires an average of three years of study. Suppose, as shown in Figure 4.7, that at UCLA's Graduate School of Management, the demand for the full-time MBA program is represented by the equation $Q_F = 20{,}000 - 40P$ where Q_F is the annual number of credit hours demanded by students qualified for admission and P is the per-credit-hour price. Demand for UCLA's evening MBA program is given by the equation $Q_E = 20{,}000 - 20P$ where Q_E is the annual number of credit hours demanded by students qualified for admission and P is the per-credit-hour price.

If UCLA charges the same per-credit-hour price for the MBA offered by its full-time and evening MBA programs, we can obtain the aggregate quantity demanded of credit hours for UCLA's MBA (Q_M) across the two programs. We can do this by horizontally adding up the quantity of credit hours demanded for each program at alternative prices. Therefore, $Q_M = Q_F + Q_E = (20{,}000 - 40P) + (20{,}000 - 20P) = 40{,}000 - 60P$.

In horizontally adding up the full-time and evening MBA demand curves at any price, of course, we must take into account the fact that at all prices above \$500, the quantity demanded of full-time MBA program credit hours is zero. Thus, as shown in Figure 4.7, the aggregate demand curve for the UCLA MBA is the same as the evening MBA demand curve above the price of \$500 ($Q_M = Q_E = 20{,}000 - 20P$ along segment EG). Below \$500, there is full-time MBA program demand, and the aggregate demand curve is obtained by horizontally summing the evening and full-time MBA demand curves

FIGURE 4.7

The Aggregate Demand for a UCLA MBA
The demand for UCLA's evening MBA program is represented by *EE′* while the demand for UCLA's full-time MBA program is represented by *FF′*. The aggregate demand curve for a UCLA MBA across these two programs is *EGH*.



(the segment *GH* of the aggregate demand curve below the price of $500 is given by the equation calculated in the preceding paragraph, $Q_M = Q_F + Q_E = 40{,}000 - 60P$). As Figure 4.7 shows, the aggregate demand for a UCLA MBA across the two programs is equal to *EGH* and is kinked at point G—at the price above which there is no full-time MBA program demand.

In horizontally summing the individual demand curves to obtain the aggregate demand curve, we have assumed that UCLA charges the same price for its MBA in both programs. As we will see in a later chapter, however, this need not be the case. Producers interested in maximizing profit may find it advantageous to focus on individual demand curves rather than the aggregate demand curve. By "segmenting" the aggregate market, producers can charge different prices to the individual demand curve segments that are inversely related to how sensitive those segments are to the price charged.

4.5 CONSUMER SURPLUS

Consumers purchase goods because they are better off (that is, on a higher indifference curve) after the purchase than they were before; otherwise, the purchase would not take place. The term **consumer surplus** refers to the net benefit, or gain, secured by an individual from consuming one market basket instead of another. For example, suppose that around exam time you purchase six cups of espresso coffee per day at $3 per cup from the campus coffeeshop. You have chosen to spend $18 per day on espresso, allocating the rest of your budget to other items. Alternatively, you could choose to not buy espresso, cut your pulse rate in half, and spend the $18 on something else; this is another possible allocation of your budget. Because you clearly feel you are better off by consuming espresso, we say that you secure a consumer surplus from being able to purchase six espressos per day at $3 per cup. We now wish to see how this surplus, or net benefit, can be measured in dollar terms.

CONSUMER SURPLUS
the net benefit or gain from consuming one market basket instead of another

To obtain a measure of consumer surplus associated with espresso purchases, first ask yourself this question: What is the maximum amount you would be willing to pay for six cups per day from the campus coffeeshop during exam time? Your answer will be the **total benefit** (or total value) of the six cups per day. Your total cost is the $18 per day that you pay to the campus coffeeshop for the espressos. The difference between these two sums is the net benefit, or consumer surplus, you receive.

TOTAL BENEFIT
the total value a consumer derives from a particular amount of a good and thus the maximum amount the consumer would be willing to pay for that amount of the good

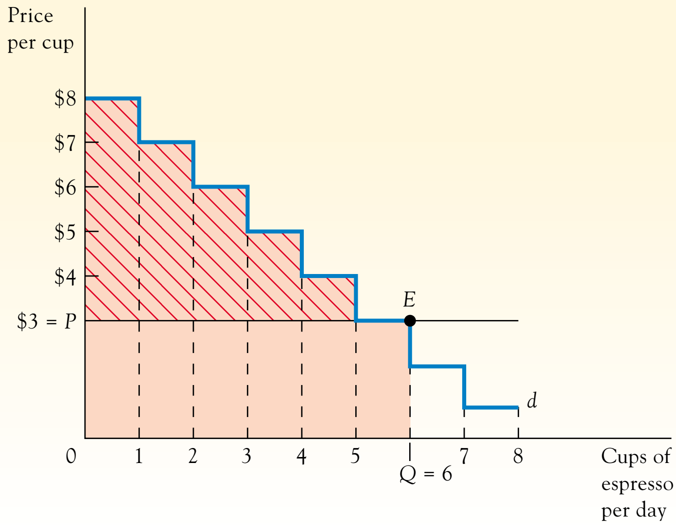
MARGINAL BENEFIT
the incremental value a consumer derives from consuming an additional unit of a good and thus the maximum amount the consumer would pay for that additional unit

The demand curve provides another, and more direct, way to measure consumer surplus. To see how the demand curve relates to consumer surplus, consider how, in our hypothetical example, your demand curve for espresso from the campus coffeeshop is actually generated. To simplify the analysis, let's initially assume that espressos are sold only in uniform unit-cups, and start with a price so high that you wouldn't buy any. We gradually lower the price until you purchase one cup per day—say, when the price reaches $8. Thus, the incremental value, the **marginal benefit**, to you of the first cup is $8; this price is the maximum amount you would pay for the first cup. Because you are willing to pay $8 for the first cup, the $8 reflects the value you place on the first cup; that is, it is a measurement, in dollar terms, of the benefit you derive from the espresso. Lowering the price further, suppose that we find that at a price of $7 you will purchase a second cup; that is, the marginal benefit of the second cup is $7. Consequently, the price at which a given unit will be purchased measures the marginal benefit of that unit to you.

Continuing this process, we can generate your entire daily demand curve for espresso at the campus coffeeshop. In our hypothetical example (where fractions of a cup cannot be purchased), your demand curve is the step-like curve *d* shown in Figure 4.8. The *area* of each of the tall rectangles measures the marginal benefit to you, the consumer, of a specific cup. For instance, the tallest rectangle has an area of $8 ($8 per cup multiplied by one cup, or $8). The marginal benefit of the first cup is $8; of the second, $7; of the third, $6; and so on.

FIGURE 4.8

Consumer Surplus
The total benefit from purchasing six units at a price of $3 per unit is the sum of the six shaded rectangles, or $33. Since the six units involve a total cost of $18, the consumer surplus is $15 and is shown by the striped area.



The *total benefit* of consuming a given quantity is the sum of the marginal benefits. If two cups are consumed, the total benefit is $15, because you would have been willing to pay as much as $8 for the first cup and $7 for the second. By determining the maximum amount you will pay, we can calculate the total benefit of the espresso to you, which is equal to the area under the demand curve up to the quantity purchased.

Now suppose, more realistically, that you can purchase each espresso cup at a price of $3. As a rational consumer, you purchase cups up to the point where the marginal benefit of a cup is just equal to the price. Now compare the total benefit from purchasing six cups at $3 per cup with the total cost:

$$\text{Total benefit} = \text{sum of marginal benefits}$$
$$= \$8 + \$7 + \$6 + \$5 + \$4 + \$3 = \$33.$$

$$\text{Total cost} = \text{sum of cost of each unit}$$
$$= \$3 \times 6 = \$18.$$

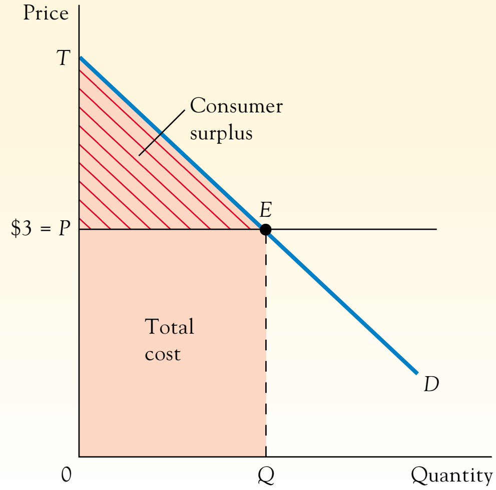
$$\text{Net benefit (consumer surplus)} = \text{total benefit} - \text{total cost}$$
$$= \$15.$$

The total daily benefit of six cups is $33 but you have paid only $18 for the espresso, so a consumer surplus, or a net gain of $15, accrues. Put simply, the consumer surplus is the difference between what you would have been willing to pay for the espresso and what you actually did.

Geometrically, we add the areas of the six rectangles reflecting the marginal benefits; then we subtract the total cost (price times quantity) represented by the area of the large rectangle, *PEQ*0, or $3 times six cups. The area that remains—the striped area in Figure 4.8 between the price line and the demand curve—is the geometric representation of consumer surplus. An alternative way to see that this area measures consumer surplus is to imagine purchasing the units of the good sequentially. The first cup is worth $8, but it costs only $3, so there is a net gain of $5 on that unit; this gain is the first striped rectangle above the price line. The second cup is also purchased for $3, but because you would have been willing to pay as much as $7 for the second cup, there is a net gain of $4 on that cup. (This gain is the second striped rectangle above the price line.) Adding up the excess of benefit over cost on

FIGURE 4.9

Consumer Surplus
With a smooth demand curve, consumer surplus equals area *TEP.*



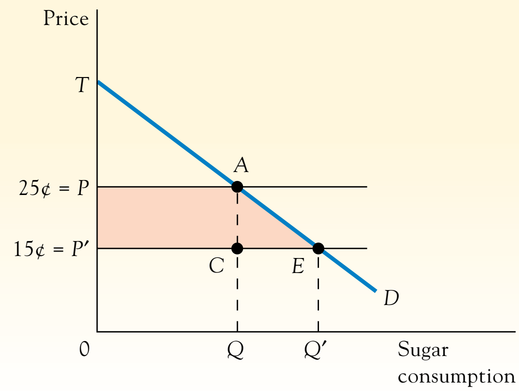
each unit purchased, we have $5 + $4 + $3 + $2 + $1 + $0 = $15, which is shown by the area between the price line and the demand curve. Note that there is no net gain on the last unit purchased. Purchases are expanded up to the point where the marginal benefit of the last unit is exactly equal to the price. Previous units purchased are worth more than their price—which, of course, is why you receive a net gain.

Figure 4.9 shows the same situation, but now we assume that espresso is divisible into small units so that a smooth demand curve *D* can be drawn. We also allow for more than just a single consumer of espresso (thus the uppercase *D* is used to express demand). Indeed, at a price of *P*, we assume that, across all consumers, the total amount of espresso purchased equals *Q*. Consumer surplus is the striped triangular area *TEP* between the demand curve and the price line. It is analogous to the areas of the rectangles above the price line in Figure 4.8, but by letting the width of the rectangles become smaller and smaller (fractional units may be purchased), we now have a smooth line rather than discrete steps. In Figure 4.9, the total benefit from consuming *Q* units is *TEQ*0, the sum of the heights of the demand curve from 0 to *Q*. (Instead of a *rectangular area*, the maximum amount that consumers are willing to pay for a particular unit is represented by the *height of the demand curve at that unit* when the units employed to measure purchases become very small.) The total cost is *PEQ*0, and the difference, *TEP*, is the consumer surplus garnered by all consumers, as a group, of the espresso sold by the campus coffeeshop.

As you might imagine, consumer surplus has many uses. To managers of business firms, consumer surplus indicates the benefits obtained by buyers over and above the prices the buyers are charged. As we will see in a later chapter, many product pricing strategies reflect an effort by firms to capture more of the consumer surplus generated by their products and to convert such surplus into profit.

The concept of consumer surplus can also be used to identify the net benefit of a change in the price of a commodity or in its level of consumption. For example, Figure 4.10 shows the U.S. demand curve for sugar. Suppose that at a price of 25 cents per pound, U.S. buyers purchase *Q* pounds per year. The consumer surplus is given by area *TAP*. Now, due to trade liberalization and the possibility of imports from overseas, suppose that the price falls to 15 cents per pound. How much better off are U.S. buyers because of the decrease in the price of sugar? There are two equivalent ways to arrive at the answer. One is to note that the consumer surplus will be *TEP′* at the lower price, which is greater than the initial consumer sur-

FIGURE 4.10



The Increase in Consumer Surplus with a Lower Price
At a price of 25 cents per pound, consumer surplus is *TAP.* At a price of 15 cents per pound, consumer surplus is *TEP*′. The increase in consumer surplus from the price reduction is thus the shaded area *PAEP*′: this area is a measure of the benefit to consumers of a reduction in the price from 25 to 15 cents.

plus, *TAP*, by the area *PAEP*′. Thus, the area *PAEP*′ is the increase in consumer surplus, and it identifies the net benefit to U.S. buyers from the lower price.

A second way to reach the same answer is to imagine U.S. buyers adjusting to the lower price in two steps. First, total consumption is tentatively held fixed at *Q*. When the price falls, the same *Q* units can be purchased for 10 cents less per pound than before; this amount is equal to area *PACP*′, and it is part of the net benefit from the lower price. Second, the lower price also makes it advantageous for buyers to expand their purchases from *Q* to *Q*′. A second net benefit is associated with this expansion because the marginal benefit of each of these pounds is greater than the per-pound price. For instance, the first pound of sugar beyond *Q* pounds has a marginal benefit of just slightly under 25 cents, but it can be purchased for 15 cents thanks to trade liberalization—a net benefit of about 10 cents for that unit. The net benefit to buyers from expanding their sugar consumption from *Q* to *Q*′ pounds is the area *AEC*. Combining the two areas of net benefit once again yields *PAEP*′ as the net benefit from the lower price.

In later chapters we will see other examples of how the concept of consumer surplus can help us to evaluate the benefits and costs of various economic phenomena.

APPLICATION 4.6 THE CONSUMER SURPLUS ASSOCIATED WITH FREE TV

Until the advent of cable, television was not sold directly to viewers. The price of viewing broadcast programming was zero (apart from the opportunity cost of the viewer's time and the electricity necessary to power the set) for a household with a television and clear reception of the signal. Most of the costs of operating over-the-air networks and stations were, and still are, covered by sales of broadcast time to advertisers.

In the heyday of free television, viewing options were limited but the consumer surplus accruing to viewers was not. In 1968, for example, the average U.S. household had access to three network stations and one independent station. The estimated annual consumer surplus garnered by viewers was $32 billion ($166 billion in 2002 dollars) due to a price of zero for broadcast television.[10] The estimated consumer surplus vastly exceeded the $3.5 billion in advertising revenues earned by all television stations in 1968.

A prominent economic study published in 1973 indicated that an expansion in viewing options, in terms of the consumer surplus generated through such an expansion, would be highly valued. According to the study, a

[10]Roger G. Noll, Merton J. Peck, and John J. McGowan, *Economic Aspects of Television Regulation* (Washington, D.C.: Brookings Institution, 1973).

fourth network would add $4.2 billion in consumer surplus as of 1968 ($22 billion in 2002 dollars). Expansion, however, was precluded by regulations as well as by the fact that it was not technologically feasible to charge viewers for the additional programming.

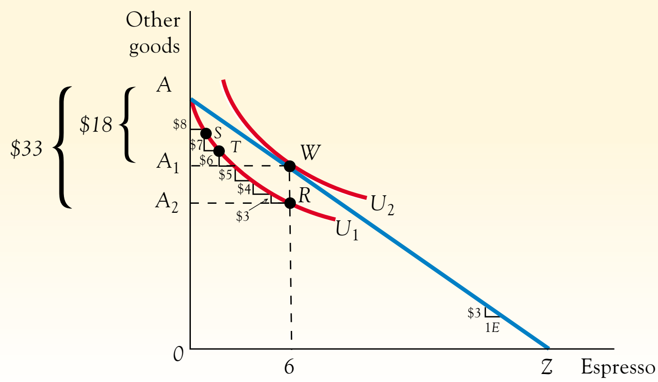
The study's results suggest why cable television has grown so rapidly over the past 35 years. Namely, by figuring out a way to exclude nonpayers and charge subscribers for their service, cable operators have been able to capture some of the television consumer surplus from either existing or newly developed programming and convert it into cable company profits. Television owners have found subscribing to cable attractive because it allows them to expand their viewing options (experiments involving cable systems with up to 500 channels of programming have recently been undertaken), enhanced options that generate consumer surplus. Currently, 69 percent of U.S. households subscribe to cable, and the average subscribing household spends approximately $40 per month on cable. In comparison, the amount of advertising revenues earned by broadcast stations averages roughly $33 per month per household.

Consumer Surplus and Indifference Curves

Consumer surplus can also be represented in our indifference curve and budget line diagrams. Let's return to our original example in which a consumer purchases six cups of espresso at a price of $3 per cup. Figure 4.11 shows the optimal consumption at point *W*, the familiar tangency between an indifference curve and the budget line. Note that the consumer is on a higher indifference curve, U_2, when purchasing six cups of espresso than when buying no espresso at all. If no espresso is bought, the optimal point would be *A* on U_1. The net benefit, or consumer surplus, from purchasing six units is clearly shown by the consumer reaching a higher indifference curve at point *W* than at point *A*.

Thus, the consumer receives a net benefit from purchasing six units instead of none. Now let's try to measure the net benefit in dollar terms. Starting at point *A*, where no espresso is purchased, let's ask this question: What is the maximum amount of money the consumer would give up for six cups of espresso? Paying the *maximum* amount means the consumer will remain on U_1, the original indifference curve, and move down to point *R*, where six units are consumed. Distance AA_2 identifies the maximum amount the consumer would be willing to pay. Note that this amount equals the sum of the amounts that would be paid for each successive unit; that is, in moving from point *A* to point *S*, the consumer would pay $8 for the first unit, $7 for the second unit (*S* to *T*), and so on. The sum of these amounts equals AA_2, or $33. The distance AA_2 measures the *total benefit* from consuming six units, and it corresponds to the area under the demand curve in a demand curve diagram.

FIGURE 4.11



Consumer Surplus and Indifference Curves
The consumer surplus associated with being able to purchase espresso at $3 per cup is shown by the consumer being on U_2 rather than U_1. In dollars, this net gain, or surplus, is the distance *WR*.

Total benefit is AA_2. However, the consumer actually purchases six units at a cost of only AA_1, or $18. The total benefit, AA_2, exceeds total cost, AA_1, by the distance A_1A_2 (also equal to the distance *WR*). The difference between total benefit and total cost—in this case $15—is the consumer surplus from purchasing six cups of espresso at a price of $3 per cup. The consumer surplus can be shown either by the area between the demand curve and the price line or as a vertical distance between indifference curves. Both this diagram and Figure 4.8 therefore show the same thing but from different perspectives.

Note one qualification: Under certain conditions consumer surplus, as measured by the area under a demand curve, is exactly equal to the measure obtained in Figure 4.11. The certain conditions, however, require a special assumption: the income effect of price changes on consumption of the good in question must be zero. This assumption is reflected by the indifference curves being vertically parallel, having the same slope as you move up a vertical line. In Figure 4.11, for example, the slope of U_1 at point *R* is the same as the slope of U_2 at point *W*. When this assumption does not hold, the area under the demand curve is only an approximation of the true measure of consumer surplus. The approximation is still generally close enough for most applications.[11]

4.6 PRICE ELASTICITY AND THE PRICE-CONSUMPTION CURVE

Price elasticity can be computed for any demand curve, whether it is the market demand curve or an individual consumer's curve. Admittedly, the price elasticity of market demand is generally of greatest interest, but that elasticity depends on the underlying elasticities of the demand curves of various consumers. In terms of our treatment of individual demand, we can now show that the slope of the individual's price-consumption curve provides important information about the elasticity of demand.

Figure 4.12 shows four hypothetical price-consumption curves. In Figure 4.12a, the curve slopes downward. This means that the price elasticity exceeds unity; that is, the consumer's demand curve will be elastic if plotted in a price–quantity diagram. A downward-sloping price-consumption curve shows that the consumer's total expenditure on college education rises when the price of such education falls, which, by definition, is an elastic demand. (When demand is elastic, the percentage change in quantity associated with a price change is larger, in absolute value terms, than the percentage change in price. Total expenditure, or price times quantity, thus moves in the same direction as quantity and in the opposite direction from price anytime the price is altered.) Recall that the distance AA_1 shows total expenditure on college education when the price of college education is given by the slope of the budget line *AZ*. (This is because *A*0 represents the consumer's income and $A_1 0$ indicates outlays on all other goods. Thus, AA_1 must represent the amount that is left to spend on college education.) When price falls, the budget line rotates to *AZ*′, and at the new optimal point total expenditure on college education is now AA_2—an increase from the original level.

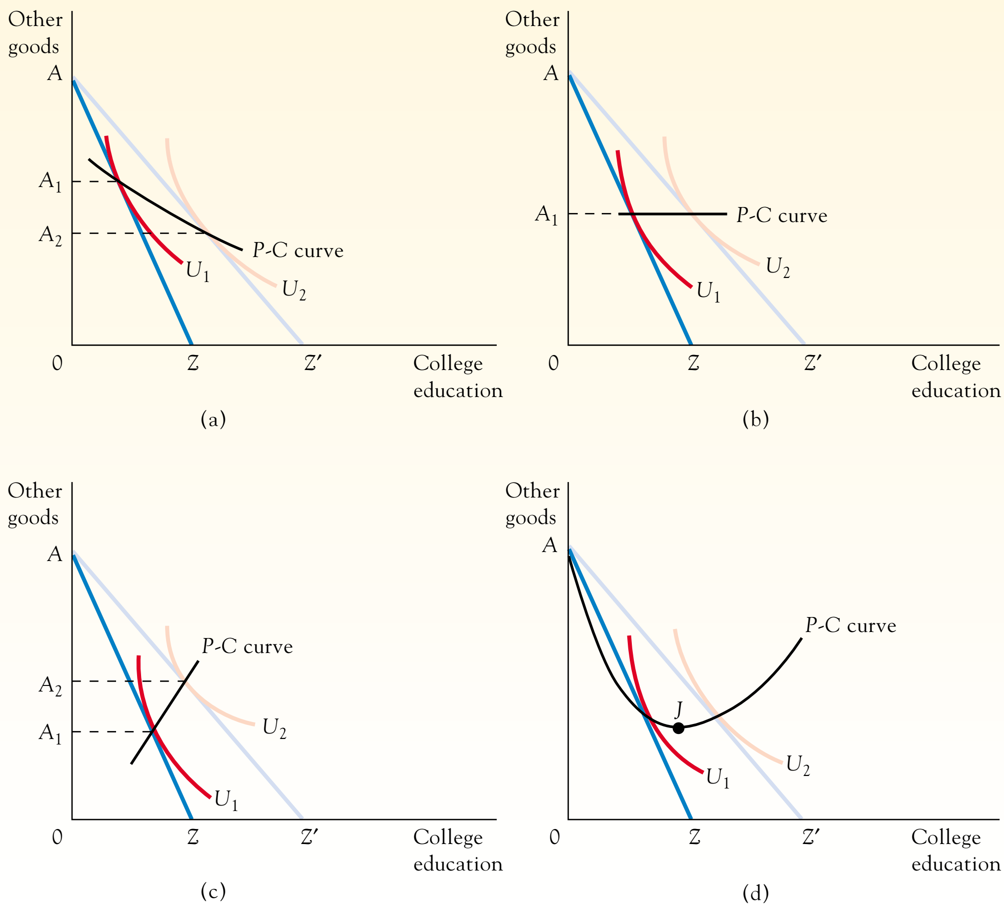
Figures 4.12b and 4.12c show the cases of unit elastic and inelastic demand, respectively. In Figure 4.12b, the price-consumption curve is a horizontal line, showing that total expenditure on college education remains unchanged at AA_1 when the price of college education is varied. This situation is, by definition, one of unit elastic demand. Figure 4.12c has an upward-sloping price-consumption curve. In this case a reduction in price reduces total expenditure on college education, by definition an inelastic demand. Expenditure is initially AA_1 but falls to AA_2 when the price is reduced. Therefore, if the price-consumption curve slopes downward, then the consumer's demand is elastic. If it is horizontal, demand is unit elastic. If it slopes upward, it is inelastic.

[11]Robert D. Willig, "Consumer Surplus Without Apology," *American Economic Review*, 65 (1976), pp. 589–597.

FIGURE 4.12

Price-Consumption Curves and the Elasticity of Demand

The slope of a consumer's price-consumption curve tells us whether demand is elastic, inelastic, or unit elastic. (a) When the price-consumption curve is negatively-sloped, demand is elastic. (b) When it is zero-sloped, demand is unit elastic. (c) When it is positively-sloped, demand is inelastic. (d) When it is U-shaped, demand is elastic at high prices and inelastic at low prices.



Finally, Figure 4.12d shows a U-shaped price-consumption curve. The elasticity of demand varies along this curve. It is elastic along the negatively-sloped *AJ* portion of the curve; becomes unit elastic at point *J*, where the slope of the curve is zero; and is inelastic along the upward-sloping portion of the curve to the right of point *J*. This type of price-consumption curve is probably typical. It begins at point *A* because at a high enough price no college education would be purchased. Thus, it must be negatively-sloped at relatively high prices (implying an elastic demand). On the other hand, there will generally be a finite quantity the consumer would consume even at a zero price, so the price-consumption curve must slope upward at relatively low prices (implying an inelastic demand). Therefore, a consumer's demand curve tends to be elastic at high prices and inelastic at low prices. This knowledge does not help us determine elasticity at a specific price because we don't know whether that specific price is "high" or "low" in this sense.

APPLICATION 4.7 THE P-C CURVE FOR A NON-PC GOOD

Cigarettes are among the leading non-politically correct goods and are fair game, consequently, for many legislators and attorneys. Indeed, juries have slapped tobacco companies with several multibillion punitive damages verdicts in recent years. However, the effect on company profits has been less significant than commonly assumed.[12] The adverse effect on profits has been mitigated partly through payment of the damages being made over a long period of time. For instance, in 1998 cigarette makers settled suits brought by the attorneys general of all 50 states by agreeing to pay the huge-sounding sum of $246 billion. For reasons that we will explain in a later chapter, however, the real cost of these damages is much smaller because the bill is due in installments over 25 years.

More importantly, the effect of the verdicts on profits has been lessened by the ability of companies to raise the extra revenue they need to pay the damages by raising prices. Because the demand for cigarettes is estimated to be inelastic (between 0.3 and 0.5), the relevant *P-C* curve is upward-sloping as in Figure 4.12c, and total expenditures made by consumers on cigarettes increase as the price of cigarettes is raised.

[12]"Yes, $145 Billion Deals Tobacco a Huge Blow, But Not a Killing One," *Wall Street Journal* (July 17, 2000), pp. A1 and A8.

4.7 NETWORK EFFECTS

NETWORK EFFECTS
the extent to which an individual consumer's demand for a good is influenced by other individuals' purchases

BANDWAGON EFFECT
a positive network effect

SNOB EFFECT
a negative network effect

Until now we have assumed that a particular consumer's demand for a good is unrelated to other consumers' demands for the good. However, this need not be the case. To the extent that an individual consumer's demand for a good is influenced by other individuals' purchases, there is a **network effect**. Network effects can be positive or negative. The positive case, or **bandwagon effect**, exists whenever the quantity of a good demanded by a particular consumer is greater the larger the number of other consumers purchasing the same good. The negative case, or **snob effect**, occurs when the quantity of a good demanded by a particular consumer is smaller the larger the number of other consumers purchasing the same good.

The Bandwagon Effect

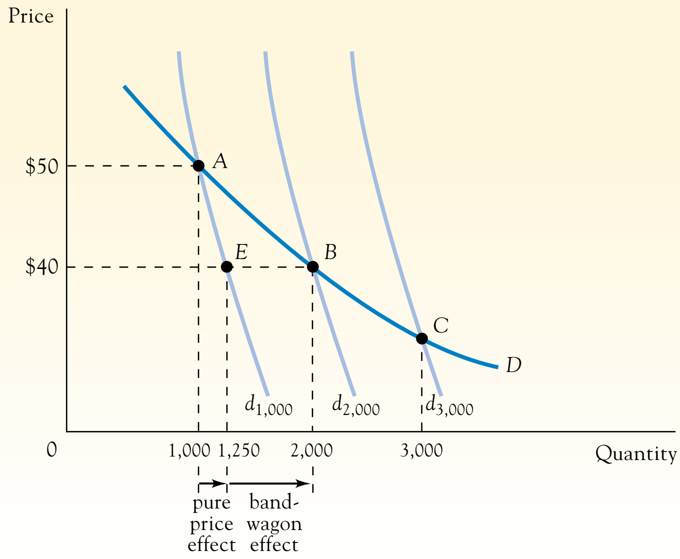
Capitalizing on bandwagon effects is critical to the marketing of some goods. For example, clothing, toy, and food manufacturers realize that their ability to sell certain products to a particular consumer will be enhanced the greater the number of other consumers purchasing the same products. Tommy Hilfiger jeans, Barbie dolls, Pokémon cards, Nike running shoes, and Evian water are all products characterized by such positive network effects. In some cases, the positive network effects stem from consumers' desires to be in fashion and the utility derived from owning popular products. In other cases, a bandwagon effect derives from the fact that the inherent value of a good to a consumer is enhanced by widespread usage of the good among other consumers. Take the case of America Online (AOL). The value of AOL to an individual consumer is increased when other consumers also use AOL if a larger customer base leads to more services, chat rooms, and e-mail contacts. The extent of a business school's alumni network similarly can increase the value of attending the school to a particular applicant. This is because a greater number of alums translates into more connections when the applicant searches for a job after graduating.

Figure 4.13 depicts the case of a bandwagon effect. If consumers believe that only 1,000 people own a good, the demand curve is $d_{1,000}$. If consumers believe that more people own

FIGURE 4.13

Bandwagon Effect

A bandwagon effect leads to greater consumer purchases of a good the more other consumers are believed to desire the same good. The market demand curve, *D*, is more elastic because the bandwagon effect increases the response in quantity demanded to any change in price.



the good and, consequently, the good is more desirable—either because it is in greater fashion or because its inherent value is increased—the demand curve is located farther to the right at any price: $d_{2,000}$ if 2,000 people are believed to own the good; $d_{3,000}$ if 3,000 people are believed to own the good; and so on.

With a bandwagon effect, the market demand curve, *D*, is more price elastic. To see why, suppose that consumers initially are willing to purchase 1,000 units if the price is $50. Now consider a decrease in price from $50 to $40. Without any bandwagon effect, the quantity demanded would increase to 1,250 along curve $d_{1,000}$. The bandwagon effect, however, results from more people purchasing the good at the lower price, and this, in turn, increases the willingness of consumers to purchase the good for its greater fashion or inherent value.

In the case of Figure 4.13, 2,000 units are purchased at a price of $40, and the bandwagon effect accounts for the increase in quantity demanded from 1,250 to 2,000 in response to the decrease in price from $50 to $40. The market demand curve is derived by connecting the points on the curves $d_{1,000}$, $d_{2,000}$, and $d_{3,000}$ corresponding to the quantities 1,000, 2,000, and 3,000. *A*, *B*, and C are the only points consistent with the expected quantities associated with each of the curves. By contrast, point *E*, representing a quantity of 1,250 on the curve $d_{1,000}$, is inconsistent with consumers' beliefs that overall purchases total 1,000 units and thus cannot lie on the market demand curve.

The market demand curve is more elastic that the individual curves $d_{1,000}$, $d_{2,000}$, and $d_{3,000}$ because the bandwagon effect increases the response in quantity demanded to any change in price. In other words, the total response in quantity demanded to a change in price is the sum of the pure price effect and the bandwagon effect. Thus, it exceeds the pure price effect in magnitude.

The Snob Effect

The snob effect is the opposite of the bandwagon effect. It occurs when a consumer is less willing to purchase a good the more widespread its usage. A vintage Jaguar car, an original copy of the Declaration of Independence, a custom-made Versace evening gown, a Picasso painting, and a hand-crafted Piaget watch are all possible examples of goods associated with snob effects. A consumer's valuation of such goods may be greater the more exclusive are the goods, on account of the prestige and admiration derived by the consumer from the goods being selectively owned.

Figure 4.14 depicts a snob effect in the case of vintage Jaguar cars. The relevant demand curves are d_{10}, d_{20}, and d_{30} if consumers believe that only 10, 20, and 30 people, respectively, own a particular model. Note that the demand curve is farther to the right at any given price the more exclusive the ownership of the vintage Jaguar model is believed to be—d_{20} is to the right of d_{30} and d_{10} is to the right of d_{20}. This reflects a snob effect: the quantity of a good demanded by a particular individual falls the more widely owned the good is considered to be by other consumers.

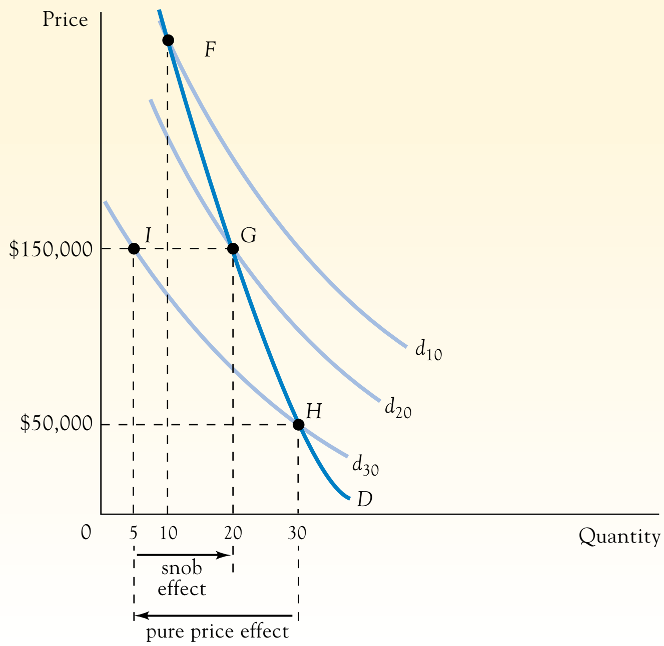
The market demand curve is more inelastic in the case of goods characterized by a snob effect. To see why, note that the market demand curve connects the points on curves d_{10}, d_{20}, and d_{30} associated with the quantities 10, 20, and 30. *F*, *G*, and *H* are the only points consistent with the expected purchases associated with curves d_{10}, d_{20}, and d_{30}. Point *I* cannot lie on the market demand curve because a quantity of 5 is inconsistent with the expectation of 30 purchases associated with d_{30}.

An alternative, and perhaps clearer, way of understanding why the market demand curve is more inelastic in the case of goods characterized by a snob effect is to examine the effect of a price increase, such as from $50,000 to $150,000 in Figure 4.14. The pure price effect of this increase decreases consumption from 30 to 5 vintage Jaguar cars along curve d_{30}. However, the snob effect associated with the enhanced exclusivity resulting from the price increase works to counteract the pure price effect and increases consumption from 5 to 20 units. On net, therefore, the price increase leads to a decrease in the quantity demand from 30 to only 20 units and is less than the decrease associated with the pure price effect. Because the snob effect runs counter to the pure price effect, the market demand curve is less price elastic—the cumulative impact of the pure price and snob effects on quantity demanded is less than the pure price effect.

FIGURE 4.14

Snob Effect

A snob effect leads to smaller consumer purchases of a good the more other consumers are believed to desire the same good. The market demand curve, *D*, is less elastic because the snob effect decreases the response to quantity demanded for any change in price.



APPLICATION 4.8

NETWORK EFFECTS AND THE DIFFUSION OF COMMUNICATIONS TECHNOLOGIES AND COMPUTER HARDWARE AND SOFTWARE

Communications technologies are prime examples of products characterized by positive network effects.[13] As the established user base of telephones, fax machines, the Internet, and e-mail grows, increasingly more individuals find adoption worthwhile. Consequently, such products tend to be characterized by relatively long developmental periods followed by rapid diffusion. Take the case of fax machines, a product that AT&T introduced an introductory version of in 1925. The technology, however, was little used until the mid-1980s, when demand for and supply of fax machines exploded. While ownership of fax machines was negligible prior to 1982, over half of American businesses had at least one fax machine by 1987.

Internet usage has followed a similar pattern. While the first email message was sent in 1969, Internet traffic did not begin to grow substantially until the late 1980s. Once it began to grow, however, it doubled annually in virtually every year after 1989.

Positive network effects are not limited to communications technologies. They are also at the heart of explaining the diffusion of computer software and hardware, where popular systems enjoy a significant competitive advantage over less popular systems. Personal computers provide a telling example. A study of 110,000 American households in 1997 suggests that the rate of adoption of personal computers may have been almost doubled on account of network effects. Moreover, the observed network effects are strongly related to usage of the Internet and e-mail.

Positive network effects also likely have played an important role in the rapid spread of popular computer software programs such as Microsoft's Windows operating system and Office (a combination of word processing, spreadsheet, data base, and presentation programs). Both products quickly acquired shares of over 90 percent of their relevant markets.

Of course, the same positive network effects propelling a product's rapid diffusion can also have adverse legal consequences. For example, the Justice Department's antitrust case against Microsoft hinged critically on the positive network effects fueling Window's success.

The Justice Department alleged that a positive network effect allowed Microsoft to capture a dominant share of the personal computer operating system market. In turn, the built-in customer base gave Microsoft a significant edge in the browser market for its Internet Explorer product over rival Netscape Navigator, said the Justice Department, because, at no extra charge to consumers, Microsoft packaged Internet Explorer with its Windows operating system.

We will explore the Microsoft antitrust case more fully in Chapter 11, but one point that deserves mention here is that positive network effects can be a two-edged sword for suppliers. Although a bandwagon effect enhances the possibility that a supplier will capture a dominant market share, it simultaneously limits the supplier's ability to exploit that position through a price increase. As we saw in Figure 4.13, the market demand curve is more price elastic when there are positive network effects present. In the case of Windows, this implies that Microsoft's ability to exploit, through a price increase, the dominant customer base that a bandwagon effect helped to build is limited by the same bandwagon effect. Should Microsoft attempt to raise Windows' price, customers would run toward alternative operating systems more quickly than they would without the bandwagon effect being present.

[13]This application is based on Carl Shapiro and Hal R. Varian, *Information Rules* (Boston: Harvard Business School Press, 1999); and Austan Goolsbee and Peter J. Klenow, "Evidence on Learning and Network Externalities in the Diffusion of Home Computers," *Journal of Law and Economics*, 45 No. 2 Pt. 1 (October 2002), pp. 317–343.

4.8 THE BASICS OF DEMAND ESTIMATION

Although indifference curves and budget lines together provide an appealing theoretical model of consumer choice, our ability to test the validity of the model and apply it to the real world rests critically on the extent to which we are able to empirically estimate individual consumers' or market demand curves. There are three methods generally relied upon to estimate demand. These are experimentation, surveys, and regression analysis. We briefly outline each of these methods as well as their accompanying pitfalls.

Experimentation

McDonald's will often run a controlled experiment to test how the demand for one of its fast-food items responds to a change in its price or to a change in the price of a complement. For example, McDonald's will select a number of franchises at which the price of french fries is lowered to determine the effect of such a change on Big Mac sandwich sales. Based on the results, the managers can estimate the sensitivity of Big Mac demand to the price of the complement, french fries, and thereby derive a relevant cross-price elasticity of demand.

While a valid mechanism for estimating demand, experimentation carries with it some limitations. Among these is that to run a true, controlled experiment, only one determinant, such as the price of french fries, should be changed at a time to determine its impact on Big Mac sales. Suppose that the price charged by Burger King for its products rises or the local income level falls at the same time that the McDonald's french fries price is altered. If this is the case, McDonald's managers will get a contaminated and unreliable measure of the impact of the price of their french fries on Big Mac sales.

Another limitation is one of generalizability. It may be incorrect to assume that the experimental results obtained in one sample of McDonald's franchises apply to all. The effect on Big Mac sales of a change in the price of french fries may be much different in Ohio than in Osaka, Japan. Experimental results from a sample of Ohio franchises thus may not generalize to those in Osaka.

Surveys

To anticipate the market reaction to a price increase, the Ford Motor Company regularly conducts consumer surveys—either by mail, telephone, or focus groups. A Californian will be contacted by telephone, for instance, and asked about the extent to which her likelihood of purchasing a Taurus automobile over the next 12 months will be diminished if the price is raised by $400.

As with experimentation, customer surveys can generate valuable information. They are not, however, foolproof. As with experimentation, one must be careful to choose a representative sample. A good example of what can happen if this rule is not heeded involves one of the first U.S. presidential polls—a survey taken prior to the 1936 election that predicted Republican Alf Landon would crush Democrat Franklin Delano Roosevelt. The exact opposite occurred. The poll surveyed citizens whose names had been taken from telephone directories and automobile registration rolls. Since the rich were more likely to have telephones and cars in 1936 and were also more likely to be Republican, the poll was based on a nonrepresentative sample of the voting population.

Furthermore, a survey's reliability is dependent on respondents telling the truth. For example, there is considerable evidence that polls will not accurately predict election results where political candidates and voters are of different ethnic backgrounds. While those surveyed say they will vote for a candidate whose ethnicity is different from their own, once in the privacy of the voting booth they are more likely to pull the lever for a candidate similar to themselves.

Perhaps the classic case of misreporting by respondents involves the story of a researcher who surveyed Americans regarding their sex lives. According to the research, there was a significant difference between the number of sexual partners that males and females in the sample reported having over their lifetimes. Men reported an average of fourteen female sex partners. Women responded that they had four male sex partners. The samples, moreover, appeared to be representative.

While the difference in the averages across the genders may at first blush appear provocative, some further thought should convince you that, from a statistical perspective, there cannot be such a difference. The averages for both genders should be identical. After all, every time heterosexual intercourse occurs with a new partner it should raise both genders' averages equally—regardless of how the averages are distributed within each gender.

Which gender is not telling the truth? Probably both of them. In response to this particular question, men likely have a tendency to overstate whereas women may undercount. If this is the case, the true, common average falls in between.

Regression Analysis

REGRESSION ANALYSIS (ECONOMETRICS) a statistical method that allows one to estimate, among other things, the sensitivity of the quantity demanded of a good to determinants such as price and income

Private and public decisionmakers regularly rely on existing data to statistically estimate demand. To see how this is done, suppose that you operate cable systems in 10 equal-sized communities (10,000 homes in each community). The systems are characterized by the data in Table 4.1. The quantity demanded of your basic tier service (Q) is represented by the number of basic tier subscribers in each community—where the basic tier features retransmitted local broadcast signals and other networks such as ESPN, MTV, and CNN. The other columns in Table 4.1 reflect the monthly basic tier price charged in each community (P), the monthly per capita income level of a community's residents (I), and the monthly price charged per additional pay tier ($PPAY$) such as HBO and Cinemax.

To determine whether it would be profitable to raise or lower basic tier prices, you would want to know how sensitive basic service demand is to its price, holding constant other determinants such as per capita income and the pay tier price. **Regression analysis**, also called **econometrics**, is a statistical method that allows you to estimate this sensitivity based on existing data. It begins by assuming that we can specify an equation for the underlying data and that the data do not "fit" the equation perfectly.

TABLE 4.1 CABLE DEMAND DATA

System Number	Basic Tier Subscribers (Q)	Basic Tier Price (P)	Per Capita Income (I)	Pay Tier Price ($PPAY$)
1	3,300	$18	$3,900	$22
2	6,600	10	5,560	10
3	3,900	18	8,900	18
4	5,000	14	8,200	16
5	5,100	15	7,950	10
6	6,900	9	6,500	7
7	6,400	12	5,900	8
8	5,900	13	7,500	15
9	5,800	12	7,864	12
10	4,800	18	4,500	12
Average	5,370	$13.90	$6,677.40	$13

Take the case of the information in Table 4.1. Let us start by supposing that only P influences Q and that the demand for basic cable in a community is best described by the following linear relationship:

$$Q_i = a + bP_i + e_i; \quad (1)$$

where the subscript i refers to the number of the system or the "observation" being considered. The variable Q that the equation is seeking to explain is called the dependent variable. Any variable such as P employed to explain the dependent variable is called an explanatory variable. The error term, e, is included in the equation to account for either mistakes in data collection; determinants of demand other than P that are inadvertently or, due to a lack of data, intentionally omitted from the relationship; or the possibility that the demand for basic cable is, to a certain extent, random and thus not predictable by economic models. The term a is the intercept of the linear equation—the number of subscribers a system will have if the basic price and the error term equal zero. And b, the coefficient on the basic tier price, indicates by how much the number of subscribers will change per dollar change in the basic tier price ($b = \Delta Q/\Delta P$).

ORDINARY LEAST-SQUARES (OLS)
a technique for estimating the equation that "best fits" the data

Regression analysis usually employs the **ordinary least-squares** or **OLS** technique to estimate equations such as the one we have specified for the demand for basic cable. OLS estimates the "best fitting" intercept and coefficient for the specified relationship and the employed data. *Best fitting* means that the estimated equation will be "as close as possible" to the observed data points. The technical criterion for "as close as possible" involves the distances between the various data points and the estimated equation.

The specific manner in which OLS determines the equation that best fits the data is beyond the scope of this book.[14] Suffice it to say that the intercept and coefficient estimated by OLS (where estimated is signified with a "^" as in $\hat{a}$ and $\hat{b}$) serves to minimize the distances between the data points and the estimated equation. The distances between the data points and the estimated equation represent the errors made by the estimated equation across the various data points.

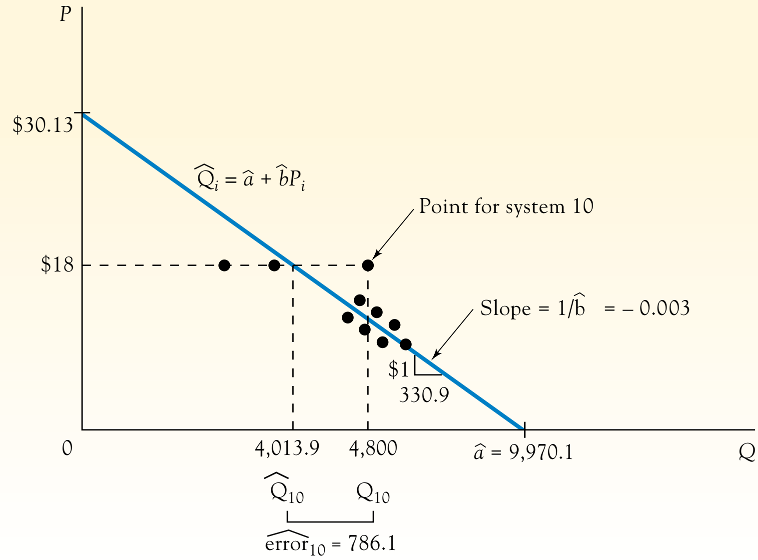
Figure 4.15 graphically depicts how OLS regression works. In the simple demand relationship assumed by equation (1), the intercept and coefficient for the estimated equation that best fits the data across the ten systems turn out to be $\hat{a} = 9{,}970.1$ and $\hat{b} = -330.9$, respectively. The intercept estimate $\hat{a}$ implies that for the sample examined and the demand relationship assumed, if price were set equal to 0, the forecast number of basic subscribers, $\hat{Q}$, would be 9,970.1. The coefficient estimate $\hat{b}$ means that for every \$1 increase in the monthly basic tier price, the number of basic subscribers decreases by 330.9 ($\hat{b} = \Delta Q/\Delta P$). The slope of the estimated regression line is $\Delta P/\Delta Q$ and thus equals $1/\hat{b} = -0.003$.

The dots in Figure 4.15 represent the actual prices and quantities of the 10 systems in our sample. For the tenth system, for example, the price, P_{10}, is \$18 and the number of basic subscribers, Q_{10}, is 4,800. The OLS-estimated number of basic subscribers for the tenth system, $\hat{Q}_{10}$, is equal to the value obtained for Q when one plugs in the tenth system's price into the estimated regression line. Thus, $\hat{Q}_{10} = 9{,}970.1 - 330.9(18) = 4{,}013.9$. The error made by OLS in estimating demand for the tenth system, $\hat{e}_{10}$, is the difference between the actual and forecast number of basic subscribers and equals 786.1 ($Q_{10} - \hat{Q}_{10} = \hat{e}_{10} = 786.1$). The OLS regression has calculated $\hat{a}$ and $\hat{b}$ so as to minimize the sum of the squares of such errors across the ten systems in the sample. From the perspective of Figure 4.15, OLS positions the regression line, $\hat{a} + \hat{b}P_i$, so as to best fit the scatterplot of data points—where the "fit" reflects the horizontal distances of the observed data points from the estimated equation.

[14]Most beginning econometrics texts explore the derivation of the intercept and coefficients through OLS in considerable detail. So long as you understand the intuition behind their derivation, that will suffice for the material in our book.

FIGURE 4.15

Ordinary Least-Squares Regression
Ordinary least-squares positions the regression line, $\hat{Q}_i = \hat{a} + \hat{b}P_i$, so as to "best fit" the sample data points.



The estimated OLS equation provides valuable demand-side information. For instance, if we wanted to calculate the elasticity of demand for basic cable service at the average basic tier price and number of basic subscribers in our sample we would use the now-familiar formula:

$$\eta = (\Delta Q/\Delta P)(\overline{P}/\overline{Q});$$

where $\overline{P}$ and $\overline{Q}$ are the average basic tier price and number of subscribers, respectively, for the sample. The first part of the right-hand side of the elasticity formula, $\Delta Q/\Delta P$, is the rate at which the number of a system's subscribers changes per dollar change in the basic price. This is none other than the $\hat{b}$ or −330.9 estimated by OLS. Employing the average values for P and Q reported in Table 4.1, one obtains an elasticity of demand of 0.9. Since this is less than unity, demand for basic cable is inelastic when evaluated at the price and number of subscribers for the average system in the sample. This indicates that profit could be increased by raising the average basic price.

Suppose that we estimated a more extensive basic cable demand relationship, such as:

$$Q_i = a + bP_i + cI_i + dPPAY_i + e_i. \qquad (2)$$

This more extensive model tries to control explicitly for more of the factors that might affect demand for basic cable. OLS regression proceeds in a fashion analogous to the one employed in estimating the simpler equation (1). OLS calculates the intercept $\hat{a}$ and coefficients $\hat{b}$, $\hat{c}$, and $\hat{d}$ so as to best fit the observed data—now incorporating information on income, I, and the price of pay tier service, $PPAY$, in the estimation process. In this more extensive model, the estimated coefficient $\hat{c}$ measures the independent effect of a $1 increase in per capita income on the number of basic subscribers in a community. Its value indicates whether basic cable is a normal or an inferior good across the systems in the sample. The estimated coefficient $\hat{c}$ associated with the pay tier price variable, $PPAY$, reflects the impact of a $1 increase in the pay tier price on the demand for basic cable, holding constant the basic tier price and the per capita income level. It tells us whether pay service is a complement or substitute for basic cable in our sample of systems.

Controlling explicitly for more variables can affect the estimate of the effect of basic price on the demand for basic service. When equation (2) is estimated, $\hat{a} = 9{,}931.0$, $\hat{b} = -230.0$, $\hat{c} = -0.01$, and $\hat{d} = -99.5$. By comparison, the estimated basic price coefficient, $\hat{b}$, was larger in magnitude when equation (1) was used. Use of equation (2) rather than equation (1) causes the estimated demand elasticity to fall as well. This is probably a truer estimate of the elasticity because it controls for additional causal factors.

We close this chapter by noting that while regression analysis is a powerful tool allowing one to estimate the effects of individual determinants on demand while holding constant other determinants' effects, it also has its difficulties. For one, the intercepts and coefficients estimated by OLS regression are only as good as the data and the models to which the analysis is applied. "Garbage in, garbage out," as the saying goes. If the sample data are nonrepresentative of the larger population or if the assumed demand relationship is incorrect (for example, linear when it should be nonlinear), unreliable estimates will result.

Application 4.9 Demand Estimation: McDonald's Versus Burger King

McDonald's makes extensive use of regression analysis in determining where to locate franchises. Sales are estimated for any possible location as a function of factors such as the prices that will be charged; demographics (including the surrounding community's income level, average family unit size, and ethnic composition); the availability of substitutes; traffic flows; and the side of the street on which the franchise will be located (sales are higher if a franchise is on the side of the street with the heaviest home-bound traffic at day's end).

By contrast, McDonald's rival Burger King has a smaller demand forecasting staff and often relies on a different, much simpler mechanism for determining franchise locations. Burger King waits for McDonald's to make the first move. After McDonald's statistically determines that a location will be profitable and begins operations on that site, Burger King opens up its own franchise nearby.

Summary

- By rotating the budget line confronting a consumer, we can determine the market basket the consumer will select at different prices, while factors such as income, preferences, and the prices of other goods are held constant. The various price–quantity combinations identified in this way can be plotted as the consumer's demand curve.
- To determine whether a demand curve must have a negative slope, we separate the effect of a change in price on quantity demanded into two components, an income effect and a substitution effect.
- For a normal good, both income and substitution effects imply greater consumption at a lower price. Thus the demand curve for a normal good must slope downward.
- For an inferior good, the income and substitution effects of a price change operate in opposing directions. If the income effect is larger, the demand curve will slope upward. However, both theoretical reasoning and empirical evidence suggest this case is quite rare.
- Consumer surplus is a measure of the net benefit a consumer receives from consuming a good. It is shown graphically by the area between the consumer's demand curve and the price line.
- Consumer surplus can also show the benefit or cost a consumer receives as a result of a change in the price of the good.
- Individual consumers' demand curves can be aggregated to obtain the market demand.

- The price-consumption curve provides important information about an individual's elasticity of demand.
- An individual consumer's purchases of a good may be influenced by other individuals' purchases through network effects.
- Three methods allow us to estimate individuals' or market demand curves: experimentation, surveys, and regression analysis or econometrics.

REVIEW QUESTIONS AND PROBLEMS

Questions and problems marked with an asterisk have solutions given in Answers to Selected Problems at the back of the book (pages xxx–xxx).

4.1. Explain how the indifference curve and budget line apparatus are used to derive a consumer's demand curve. For a demand curve, certain things are held constant. What are they, and how does this approach hold them constant?

4.2. If the per-unit price of college education rises and the prices of all other items fall, is it possible for the consumer to end up on the same indifference curve as before the price changes? If so, will the consumer be purchasing the same market basket? Support your answer with a diagram.

4.3. "A Giffen good must be an inferior good, but an inferior good need not be a Giffen good." Explain this statement fully, using the concepts of income and substitution effects.

***4.4.** Assume that Joe would like to purchase 50 gallons of gasoline monthly at a price of $1.50 per gallon. However, the $1.50 price is the result of a government price ceiling, so there is a shortage, and Joe can only get 25 gallons. Show what this situation looks like by using indifference curves and a budget line. Then, show that Joe will be willing to pay a price higher than $1.50 to get additional units of gasoline. (This result is the demand-side reason for the emergence of a black market.)

4.5. Delores has a different price-consumption curve associated with each possible income level. If two of these curves intersect, are Delores' preferences rational?

***4.6.** If Edie's income rises by 50 percent and, simultaneously, the price of automobile maintenance increases by 50 percent, can we predict how Edie's consumption of automobile maintenance will be affected? Can we predict how, on average, Edie's consumption of other goods will be affected? Use the concepts of income and substitution effects to answer this question.

4.7. Assume that Dan's income-consumption curve for potatoes is a vertical line when potatoes are on the horizontal axis. Show that Dan's demand curve for potatoes must be downward-sloping.

4.8. Given the OLS estimates for the coefficient and intercept in the basic tier cable demand equation (1), calculate the point demand elasticity for system number 7.

4.9. Given the OLS estimates for the coefficients and intercept in the basic tier cable demand equation (2), calculate the following:

a. Income elasticity of demand for basic service evaluated at the average values for monthly per capita income and the number of basic subscribers across the sample of ten systems. Based on your calculation, is basic cable a normal or an inferior good?

b. Cross-price elasticity of demand for basic service with respect to the pay tier price evaluated at the average values for the pay tier price and the number of basic subscribers across the 10 systems in the sample. Based on your calculation, is pay tier service a substitute or a complement for basic service?

c. The income elasticity of demand for basic service evaluated at the income and quantity data for system number 3.

4.10. Suppose that Lorena consumes only three different goods: steak knives, butter knives, and butcher knives. If, according to Lorena's preferences, butter and butcher knives are inferior goods, must steak knives be a normal good? Explain your answer.

4.11. Suppose that there are only five consumers of a software game program. The demand curve for each of the consumers is identical. Will the market demand curve that is obtained by horizontally summing across the five individual consumers' demand curves be less or more price elastic at any price than the demand curve for any of the individual consumers?

4.12. Suppose that the Downtown Athletic Club increases its monthly membership charge from $150 to $200. Among the businesspeople belonging to the Club, would you expect lower-level business managers to be more sensitive to the price increase than senior managers? Explain using indifference curves.

4.13. Suppose that George is interested in only two goods, cigars and scotch. Employ the indifference curve/budget line apparatus to show a case where a decrease in the price of cigars leads to an increase in George's scotch consumption. Does this imply that cigars and scotch are complements to George? Explain your answer.

4.14. Repeat the preceding question but assume that a decrease in the price of cigars leads to a decrease in George's scotch consumption. Does this imply that scotch is an inferior good in George's case?

4.15. In the tax-plus-rebate example discussed in the text, suppose that the government adjusts the size of the rebate so that the consumer stays on her initial indifference curve (U_2 in Figure 4.4). Show the results in a diagram. Can the government achieve this result for all consumers? Why or why not?

***4.16.** When the price of gasoline in Italy is $5 per gallon, Fabio consumes 1,000 gallons per year. The price rises to $5.50 and, to offset the harm to Fabio, the Italian government gives him a cash transfer of $500 a year. Will Fabio be better or worse off after the price rise plus transfer? What will happen to his gasoline consumption?

4.17. Left and right shoes are perfect complements for most people. If only the price of right shoes increased, what would be the substitution effect of such a price change on the typical consumer's consumption of right shoes (assume that the only two goods that the consumer cares about are right and left shoes)? What about the income effect?

4.18. If Clint's elasticity of demand for cigars is equal to zero, are cigars a normal or an inferior good for Clint? Explain.

4.19. Define consumer surplus, and explain how you would show it in a diagram containing a demand curve for some product. What would consumer surplus equal in Figure 4.8 if the demand was perfectly elastic at the market price of $3 per espresso cup?

4.20. Diamonds clearly satisfy less important needs than water, which is essential to life. Yet according to market prices, the essential commodity, water, is worth less than the less essential commodity, diamonds. Why would a vital commodity such as water sell for so much less than diamonds? Does this imply that there is something wrong with a market system that values diamonds more than water? Explain using demand and supply curves for water and diamonds. In your explanation, distinguish between the marginal and total benefit of the two commodities.

4.21. Noneconomists sometimes refer to medical care as "invaluable" or "priceless." Do you think these terms may be simply imprecise ways of saying that the consumer surplus associated with medical care is very large? Suppose that the consumer surplus is immense. Explain why this is irrelevant in deciding whether to provide more medical care. What is relevant?

4.22. "The price of water is a measure of water's marginal benefit to consumers." Is this statement true for all consumers of water? If a government price ceiling is set below the equilibrium price, will the price equal the marginal benefit of water?

4.23. Could the snob effect ever overpower the combined substitution and income effects associated with an increase in the price of a good? Explain why or why not.

4.24. Explain how a bandwagon effect might speed up the rate at which DVD players are adopted by consumers. Do likewise for the case of cable television subscriptions.

4.25. Suppose that the *P-C* curve associated with a pharmaceutical drug is downward-sloping. If the government underwrites a certain percentage of consumers' drug purchases, will the government outlays associated with such a program be greater the larger the percentage of the purchases underwritten? Explain why or why not. What if the *P-C* curve is upward-sloping?

4.26. During the 1970s, 55 percent of banks with more than 15 branches installed atomated teller machines (ATMs), as opposed to 16 percent of banks with only 2 branches. Explain why this phenomenon attests to the presence of positive network effects.

4.27. If the price of hamburger is increased and a consumer's quantity demanded of hamburger decreases, the income effect is smaller than the substitution effect. True, false, or uncertain? Explain.

4.28. Every market generates at least some consumer surplus and the amount generated depends critically on the prevailing price. True, false, or uncertain? Explain.