5 CHAPTER

Applying Consumer Theory

I have enough money to last me the rest of my life, unless I buy something. —Jackie Mason

We used consumer theory in Chapter 4 to show how a consumer chooses a bundle of goods, subject to a budget constraint, so as to maximize happiness. Here we apply consumer theory to derive demand curves and examine their properties.

We start by using consumer theory to show how to determine the shape of a demand curve for a good by varying the price of a good, holding other prices and income constant. Firms use information about the shape of demand curves when setting prices. Governments apply this information in predicting the impact of policies such as taxes and price controls.

We then use consumer theory to show how an increase in income causes the demand curve to shift. Firms use information about the relationship between income and demand to predict which less-developed countries will substantially increase their demand for the firms' products.

Next, we show that an increase in the price of a good has two effects on demand. First, consumers would buy less of the now relatively more expensive good even if they were compensated with cash for the price increase. Second, consumers' incomes can't buy as much as before because of the higher price, so consumers buy less of at least some goods.

We use this analysis of these two demand effects of a price increase to show why the government's measure of inflation, the Consumer Price Index (CPI), overestimates the amount of inflation. Because of this bias in the CPI, some people gain and some lose from contracts that adjust payment on the basis of the government's inflation index. If you signed a long-term lease for an apartment in which your rent payments increase over time in proportion to the change in the CPI, you lose and your landlord gains from this bias.

Finally, we show how we can use the consumer theory of demand to determine an individual's labor *supply* curve. Knowing the shape of workers' labor supply curves is important in analyzing the effect of income tax rates on work and on tax collections. Many politicians, including Presidents John F. Kennedy, Ronald Regan, and George W. Bush, have argued that if the income tax rates were cut, workers would work so many more hours that tax revenues would increase. If so, everyone could be made better off by a tax cut. If not, the deficit could grow to record levels. Economists use empirical studies based on consumer theory to predict the effect of the tax rate cut on tax collections, as we discuss at the end of this chapter.

1. **Deriving demand curves:** We use consumer theory to derive demand curves, showing how a change in price causes a shift along a demand curve.
2. **How changes in income shift demand curves:** We use consumer theory to determine how a demand curve shifts because of a change in income.
3. **Effects of a price change:** A change in price has two effects on demand, one having to do with a change in relative prices and the other concerning a change in the consumer's opportunities.
4. **Cost-of-living adjustments:** Using this analysis of the two effects of price changes, we show that the CPI overestimates the rate of inflation.
5. **Deriving labor supply curves:** Using consumer theory to derive the demand curve for leisure, we can derive workers' labor supply curves and use them to determine how a reduction in the income tax rate affects labor supply and tax revenues.

In this chapter, we examine five main topics

5.1 DERIVING DEMAND CURVES

We use consumer theory to show by how much the quantity demanded of a good falls as its price rises. An individual chooses an optimal bundle of goods by picking the point on the highest indifference curve that touches the budget line (Chapter 4). When a price changes, the budget constraint the consumer faces shifts, so the consumer chooses a new optimal bundle. By varying one price and holding other prices and income constant, we determine how the quantity demanded changes as the price changes, which is the information we need to draw the demand curve. After deriving an individual's demand curve, we show the relationship between consumer tastes and the shape of the demand curve, which is summarized by the elasticity of demand (Chapter 3).

We derive a demand curve using the information about tastes from indifference curves (see Appendix 4B for a mathematical approach). To illustrate how to construct a demand curve, we estimated a set of indifference curves between wine and beer, using data for American consumers. Panel a of Figure 5.1 shows three of the estimated indifference curves for a typical U.S. consumer, whom we call Mimi.[1] These indifference curves are convex to the origin: Mimi views beer and wine as imperfect substitutes (Chapter 4). We can construct Mimi's demand curve for beer by holding her budget, her tastes, and the price of wine constant at their initial levels and varying the price of beer.

The vertical axis in panel a measures the number of gallons of wine Mimi consumes each year, and the horizontal axis measures the number of gallons of beer she drinks per year. Mimi spends $Y = \$419$ per year on beer and wine. The price of beer, p_b, is \$12 per unit, and the price of wine, p_w, is \$35 per unit.[2] The slope of her budget line, L^1, is $-p_b/p_w = -12/35 \approx -\frac{1}{3}$. At those prices, Mimi consumes bundle e_1, 26.7

[1]My mother, Mimi, wanted the most degenerate character in the book named after her. She and I hope that you do not consume as much beer or wine as the typical American in this example.

[2]To ensure that the prices are whole numbers, we state the prices with respect to an unusual unit of measure (not gallons).

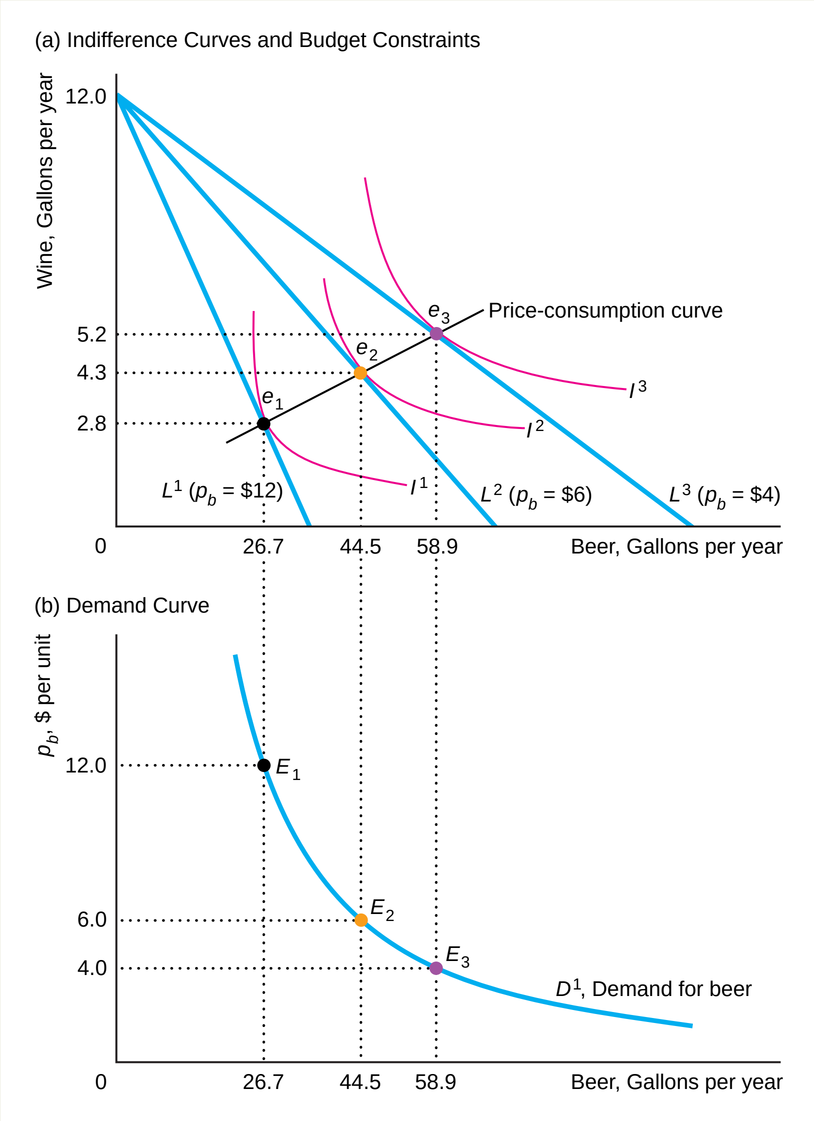


Figure 5.1 Deriving an Individual's Demand Curve. If the price of beer falls, holding the price of wine, the budget, and tastes constant, the typical American consumer buys more beer, according to our estimates. (a) At the actual budget line, L^1, where the price of beer is \$12 per unit and the price of wine is \$35 per unit, the average consumer's indifference curve I^1 is tangent at Bundle e_1, 26.7 gallons of beer per year and 2.8 gallons of wine per year. If the price of beer falls to \$6 per unit, the new budget constraint is L^2, and the average consumer buys 44.5 gallons of beer per year and 4.3 gallons of wine per year. (b) By varying the price of beer, we trace out the individual's demand curve, D_1. The beer price-quantity combinations E_1, E_2, and E_3 on the demand curve for beer in panel b correspond to optimal Bundles e_1, e_2, and e_3 in panel a.

gallons of beer per year and 2.8 gallons of wine per year, a combination that is determined by the tangency of indifference curve I^1 and budget line L^1.[3]

If the price of beer falls in half to \$6 per unit, while the price of wine and her budget remain constant, Mimi's budget line rotates outward to L^2. If she were to spend all her money on wine, she could buy the same 12 (≈ 419/35) gallons of wine per year as before, so the intercept on the vertical axis of L^2 is the same as for L^1. However, if she were to spend all her money on beer, she could buy twice as much as before (70 instead of 35 gallons of beer), so L^2 hits the horizontal axis twice as far from the origin as L^1. As a result, L^2 has a flatter slope than L^1, about $-\frac{1}{6}$ (≈ −6/35). The slope is flatter because the price of beer has fallen relative to the price of wine.

Because beer is now relatively less expensive, Mimi drinks relatively more beer. She chooses Bundle e_2, 44.5 gallons of beer per year and 4.3 gallons of wine per year, where her indifference curve I^2 is tangent to L^2. If the price of beer falls again, say, to \$4 per unit, Mimi consumes Bundle e_3, 58.9 gallons of beer per year and 5.2 gallons of wine per year.[4] The lower the price of beer, the happier Mimi is because she can consume more on the same budget: She is on a higher indifference curve (or perhaps just higher).

Panel a also shows the *price-consumption curve*, which is the line through the equilibrium bundles, such as e_1, e_2, and e_3, that Mimi would consume at each price of beer, when the price of wine and Mimi's budget are held constant. Because the price-consumption curve is upward sloping, we know that Mimi's consumption of both beer and wine increases as the price of beer falls.

We can use the same information in the price-consumption curve to draw Mimi's demand curve for beer, D^1, in panel b. Corresponding to each possible price of beer on the vertical axis of panel b, we record on the horizontal axis the quantity of beer demanded by Mimi from the price-consumption curve.

Points E_1, E_2, and E_3 on the demand curve in panel b correspond to Bundles e_1, e_2, and e_3 on the price-consumption curve in panel a. Both e_1 and E_1 show that when the price of beer is \$12, Mimi demands 26.7 gallons of beer per year. When the price falls to \$6 per unit, Mimi increases her consumption to 44.5 gallons of beer, point E_2. The demand curve, D^1, is downward sloping as predicted by the Law of Demand.

We can use the relationship between the points in panels a and b to show that Mimi's utility is lower at point E_1 on D^1 than at point E_2. Point E_1 corresponds to Bundle e_1 on indifference curve I^1, whereas E_2 corresponds to Bundle e_2 on indifference curve I^2, which is farther from the origin than I^1, so Mimi's utility is higher at E_2 than at E_1. Mimi is better off at E_2 than at E_1 because the price of beer is lower at E_2, so she can buy more goods with the same budget.

[3]These figures are the U.S. average annual per capita consumption of wine and beer. These numbers are startlingly high given that they reflect an average over teetotalers and (apparently heavy) drinkers. According to a 2002 Organization for Economic Cooperation and Development report, alcohol consumption in liters per capita for people 15 years and older was 8.3 in the United States compared to 4.6 Mexico, 5.6 Norway, 6.3 Iceland, 7.7 Canada, 8.7 Italy, 8.8 New Zealand, 9.8 Australia, 10.0 Netherlands, 10.2 United Kingdom, 10.5 Germany, 11.2 Switzerland, 11.8 Czech Republic, 12.3 Ireland, 12.9 France, 13.0 Portugal, and 14.9 Luxembourg.

[4]These quantity numbers are probably higher than they would be in reality because we are assuming that Mimi continues to spend the same total amount of money on beer and wine as the price of beer drops.

5.2 HOW CHANGES IN INCOME SHIFT DEMAND CURVES

To trace out the demand curve, we looked at how an increase in the good's price—holding income, tastes, and other prices constant—causes a downward *movement along the demand curve*. Now we examine how an increase in income, when all prices are held constant, causes a *shift of the demand curve*.

Businesses routinely use information on the relationship between income and the quantity demanded. For example, in deciding where to market its products, Whirlpool wants to know which countries are likely to spend a relatively large percentage of any extra income on refrigerators and washing machines.

Effects of a Rise in Income

We illustrate the relationship between the quantity demanded and income by examining how Mimi's behavior changes when her income rises, while the prices of beer and wine remain constant. Figure 5.2 shows three ways of looking at the relationship between income and the quantity demanded. All three diagrams have the same horizontal axis: the quantity of beer consumed per year. In the consumer theory diagram, panel a, the vertical axis is the quantity of wine consumed per year. In the demand curve diagram, panel b, the vertical axis is the price of beer per unit. Finally, in panel c, which shows the relationship between income and quantity directly, the vertical axis is Mimi's budget, Y.

A rise in Mimi's income causes the budget constraint to shift outward in panel a, which increases Mimi's opportunities. Her budget constraint L^1 at her original income, Y = \$419, is tangent to her indifference curve I^1 at e_1.

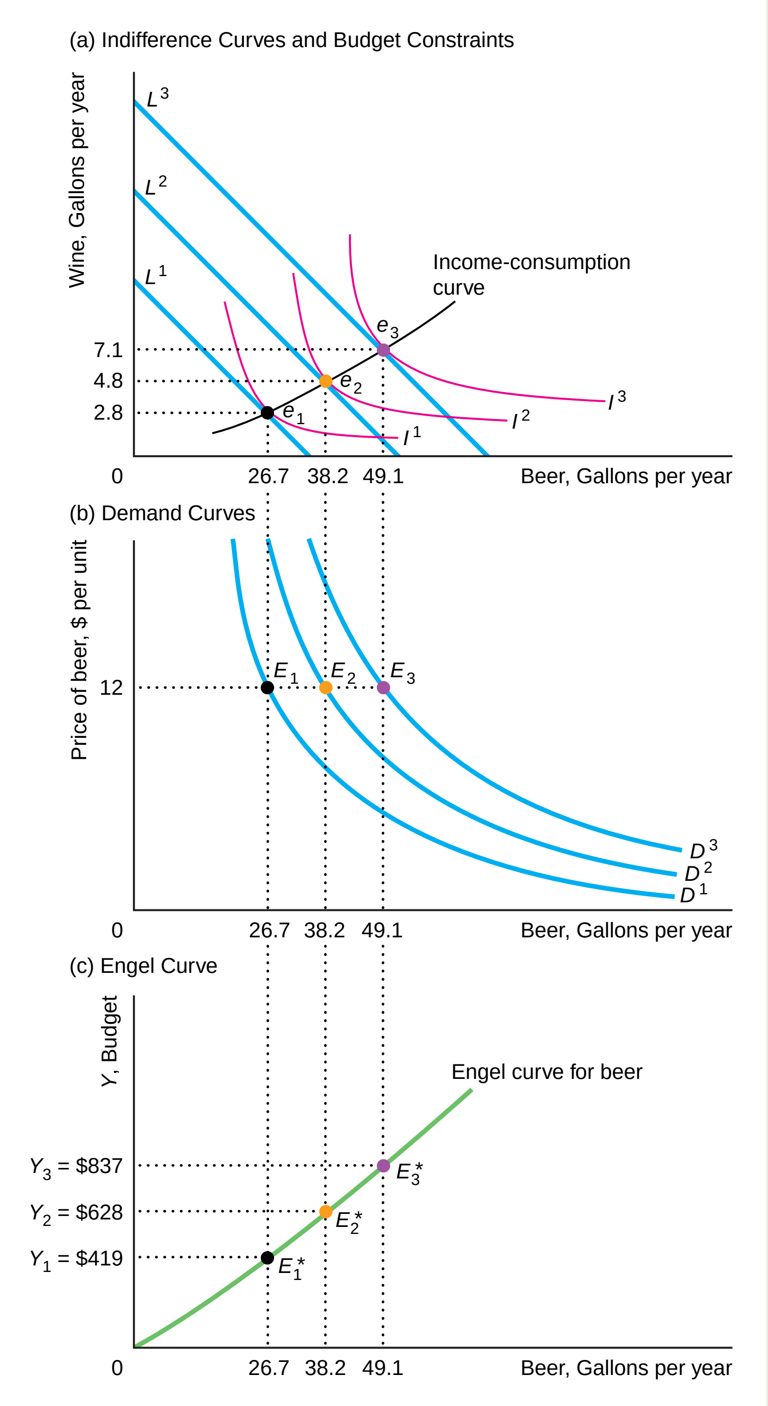
As before, Mimi's demand curve for beer is D^1 in panel b. Point E_1 on D^1, which corresponds to point e_1 in panel a, shows how much beer, 26.7 gallons per year, Mimi consumes when the price of beer is \$12 per unit (and the price of wine is \$35 per unit).

Now suppose that Mimi's beer and wine budget, Y, increases by roughly 50% to \$628 per year. Her new budget line, L^2 in panel a, is farther from the origin but parallel to her original budget constraint, L^1, because the prices of beer and wine are unchanged. Given this larger budget, Mimi chooses Bundle e_2. The increase in her income causes her demand curve to shift to D^2, in panel b. Holding Y at \$628, we can derive D^2 by varying the price of beer, in the same way as we derived D^1 in Figure 5.1. When the price of beer is \$12 per unit, she buys 38.2 gallons of beer per year, E_2 on D^2. Similarly, if Mimi's income increases to \$837 per year, her demand curve shifts to D^3.

The *income-consumption curve* through Bundles e_1, e_2, and e_3 in panel a shows how Mimi's consumption of beer and wine increases as her income rises. As Mimi's income goes up, her consumption of both wine and beer increases.

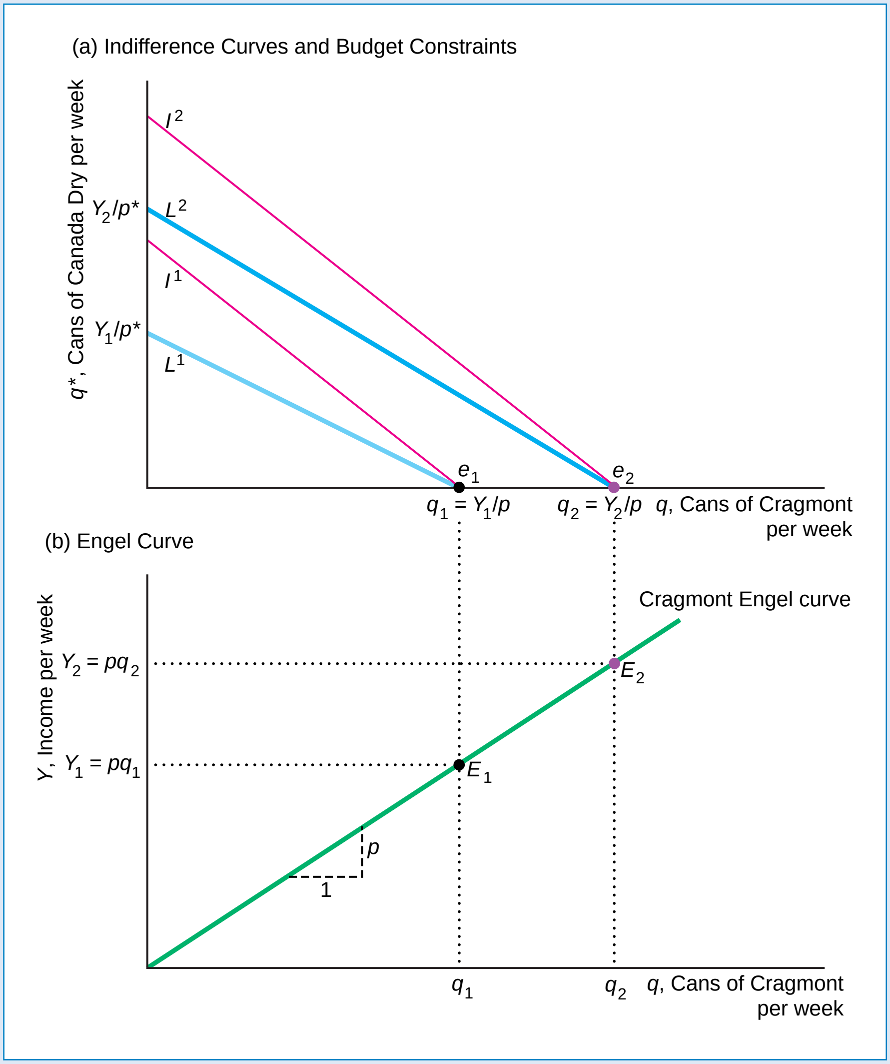
We can show the relationship between the quantity demanded and income directly rather than by shifting demand curves to illustrate the effect. In panel c, we plot an **Engel curve**, which shows the relationship between the quantity demanded of a single good and income, holding prices constant. Income is on the vertical axis, and the quantity of beer demanded is on the horizontal axis. On Mimi's Engel curve for beer, points E_1^*, E_2^*, and E_3^* correspond to points E_1, E_2, and E_3 in panel b and to e_1, e_2, and e_3 in panel a.

Figure 5.2 Effect of a Budget Increase on an Individual's Demand Curve. As the annual budget for wine and beer, Y, increases from \$419 to \$628 and then to \$837, holding prices constant, the typical consumer buys more of both products, as shown by the upward slope of the income-consumption curve (a). That the typical consumer buys more beer as income increases is shown by the outward shift of the demand curve for beer (b) and the upward slope of the Engel curve for beer (c).



Solved Problem 5.1

Mahdu views Cragmont and Canada Dry ginger ales as perfect substitutes: He is indifferent as to which one he drinks. The price of a 12-ounce can of Cragmont, p, is less than the price of a 12-ounce can of Canada Dry, p^*. What does Mahdu's Engel curve for Cragmont ginger ale look like? How much does his weekly ginger ale budget have to rise for Mahdu to buy one more can of Cragmont ginger ale per week?



Answer

1. *Use indifference curves to derive Mahdu's equilibrium choice*: Because Mahdu views the two brands as perfect substitutes, his indifference curves, such as I^1 and I^2 in panel a of the graphs, are straight lines with a slope of −1 (see Chapter 4). When his income is Y_1, his budget line hits the Canada

Dry axis at Y_1/p^* and his Cragmont axis at Y_1/p. Mahdu maximizes his utility by consuming Y_1/p cans of the less expensive Cragmont ginger ale and no Canada Dry (corner solution). As his income rises, say, to Y_2, his budget line shifts outward and is parallel to the original one, with the same slope of $-p/p^*$. Thus at each income level, his budget lines are flatter than his indifference curves, so his equilibria lie along the Cragmont axis.

2. *Use the first figure to derive his Engel curve*: Because his entire budget, Y, goes to buying Cragmont, Mahdu buys $q = Y/p$ cans of Cragmont ginger ale. This expression, which shows the relationship between his income and the quantity of Cragmont ginger ale he buys, is Mahdu's Engel curve for Cragmont. The points E_1 and E_2 on the Engel curve in panel b correspond to e_1 and e_2 in panel a. We can rewrite this expression for his Engel curve as $Y = pq$. This relationship is drawn in panel b as a straight line with a slope of p. As q increases by one can ("run"), Y increases by p ("rise"). Because all his ginger ale budget goes to buying Cragmont, his income needs to rise by only p for him to buy one more can of Cragmont per week.

Consumer Theory and Income Elasticities

Income elasticities tell us how much the quantity demanded changes as income increases. We can use income elasticities to summarize the shape of the Engel curve, the shape of the income-consumption curve, or the movement of the demand curves when income increases. For example, firms use income elasticities to predict the impact of income taxes on consumption. We first discuss the definition of income elasticities and then show how they are related to the income-consumption curve.

Income Elasticities. We defined the income elasticity of demand in Chapter 3 as

$$\xi = \frac{\text{percentage change in quantity demanded}}{\text{percentage change in income}} = \frac{\Delta Q / Q}{\Delta Y / Y},$$

where ξ is the Greek letter xi. Mimi's income elasticity of beer, ξ_b, is 0.88, and that of wine, ξ_w, is 1.38 (based on our estimates for the average American consumer). When her income goes up by 1%, she consumes 0.88% more beer and 1.38% more wine. Thus according to these estimates, as income falls, consumption of beer and wine by the average American falls—contrary to frequent (unsubstantiated) claims in the media that people drink more as their incomes fall during recessions.

Most goods, like beer and wine, have positive income elasticities. A good is called a **normal good** if as much or more of it is demanded as income rises. Thus a good is a normal good if its income elasticity is greater than or equal to zero: $\xi \geq 0$.

Some goods, however, have negative income elasticities: $\xi < 0$. A good is called an **inferior good** if less of it is demanded as income rises. No value judgment is intended by the use of the term *inferior*. An inferior good need not be defective or of low quality. Some of the better-known examples of inferior goods are foods such as potatoes and cassava that very poor people typically eat in large quantities. Some economists—apparently seriously—claim that human meat is an inferior good: Only when the price of other foods is very high and people are starving will they turn to cannibalism.

A good that is inferior for some people may be superior for others. One strange example concerns treating children as a consumption good. Even though they can't buy children in a market, people can decide how many children to have. Willis (1973) estimated the income elasticity for the number of children in a family. He found that children are an inferior good, $\xi = -0.18$, if the wife has relatively little education and the family has average income: These families have fewer children as their income increases. In contrast, children are a normal good, $\xi = 0.044$, in families in which the wife is relatively well educated. For both types of families, the income elasticities are close to zero, so the number of children is not very sensitive to income.

Income-Consumption Curves and Income Elasticities. The shape of the income-consumption curve for two goods tells us the sign of the income elasticities: whether the income elasticities for those goods are positive or negative. We know that Mimi's income elasticities of beer and wine are positive because the income-consumption curve in panel a of Figure 5.2 is upward sloping. As income rises, the budget line shifts outward and hits the upward-sloping income-consumption line at higher levels of both goods. Thus as her income rises, Mimi demands more beer and wine, so her income elasticities for beer and wine are positive. Because the income elasticity for beer is positive, the demand curve for beer shifts to the right in panel b of Figure 5.2 as income increases.

To illustrate the relationship between the slope of the income-consumption curve and the sign of income elasticities, we examine Peter's choices of food and housing. Peter purchases Bundle *e* in Figure 5.3 when his budget constraint is L^1. When his income increases, so his budget constraint is L^2, he selects a bundle on L^2. Which bundle he buys depends on his tastes—his indifference curves.

The horizontal and vertical dotted lines through *e* divide the new budget line, L^2, into three sections. In which of these three sections the new optimal bundle is located determines Peter's income elasticities of food and clothing.

Suppose that Peter's indifference curve is tangent to L^2 at a point in the upper-left section of L^2 (to the left of the vertical dotted line that goes through *e*) such as *a*. If Peter's income-consumption curve is ICC^1, which goes from *e* through *a*, he buys more housing and less food as his income rises. (We draw the possible *ICC* curves as straight lines for simplicity. In general, they may curve.) Housing is a normal good, and food is an inferior good.

If instead the new optimal bundle is located in the middle section of L^2 (above the horizontal dotted line and to the right of the vertical dotted line), such as at *b*, his income-consumption curve ICC^2 through *e* and *b* is upward sloping. He buys more of both goods as his income rises, so both food and housing are normal goods.

Third, suppose that his new optimal bundle is in the bottom-right segment of L^2 (below the horizontal dotted line). If his new optimal bundle is *c*, his income-consumption curve ICC^3 slopes downward from *e* through *c*. As his income rises, Peter consumes more food and less housing, so food is a normal good and housing is an inferior good.

Some Goods Must Be Normal. It is impossible for all goods to be inferior. We illustrate this point using Figure 5.3. At his original income, Peter faced budget constraint L^1 and bought the combination of food and housing *e*. When his income goes up, his budget constraint shifts outward to L^2. Depending on his tastes (the shape of his

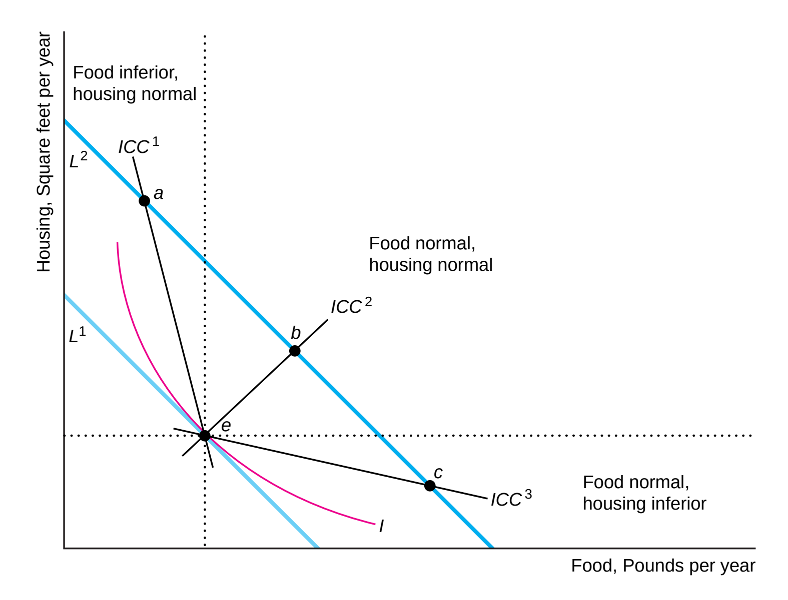


Figure 5.3 Income-Consumption Curves and Income Elasticities. At the initial income, the budget constraint is L^1 and the optimal bundle is *e*. After income rises, the new constraint is L^2. With an upward-sloping income-consumption curve such as ICC^2, both goods are normal. With an income-consumption curve such as ICC^1 that goes through the upper-left section of L^2 (to the left of the vertical dotted line through *e*), housing is normal and food is inferior. With an income-consumption curve such as ICC^3 that cuts L^2 in the lower-right section (below the horizontal dotted line through *e*), food is normal and housing is inferior.

indifference curves), he may buy more housing and less food, such as Bundle *a*; more of both, such as *b*; or more food and less housing, such as *c*. Therefore, either both goods are normal or one good is normal and the other is inferior.

If both goods were inferior, Peter would buy less of both goods as his income rises—which makes no sense. Were he to buy less of both, he would be buying a bundle that lies inside his original budget constraint L^1. Even at his original, relatively low income, he could have purchased that bundle but chose not to, buying *e* instead. By the more-is-better assumption of Chapter 4, there is a bundle on the budget constraint that gives Peter more utility than any given bundle inside the constraint.

Even if an individual does not buy more of the usual goods and services, that person may put the extra money into savings. Empirical studies find that savings is a normal good.

Income Elasticities May Vary with Income. A good may be normal at some income levels and inferior at others. When Gail was poor and her income increased slightly, she ate meat more frequently, and her meat of choice was hamburger. Thus, when her income was low, hamburger was a normal good. As her income increased further, however, she switched from hamburgers to steak. Thus, at higher incomes, hamburger is an inferior good.

We show Gail's choice between hamburger (horizontal axis) and all other goods (vertical axis) in panel a of Figure 5.4. As Gail's income increases, her budget line shifts outward, from L^1 to L^2, and she buys more hamburger: Bundle e_2 lies to the right of e_1. As her income increases further, shifting her budget line outward to L^3, Gail reduces her consumption of hamburger: Bundle e_3 lies to the left of e_2.

Gail's Engel curve in panel b captures the same relationship. At low incomes, her Engel curve is upward sloping, indicating that she buys more hamburger as her income rises. At higher incomes, her Engel curve is backward bending.

As their incomes rise, many consumers switch between lower-quality (hamburger) and higher-quality (steak) versions of the same good. This switching behavior explains the pattern of income elasticities across different-quality cars.

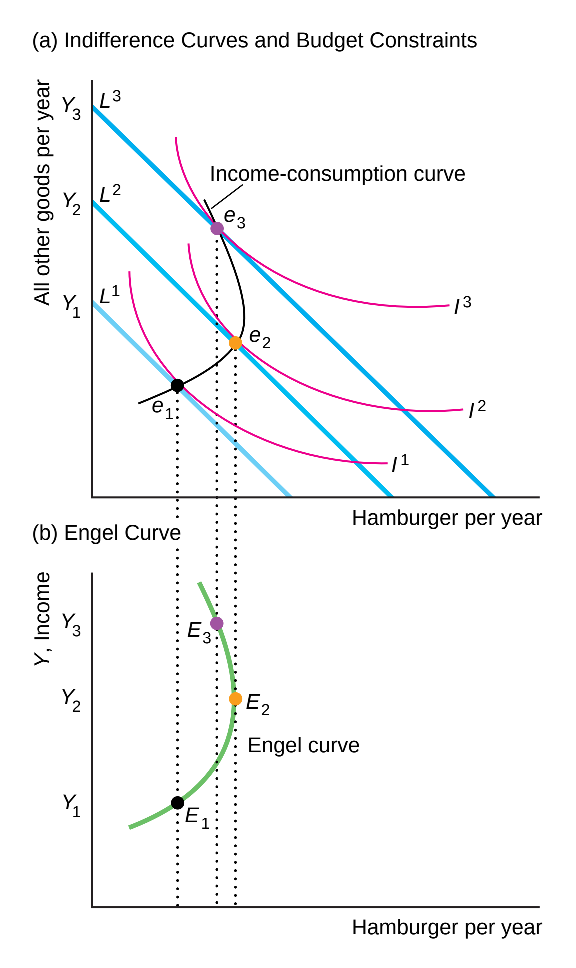


Figure 5.4 A Good That Is Both Inferior and Normal. When she was poor and her income increased, Gail bought more hamburger; however, when she became wealthier and her income rose, she bought less hamburger and more steak. (a) The forward slope of the income-consumption curve from e_1 to e_2 and the backward bend from e_2 to e_3 show this pattern. (b) The forward slope of the Engel curve at low incomes, E_1 to E_2, and the backward bend at higher incomes, E_2 to E_3, also show this pattern.

Application

INCOME ELASTICITIES OF DEMAND FOR CARS

> *I had to stop driving my car for a while . . . the tires got dizzy . . .*
>
> —Stephen Wright

As their incomes rise, some consumers buy their first car or an additional car, but others trade in their plain old car for a new sports car or luxury car. We expect that consumers will buy relatively more fancy cars than plain ones as incomes rise. In economic jargon, the income elasticity of demand is higher for sports cars and luxury cars than for other cars.

Bordley and McDonald (1993) estimated the income elasticity of demand for various types of cars. The income elasticity of demand is 1.8 on average across all cars, 1.5 for an economy car, 1.6 for small cars, 1.8 for compact and midsize cars, 1.9 for large and sporty cars, and 2.5 for luxury cars. Thus as expected, purchases of all types of cars rise faster than incomes, and purchases of large and sporty cars or luxury cars rise by more than purchases of economy, small, and compact and midsize cars.

Car Model	Income Elasticity	Car Model	Income Elasticity
Accord	2.2	Jaguar X-Type	4.5
BMW 700 Series	4.4	Jetta	2.1
Buick	2.8	Maxima	2.5
Cadillac	3.3	Mercedes	4.4
Camry	2.3	Mustang	1.9
Chevette	1.2	Olds	2.4
Civic	2.6	Porsche	4.2
Corvette	3.2	Taurus	2.1
Grand Am	1.8	Volvo	3.4

The table shows the income elasticities for various cars. If average incomes increase by 1%, demand for small, utilitarian (no longer made) Chevettes grows by about the same amount (1.2%), but demand for sporty Corvettes grows more than three times as much (3.2%).

Knowing these income elasticities, an auto manufacturer expects the demand for its fancy cars to rise more rapidly than demand for other cars during boom periods, when incomes are rising, and the demand for fancy cars to plummet more rapidly than the demand for other cars during busts, when incomes fall.

Do auto manufacturers really care about this information? Definitely. One of the authors of this study is employed by General Motors Research Labs.

5.3 EFFECTS OF A PRICE CHANGE

An increase in a price of a good, holding other prices and income constant, has two effects on an individual's demand. One is the *substitution effect*: If utility is held constant, as the price of the good increases, consumers *substitute* other, now relatively cheaper goods for that one. The other is the *income effect*: An increase in price reduces a consumer's buying power, effectively reducing the consumer's *income* and causing the consumer to buy less of at least some goods. A doubling of the price of all the goods the consumer buys is equivalent to a drop in income to half its original level (Chapter 4). Even a rise in the price of only one good reduces a consumer's ability to buy the same amount of all goods as before. For example, if the price of food increases in China, the effective purchasing power of a Chinese consumer falls substantially because one-third of Chinese consumers' income is spent on food.[5]

When a price goes up, the total change in the quantity purchased is the sum of the substitution and income effects.[6] When estimating the effects of a price change on the quantity an individual demands, economists decompose this combined effect into the two separate components. By decomposing the change in demand into two effects, economists gain extra information that they can use to answer questions about whether inflation measures are accurate and whether an increase in tax rates will raise tax revenue, as we demonstrate at the end of this chapter.

Income and Substitution Effects with a Normal Good

We illustrate the substitution and income effects in Figure 5.5, which shows how Mimi changes her allocation of income when the price of beer falls from \$12 to \$4 per unit. With this decrease, Mimi's budget constraint rotates outward from L^1 to L^2. The new budget constraint is flatter, $-p_b/p_w = -4/35 \approx -\frac{1}{9}$, than L^1, $-12/35 \approx -\frac{1}{3}$, because beer is now less expensive relative to wine.

Mimi can choose between more wine-beer bundles than she could at the higher price. The area between the two budget constraints is the increase in her opportunity set (Chapter 4) from the drop in the price of beer.

At the original price of beer and with a budget of \$419, Mimi chooses Bundle e_1 (26.7 gallons of beer and 2.8 gallons of wine per year), where her indifference curve I^1 is tangent to her budget constraint L^1. When the price of beer drops, Mimi's new equilibrium bundle is e_2 (where she buys 58.9 gallons of beer), which occurs where her indifference curve I^2 is tangent to L^2.

The movement from e_1 to e_2 is the total change in her consumption owing to the fall in the price of beer. In particular, the *total effect* on Mimi's consumption of beer from the drop in the price of beer is that she now drinks 32.2 (= 58.9 – 26.7) more gallons of beer per year. In the figure, the arrow pointing to the right and labeled "Total effect" shows this increase in beer consumption. We can break the total effect into a substitution and an income effect.

[5] Chinese State Statistical Bureau, *Statistical Yearbook of China* (Beijing: State Statistical Bureau Publishing House, 2000).

[6] See Appendix 5A for the mathematical relationship, called the Slutsky equation. See also the discussion of the Slutsky equation at **www.aw.com/perloff**, "Measuring the Substitution and Income Effects."

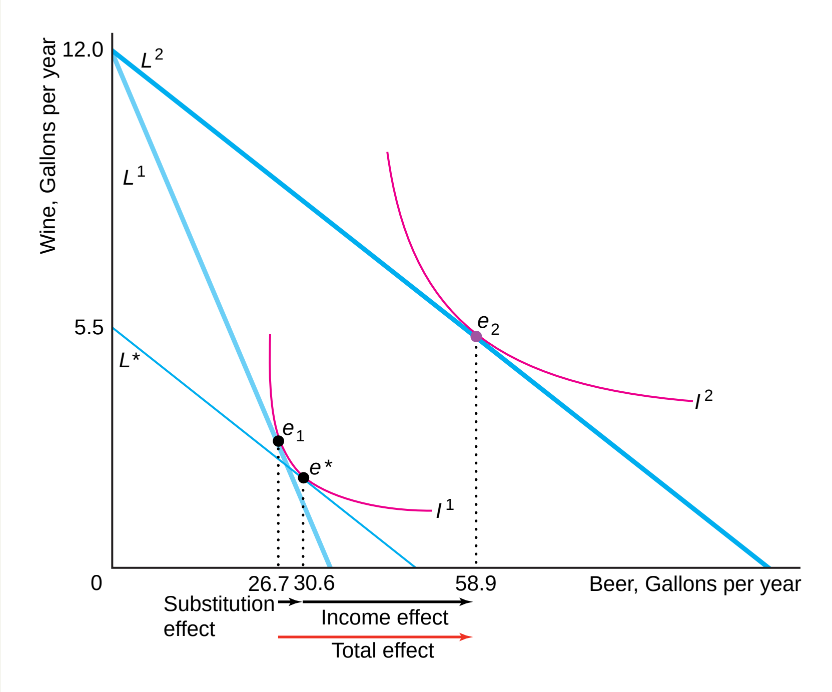


Figure 5.5 Substitution and Income Effects with Normal Goods. A decrease in the price of beer causes Mimi's budget line to rotate from L^1 to L^2. The imaginary budget line L^* has the same slope as L^2 and is tangent to indifference curve I^1. The shift of the optimal bundle from e_1 to e_2 is the *total effect* of the price change. The total effect can be decomposed into the *substitution effect*—movement from e_1 to e^*—and the *income effect*—movement from e^* to e_2.

The **substitution effect** is the change in the quantity of a good that a consumer demands when the good's price changes, holding other prices and the consumer's utility constant. That is, the substitution effect is the change in the quantity demanded from a *compensated change in the price* of beer, when we decrease Mimi's income by enough to offset the drop in the price of beer so that her utility stays constant. To determine the substitution effect, we draw an imaginary budget constraint, L^*, that is parallel to L^2 and tangent to Mimi's original indifference curve, I^1. This imaginary budget constraint, L^*, has the same slope, $-\frac{1}{9}$, as L^2 because both curves are based on the lower price of beer. For L^* to be tangent to I^1, we need to reduce Mimi's budget from \$419 to \$194 to offset the benefit of the lower price of beer. If Mimi's budget constraint were L^*, she would choose Bundle e^*, where she consumes 30.6 gallons of beer.

Thus if the price of beer falls relative to that of wine and Mimi's utility is held constant by lowering her income, Mimi's optimal bundle shifts from e_1 to e^*, which is the substitution effect. She buys 3.9 (= 30.6 – 26.7) gallons more beer per year, as the arrow pointing to the right labeled "Substitution effect" shows.

The **income effect** is the change in the quantity of a good a consumer demands because of a change in income, holding prices constant. The change in income is due to the change in the price of beer, which allows Mimi to buy more with her same budget. The parallel shift of the budget constraint from L^* to L^2 captures this effective increase in income. The movement from e^* to e_2 is the income effect, as the arrow pointing to the right labeled "Income effect" shows. As her budget increases from \$194 to \$419, Mimi consumes 28.3 (= 58.9 – 30.6) more gallons of beer per year.

The *total effect* from the price change is the *sum of the substitution and income effects*, as the arrows show. Mimi's total effect (in gallons of beer per year) from a drop in the price of beer is

$$\begin{array}{ccccc} \text{Total effect} & = & \text{substitution effect} & + & \text{income effect} \\ 32.2 & = & 3.9 & + & 28.3. \end{array}$$

Because indifference curves are convex to the origin, *the substitution effect is unambiguous:* More of a good is consumed when its price falls. A consumer always substitutes a less expensive good for a more expensive one, holding utility constant.

The direction of the income effect depends on the income elasticity. Because beer is a normal good for Mimi, her income effect is positive. Thus both Mimi's substitution effect and her income effect go in the same direction.

Income and Substitution Effects with an Inferior Good

If a good is inferior, the income effect goes in the opposite direction from the substitution effect. For most inferior goods, the income effect is smaller than the substitution effect. As a result, the total effect moves in the same direction as the substitution effect, but the total effect is smaller. However, the income effect can more than offset the substitution effect in extreme cases. We now examine such a case.

Dennis chooses between spending his money on Chicago Bulls basketball games and on movies, as Figure 5.6 shows. When the price of movies falls, Dennis's budget line shifts from L^1 to L^2. The total effect of the price fall is the movement from e_1 to e_2. We can break this total movement into an income effect and a substitution effect.

Dennis's income effect, the movement to the left from Bundle e^* to Bundle e_2, is negative, as the arrow pointing left labeled "Income effect" shows. The income effect is negative because Dennis regards movies as an inferior good.

Dennis's substitution effect for movies is positive because movies are now less expensive than they were before the price change. The substitution effect is the movement to the right from e_1 to e^*.

The total effect of a price change, then, depends on which effect is larger. Because Dennis's negative income effect for movies more than offsets his positive substitution effect, the total effect of a drop in the price of movies is negative.[7]

A good is called a **Giffen good** if a decrease in its price causes the quantity demanded to fall.[8] Thus going to the movies is a Giffen good for Dennis. The price

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[7]Economists mathematically decompose the total effect of a price change into substitution and income effects to answer various business and policy questions: see **www.aw.com/perloff**, Chapter 5, "Measuring the Substitution and Income Effects" and "International Comparison of Substitution and Income Effects."

[8]Robert Giffen, a nineteenth-century British economist, argued that poor people in Ireland increased their consumption of potatoes when the price rose because of a blight. However, more recent studies of the Irish potato famine dispute this observation.

decrease has an effect that is similar to an income increase: His opportunity set increases as the price of movies drops. Dennis spends the money he saves on movies to buy more basketball tickets. Indeed, he decides to increase his purchase of basketball tickets even further by reducing his purchase of movie tickets.

The demand curve for a Giffen good has an upward slope! Dennis's demand curve for movies is upward sloping because he goes to more movies at the high price, e_1, than at the low price, e_2.

The Law of Demand (Chapter 2), however, says that demand curves slope downward. You're no doubt wondering how I'm going to worm my way out this apparent contradiction. The answer is that I claimed that the Law of Demand was an empirical regularity, not a theoretical necessity. Although it's theoretically possible for a demand curve to slope upward, economists have found few, if any, real-world examples of Giffen goods.[9]

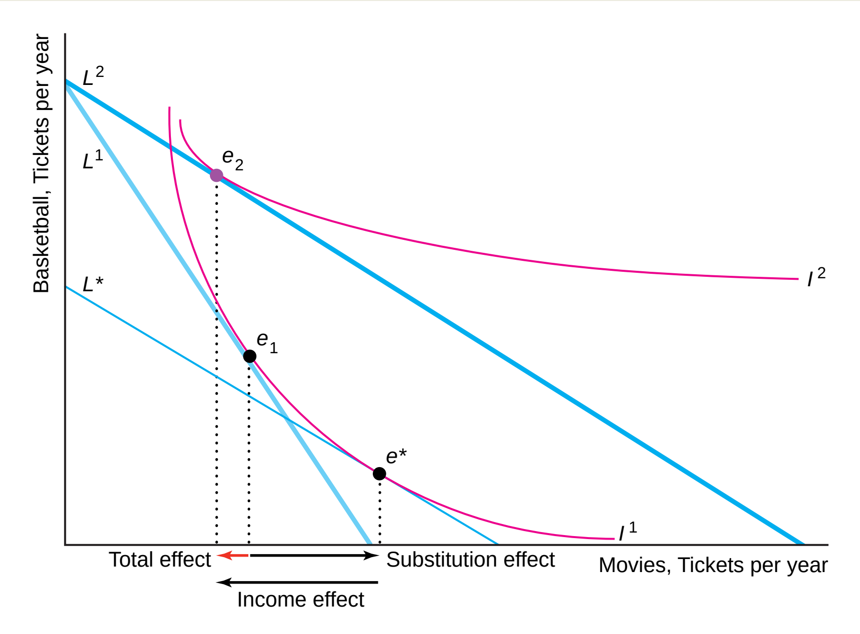


Figure 5.6 Giffen Good. Because a movie ticket is an inferior good for Dennis, the income effect, the movement from e^* to e_2, resulting from a drop in the price of movies is negative. This negative income effect more than offsets the positive substitution effect, the movement from e_1 to e^*, so the total effect, the movement from e_1 to e_2, is negative. Thus a movie ticket is a Giffen good because as its price drops, Dennis consumes less of it.

[9]Battalio, Kagel, and Kogut (1991), however, showed in an experiment that quinine water is a Giffen good for lab rats!

Solved Problem 5.2

Next to its plant, a manufacturer of dinner plates has an outlet store that sells plates of both first quality (perfect plates) and second quality (plates with slight blemishes). The outlet store sells a relatively large share of seconds. At its outlet stores elsewhere, the firm sells many more first-quality plates than second-quality plates. Why? (Assume that consumers' tastes with respect to plates are the same everywhere and that there is a cost, s, of shipping each plate from the factory to the firm's other stores.)

Answer

1. *Determine how the relative prices of plates differ between the two types of stores*: The slope of the budget line consumers face at the factory outlet store is $-p_1/p_2$, where p_1 is the price of first-quality plates and p_2 is the price of the seconds. It costs the same, s, to ship a first-quality plate as a second because they weigh the same and have to be handled in the same way. At all other stores, the firm adds the cost of shipping to the price it charges at its factory outlet store, so the price of a first-quality plate is $p_1 + s$ and the price of a second is $p_2 + s$. As a result, the slope of the budget line consumers face at the other retail stores is $-(p_1 + s)/(p_2 + s)$. The seconds are relatively less expensive at the factory outlet than at other stores. For example, if $p_1 = \$2$, $p_2 = \$1$, and $s = \$1$ per plate, the slope of the budget line is -2 at the outlet store and $-3/2$ elsewhere. Thus the first-quality plate costs twice as much as a second at the outlet store but only 1.5 times as much elsewhere.

2. *Use the relative price difference to explain why relatively more seconds are bought at the factory outlet*: Holding a consumer's income and tastes fixed, if the price of seconds rises relative to that of firsts (as we go from the factory outlet to other retail shops), most consumers will buy relatively more firsts. The substitution effect is unambiguous: Were they compensated so that their utilities were held constant, consumers would unambiguously substitute firsts for seconds. It is possible that the income effect could go in the other direction; however, as most consumers spend relatively little of their total budget on plates, the income effect is presumably small relative to the substitution effect. Thus we expect relatively fewer seconds to be bought at the retail stores than at the factory outlet. (Question 9 at the end of the chapter asks you to illustrate this answer using graphs.)

SHIPPING THE GOOD STUFF AWAY

According to the economic theory discussed in Solved Problem 5.2, we expect that the relatively larger share of higher-quality goods will be shipped, the greater the per-unit shipping fee. Is this theory true, and is the effect large? To answer these questions, Hummels and Skiba (2002) examined shipments between 6,000 country pairs for more than 5,000 goods. They found that doubling per-unit shipping costs results in a 70 to 143% increase in the average price (excluding the cost of shipping) as a larger share of top-quality products are shipped.

The greater the distance between the trading countries, the higher the cost of shipping. Hummels and Skiba speculate that the relatively high quality of Japanese goods is due to that country's relatively great distance to major importers.

They also looked at the effects of *ad valorem* tariff: a tax on imported goods that increases with price (see Chapter 3). Such a tariff raises the relative price of higher quality goods (given that there is also a per-unit shipping fee). Doubling the *ad valorem* tariff decreases the average price threefold to fourfold as average quality falls. Thus, by using an *ad valorem* rather than a specific (per-unit) tariff, importing countries reduce the quality of imported goods.

5.4 COST-OF-LIVING ADJUSTMENTS

In spite of the cost of living, it's still popular. —Kathleen Norris

By knowing both the substitution and income effects, we can answer questions that we could not if we knew only the total effect. For example, if firms have an estimate of the income effect, they can predict the impact of a negative income tax (a gift of money from the government) on the consumption of their products. Similarly, if we know the size of both effects, we can determine how accurately the government measures inflation.

Many long-term contracts and government programs include *cost-of-living adjustments (COLAs)*, which raise prices or incomes in proportion to an index of inflation. Not only business contracts but also rental contracts, alimony payments, salaries, pensions, and Social Security payments are frequently adjusted in this manner over time. We will use consumer theory to show that a cost-of-living measure that governments commonly use overestimates how the true cost of living changes over time. Because of this overestimate, you overpay your landlord if the rent on your apartment rises with this measure.

Inflation Indexes

The prices of most goods rise over time. We call the increase in the overall price level *inflation*.

Real Versus Nominal Prices. The actual price of a good is called the *nominal price*. The price adjusted for inflation is the *real price*.

Because the overall level of prices rises over time, nominal prices usually increase more rapidly than real prices. For example, the nominal price of a McDonald's hamburger rose from 15¢ in 1955 to 79¢ in 2002, over a fivefold increase. However, the real price of a burger fell because the prices of other goods rose more rapidly than that of a burger.

How do we adjust for inflation to calculate the real price? Governments measure the cost of a standard bundle of goods for use in comparing prices over time. This measure is called the Consumer Price Index (CPI). Each month, the government reports how much it costs to buy the bundle of goods that an average consumer purchased in a *base* year (with the base year changing every few years).

By comparing the cost of buying this bundle over time, we can determine how much the overall price level has increased. In the United States, the CPI was 26.8 in 1955 and 181.3 in November 2002.[10] The cost of buying the bundle of goods increased 676% (≈181.3/26.8) from 1955 to 2002.

We can use the CPI to calculate the real price of a hamburger over time. In terms of 2002 dollars, the real price of a hamburger in 1955 was

$$\frac{\text{CPI for 2002}}{\text{CPI for 1955}} \times \text{price of a burger} = \frac{181.3}{26.8} \times 15¢ \approx \$1.01.$$

If you could have purchased the hamburger in 1955 with 2002 dollars—which are worth less than 1955 dollars—the hamburger would have cost $1.01. The real price in 2002 dollars (and the nominal price) of a hamburger in 2002 was only 79¢. Thus the real price of a hamburger fell by about a fourth. If we compared the real prices in both years using 1955 dollars, we would reach the same conclusion that the real price of hamburgers fell by about a fourth.

Calculating Inflation Indexes. The government collects data on the quantities and prices of 364 individual goods and services, such as housing, dental services, watch and jewelry repairs, college tuition fees, taxi fares, women's hairpieces and wigs, hearing aids, slipcovers and decorative pillows, bananas, pork sausage, and funeral expenses. These prices rise at different rates. If the government merely reported all these price increases separately, most of us would find this information overwhelming. It is much more convenient to use a single summary statistic, the CPI, which tells us how prices rose *on average*.

We can use an example with only two goods, clothing and food, to show how the CPI is calculated. In the first year, consumers buy C_1 units of clothing and F_1 units of food at prices p_C^1 and p_F^1. We use this bundle of goods, C_1 and F_1, as our base bundle for comparison. In the second year, consumers buy C_2 and F_2 units at prices p_C^2 and p_F^2.

The government knows from its survey of prices each year that the price of clothing in the second year is p_C^2/p_C^1 times as large as the price the previous year and the price of food is p_F^2/p_F^1 times as large. If the price of clothing was $1 in the first year and $2 in the second year, the price of clothing in the second year is $\frac{2}{1} = 2$ times, or 100%, larger than in the first year.

One way we can average the price increases of each good is to weight them equally. But do we really want to do that? Do we want to give as much weight to the price increase for skateboards as to the price increase for automobiles? An alter-

[10]The number 168.7 is not an actual dollar amount. Rather, it is the actual dollar cost of buying the bundle divided by a constant. That constant was chosen so that the average expenditure in the period 1982–1984 was 100.

native approach is to give a larger weight to the price change of a good as we spend more of our income on that good, its budget share. The CPI takes this approach to weighting, using budget shares.[11]

The CPI for the first year is the amount of income it takes to buy the market basket actually purchased that year:

$$Y_1 = p_C^1 C_1 + p_F^1 F_1. \tag{5.1}$$

The cost of buying the first year's bundle in the second year is

$$Y_2 = p_C^2 C_1 + p_F^2 F_1. \tag{5.2}$$

To calculate the rate of inflation, we determine how much more income it would take to buy the first year's bundle in the second year, which is the ratio of Equation 5.1 to Equation 5.2:

$$\frac{Y_2}{Y_1} = \frac{p_C^2 C_1 + p_F^2 F_1}{p_C^1 C_1 + p_F^1 F_1}.$$

For example, from 1996 to 1997, the U.S. CPI rose by $1.023 \approx Y_2/Y_1$ from $Y_1 = 156.9$ to $Y_2 = 160.5$. Thus it cost 2.3% more in 1997 than in 1996 to buy the same bundle of goods.

The ratio Y_2/Y_1 reflects how much prices rise on average. By multiplying and dividing the first term in the numerator by p_C^1 and multiplying and dividing the second term by p_F^1, we find that this index is equivalent to

$$\frac{Y_2}{Y_1} = \frac{\left(\frac{p_C^2}{p_C^1}\right) p_C^1 C_1 + \left(\frac{p_F^2}{p_F^1}\right) p_F^1 F_1}{Y_1} = \left(\frac{p_C^2}{p_C^1}\right)\theta_C + \left(\frac{p_F^2}{p_F^1}\right)\theta_F,$$

where $\theta_C = p_C^1 C_1/Y_1$ and $\theta_F = p_F^1 F_1/Y_1$ are the budget shares of clothing and food in the first or base year. The CPI is a *weighted average* of the price increase for each good, p_C^2/p_C^1 and p_F^2/p_F^1, where the weights are each good's budget share in the base year, θ_C and θ_F.

DOES INFLATION HURT?

Due to inflation, the nominal prices of many goods have increased over time. But so have wages. Are consumers better off or worse off today than in the past?

Consumers today have a much wider choice of goods, most of which are of notably higher quality than the comparable items that their grandparents used. Today's color television set is much better than the old, unreliable black-and-

[11]This discussion of the CPI is simplified in a number of ways. Sophisticated adjustments are made to the CPI that are ignored here, including repeated updating of the base year (chaining). See Pollak (1989) and Diewert and Nakamura (1993).

white TVs of the 1950s. Even if we don't control for the quality difference, it takes a worker fewer hours to "earn" a television. In 1971, the typical worker toiled for 174 hours to have enough money to buy a 25-inch color set. Today, a much more reliable TV could be obtained after just 23 hours of work.

In 1900, the year the Hershey chocolate bar was invented, an average worker could buy it for 5¢ after 19.9 minutes of work. Today, a worker can buy one for 50¢ after only a couple minutes of work.

A Model T Ford could be had for $850 in 1908 after more than two years (4,696 hours) of work. Today, a Ford Taurus—a far superior vehicle—costs $19,000, or about 8 months of work. Dental braces were $900 in 1950, or 625 hours of work, while today's much superior product costs $3,800, which can be paid for with 263 hours of work.

Unfortunately, not everything is cheaper today. In 1926, a movie ticket cost 17¢, or 19 minutes of work. Today a ticket requires 23 minutes of work.

Effects of Inflation Adjustments

A CPI adjustment of prices in a long-term contract overcompensates for inflation. We use an example involving an employment contract to illustrate the difference between using the CPI to adjust a long-term contract and using a true cost-of-living adjustment, which holds utility constant.

CPI Adjustment. Klaas signed a long-term contract when he was hired. According to the COLA clause in his contract, his employer increases his salary each year by the same percentage as that by which the CPI increases. If the CPI this year is 5% higher than the CPI last year, Klaas's salary rises automatically by 5% over last year's.

Klaas spends all his money on clothing and food. His budget constraint in the first year is $Y_1 = p_C^1 C + p_F^1 F$, which we rewrite as

$$C = \frac{Y_1}{p_C^1} - \frac{p_F^1}{p_C^1} F.$$

The intercept of the budget constraint, L^1, on the vertical (clothing) axis in Figure 5.7 is Y_1/p_C^1, and the slope of the constraint is $-p_F^1/p_C^1$. The tangency of his indifference curve I^1 and the budget constraint L^1 determine his equilibrium consumption bundle in the first year, e_1, where he purchases C_1 and F_1.

In the second year, his salary rises with the CPI to Y_2, so his budget constraint, L^2, in that year is

$$C = \frac{Y_2}{p_C^2} - \frac{p_F^2}{p_C^2} F.$$

The new constraint, L^2, has a flatter slope, $-p_F^2/p_C^2$, than L^1 because the price of clothing rose more than the price of food. The new constraint goes through the original equilibrium bundle, e_1, because, by increasing his salary using the CPI, the firm

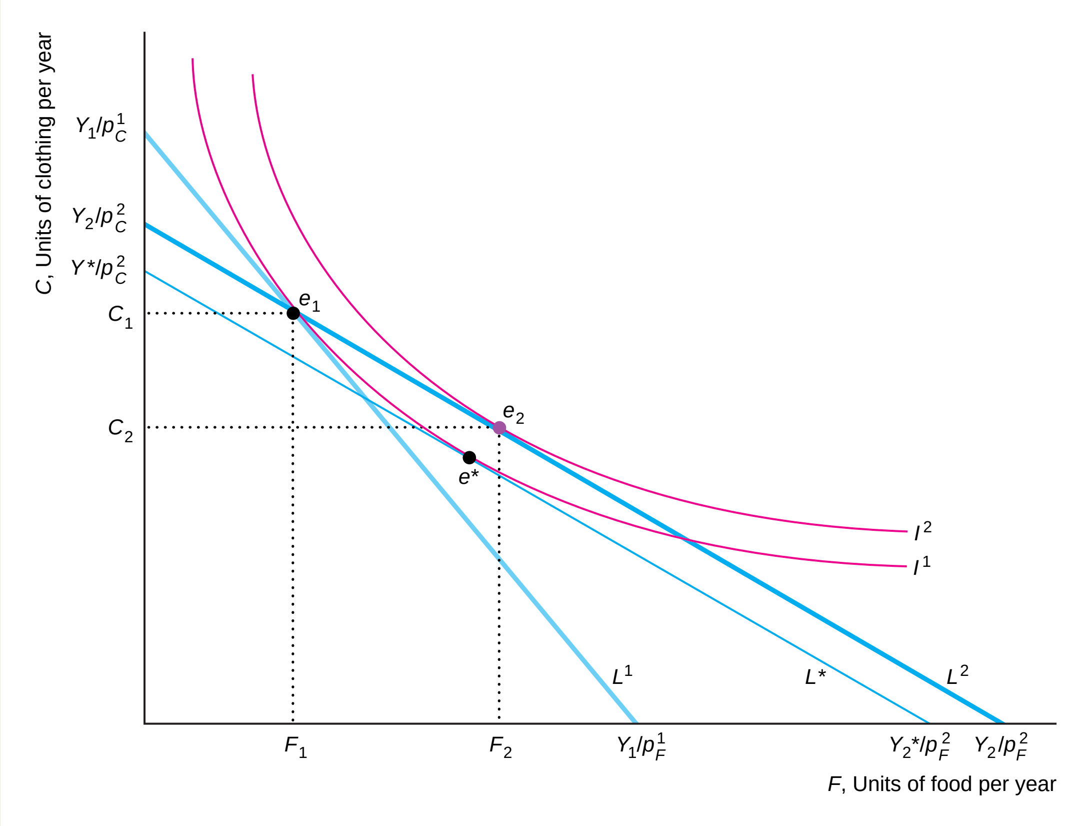


Figure 5.7 The Consumer Price Index. In the first year, when Klaas has an income of Y_1, his optimal bundle is e_1, where indifference curve I^1 is tangent to his budget constraint, L^1. In the second year, the price of clothing rises more than the price of food. Because his salary increases in proportion to the CPI, his second-year budget constraint, L^2, goes through e_1, so he can buy the same bundle as in the first year. His new optimal bundle, however, is e_2, where I^2 is tangent to L^2. The CPI adjustment overcompensates him for the increase in prices: Klaas is better off in the second year because his utility is greater on I^2 than on I^1. With a smaller true cost-of-living adjustment, Klaas's budget constraint, L^*, is tangent to I^1 at e^*.

ensures that Klaas can buy the same bundle of goods in the second year that he chose in the first year.

He *can* buy the same bundle, but *does* he? The answer is no. His optimal bundle in the second year is e_2, where indifference curve I^2 is tangent to his new budget constraint L^2. The movement from e_1 to e_2 is the *total effect* from the changes in the real prices of clothing and food. *This adjustment to his income does not keep him on his original indifference curve*, I^1.

Indeed, Klaas is better off in the second year than in the first. The CPI adjustment *overcompensates* for the change in inflation in the sense that his utility increases.

Klaas is better off because the prices of clothing and food did not increase by the same amount. Suppose that the price of clothing and food had both increased by *exactly* the same amount. After a CPI adjustment, Klaas's budget constraint in the second year, L^2, would be exactly the same as in the first year, L^1, so he would choose exactly the same bundle, e_1, in the second year as in the first year.

Because the price of food rose by less than the price of clothing, L^2 is not the same as L^1. Food became cheaper relative to clothing. So by consuming more food and less clothing, Klaas has higher utility in the second year.

Had clothing become relatively less expensive, Klaas would have raised his utility in the second year by consuming relatively more clothing. Thus it doesn't matter which good becomes relatively less expensive over time—it's only necessary for one of them to become a relative bargain for Klaas to benefit from the CPI compensation.

True Cost-of-Living Adjustment. We now know that a CPI adjustment overcompensates for inflation. What we want is a *true cost-of-living index*: an inflation index that holds utility constant over time.

How big an increase in Klaas's salary would leave him exactly as well off in the second year as in the first? We can answer this question applying the same technique we use to identify the substitution and income effects. We draw an imaginary budget line, L^* in Figure 5.7, that is tangent to I^1, so that Klaas's utility remains constant, but that has the same slope as L^2. The income, Y^*, corresponding to that imaginary budget constraint is the amount that leaves Klaas's utility constant. Had Klaas received Y^* in the second year instead of Y_2, he would have chosen Bundle e^* instead of e_2. Because e^* is on the same indifference curve, I^1, as e_1, Klaas's utility would be the same in both years.

The numerical example in Table 5.1 illustrates how the CPI overcompensates Klaas.[12] Suppose that p_C^1 is \$1, p_C^2 is \$2, p_F^1 is \$4, and p_F^2 is \$5. In the first year, Klaas spends his income, Y_1, of \$400 on $C_1 = 200$ units of clothing and $F_1 = 50$ units of food and has a utility of 2,000, which is the level of utility on I^1. If his income did not increase in the second year, he would substitute toward the relatively inexpensive food, cutting his consumption of clothing in half but reducing his consumption of food by only a fifth. His utility would fall to 1,265.

Table 5.1 Cost-of-Living Adjustments

	p_C	p_F	Income, Y	Clothing	Food	Utility, U
First year	\$1	\$4	Y_1 = \$400	200	50	2,000
Second year	\$2	\$5				
No adjustment			Y_1 = \$400	100	40	≈1,265
CPI adjustment			Y_2 = \$650	162.5	65	≈2,055
True COLA			Y^* ≈ \$632.50	≈158.1	≈63.2	2,000

[12]We assume that Klaas has a utility function $U = 20\sqrt{CF}$, which we used to draw Figure 5.7.

If his second-year income increases in proportion to the CPI, he can buy the same bundle, e_1, in the second year as in the first. His second-year income is Y_2 = \$650 (= $p_C^2 C_1 + p_F^2 F_1$ = \$2 × 200 + \$5 × 50). Klaas is better off if his budget increases to Y_2. He substitutes toward the relatively inexpensive food, buying less clothing than in the first year but more food, e_2. His utility rises from 2,000 to approximately 2,055 (the level of utility on I^2).

How much would his income have to rise to leave him only as well off as he was in the first year? If his second-year income is $Y^* \approx$ \$632.50, by appropriate substitution toward food, e^*, he can achieve the same level of utility, 2,000, as in the first year.

We can use the income that just compensates Klaas, Y^*, to construct a true cost-of-living index. In our numerical example, the true cost-of-living index rose 58.1% (≈ [632.50 – 400]/400), while the CPI rose 62.5% (= [650 – 400]/400).

Size of the CPI Substitution Bias. We have just demonstrated that the CPI has an *upward bias* in the sense that an individual's utility rises if we increase that person's income by the same percentage as that by which the CPI rises. If we make the CPI adjustment, we are implicitly assuming—incorrectly—that consumers do not substitute toward relatively inexpensive goods when prices change but keep buying the same bundle of goods over time. We call this overcompensation a *substitution bias*.

The CPI calculates the increase in prices as Y_2/Y_1. We can rewrite this expression as

$$\frac{Y_2}{Y_1} = \frac{Y^*}{Y_1}\frac{Y_2}{Y^*}.$$

The first term to the right of the equal sign, Y^*/Y_1, is the increase in the true cost of living. The second term, Y_2/Y^*, reflects the substitution bias in the CPI. It is greater than one because $Y_2 > Y^*$. In the example in Table 5.1, $Y_2/Y^* = 650/632.50 \approx 1.028$, so the CPI overestimates the increase in the cost of living by about 2.8%.

There is no substitution bias if all prices increase at the same rate so that relative prices remain constant. The faster some prices rise relative to others, the more pronounced is the upward bias caused by substitution to now less expensive goods.

FIXING THE CPI SUBSTITUTION BIAS

Several studies estimate that, due to the substitution bias, the CPI inflation rate is about half a percentage point too high per year. What can be done to correct this bias? One approach is to estimate utility functions for individuals and use that data to calculate a true cost-of-living index. However, given the wide variety of tastes across individuals, as well as various technical estimation problems, this approach is not practical.

A second method is to use a *Paasche* index, which weights prices using the current quantities of goods purchased. In contrast, the CPI (which is also called a *Laspeyres* index) uses quantities from the earlier, base period. A Paasche index is likely to overstate the degree of substitution and thus to understate the change in the cost-of-living index (see Question 18 at the end of this chapter). Hence, replacing the traditional Laspeyres index with the Paasche would merely replace an overestimate with an underestimate of the rate of inflation.

A third compromise approach is to take an average of the Laspeyres and Paasche indexes because the true cost-of-living index lies between the two indexes. The most widely touted average is the *Fisher* index, which is the geometric mean of the Laspeyres and Paasche indexes (the square root of their product). If we use the Fisher index, we are implicitly assuming that there is a unitary elasticity of substitution among goods so that the share of consumer expenditures on each item remains constant as relative prices change (in contrast to the Laspeyres approach, where we assume that the quantities remain fixed).

Not everyone agrees that averaging the Laspeyres and Paasche indexes would be an improvement. For example, if people do not substitute, the CPI (Laspeyres) index is correct and the Fisher index, based on the geometric average, would underestimate the rate of inflation.

Nonetheless, in recent years, the Bureau of Labor Statistics (BLS), which calculates the CPI, has made several adjustments to its CPI methodology, including using this averaging approach. Starting in 1999, the BLS replaced the Laspeyres index with a Fisher approach to calculate almost all of its 200 basic indexes (such as "ice cream and related products") within the CPI. It still uses the Laspeyres approach for a few of the categories where it does not expect much substitution, such as utilities (electricity, gas, cable television, and telephones), medical care, and housing. The BLS still uses the Laspeyres method to combine the basic indexes to obtain the final CPI. In 2002, the BLS began reporting a supplemental, experimental index that combines the basic indexes using averages. This experimental CPI shows a lower rate of inflation than the official (Laspeyres) CPI.

Starting in 2002, the BLS will update the CPI weights (the market basket shares of consumption) every two years instead of only every decade or so as the bureau had done previously. More frequent updating reduces the substitution bias in a Laspeyres index because market basket shares are frozen for a shorter period of time. According to the BLS, had it used updated weights between 1989 and 1997, the CPI would have increased by only 31.9% rather than the reported 33.9%. Thus, the BLS predicts that this change will reduce the rate of increase in the CPI by approximately 0.2 percentage points per year.

Overestimating the rate of inflation has important implications for U.S. society because Social Security, various retirement plans, welfare, and many other programs include CPI-based cost-of-living adjustments. According to one estimate, the bias in the CPI alone makes it the fourth-largest "federal program" after Social Security, health care, and defense. For example, the U.S. Postal Service (USPS) has a CPI-based COLA in its union contracts. In 2002, a typical employee earned $59,900 a year, including benefits. A substitution bias of half a percent a year costs the USPS nearly $300 per employee. Because the USPS has about 860,000 employees, the bias costs the USPS over $257 million per year—and benefits its employees by the same amount.

5.5 DERIVING LABOR SUPPLY CURVES

Throughout this chapter, we've used consumer theory to examine consumers' *demand* behavior. Perhaps surprisingly, we can use the consumer theory model to derive the *supply curve* of labor. We are going to do that by deriving a demand curve for time spent *not* working and then use that demand curve to draw the supply curve of hours spent working.

Labor-Leisure Choice

People choose between working to earn money to buy goods and services and consuming *leisure*: all time spent not working. In addition to sleeping, eating, and playing, leisure includes time spent cooking meals and fixing things around the house. The number of hours worked per day, H, equals 24 minus the hours of leisure or nonwork, N, in a day:

$$H = 24 - N.$$

Using consumer theory, we can determine the demand curve for leisure once we know the price of leisure. What does it cost you to watch TV or go to school or do anything for an hour other than work? It costs you the wage, w, you could have earned from an hour's work: The price of leisure is forgone earnings. The higher your wage, the more an hour of leisure costs you. For this reason, taking an afternoon off costs a lawyer who earns $250 an hour much more than it costs someone who earns the minimum wage.

We use an example to show how the number of hours of leisure and work depends on the wage, unearned income (such as inheritances and gifts from parents), and tastes. Jackie spends her total income, Y, on various goods. For simplicity, we assume that the price of these goods is $1 per unit, so she buys Y goods. Her utility, U, depends on how many goods and how much leisure she consumes:

$$U = U(Y, N).$$

Initially, we assume that Jackie can choose to work as many or as few hours as she wants for an hourly wage of w. Jackie's earned income equals her wage times the number of hours she works, wH. Her total income, Y, is her earned income plus her unearned income, Y^*:

$$Y = wH + Y^*.$$

Panel a of Figure 5.8 shows Jackie's choice between leisure and goods. The vertical axis shows how many goods, Y, Jackie buys. The horizontal axis shows both hours of leisure, N, which are measured from left to right, and hours of work, H, which are measured from right to left. Jackie maximizes her utility given the *two* constraints she faces. First, she faces a time constraint, which is a vertical line at 24 hours of leisure. There are only 24 hours in a day; all the money in the world won't buy her more hours in a day. Second, Jackie faces a budget constraint. Because Jackie has no unearned income, her initial budget constraint, L^1, is $Y = w_1H = w_1(24 - N)$. The slope of her budget constraint is $-w_1$, because each extra hour of leisure she consumes costs her w_1 goods.

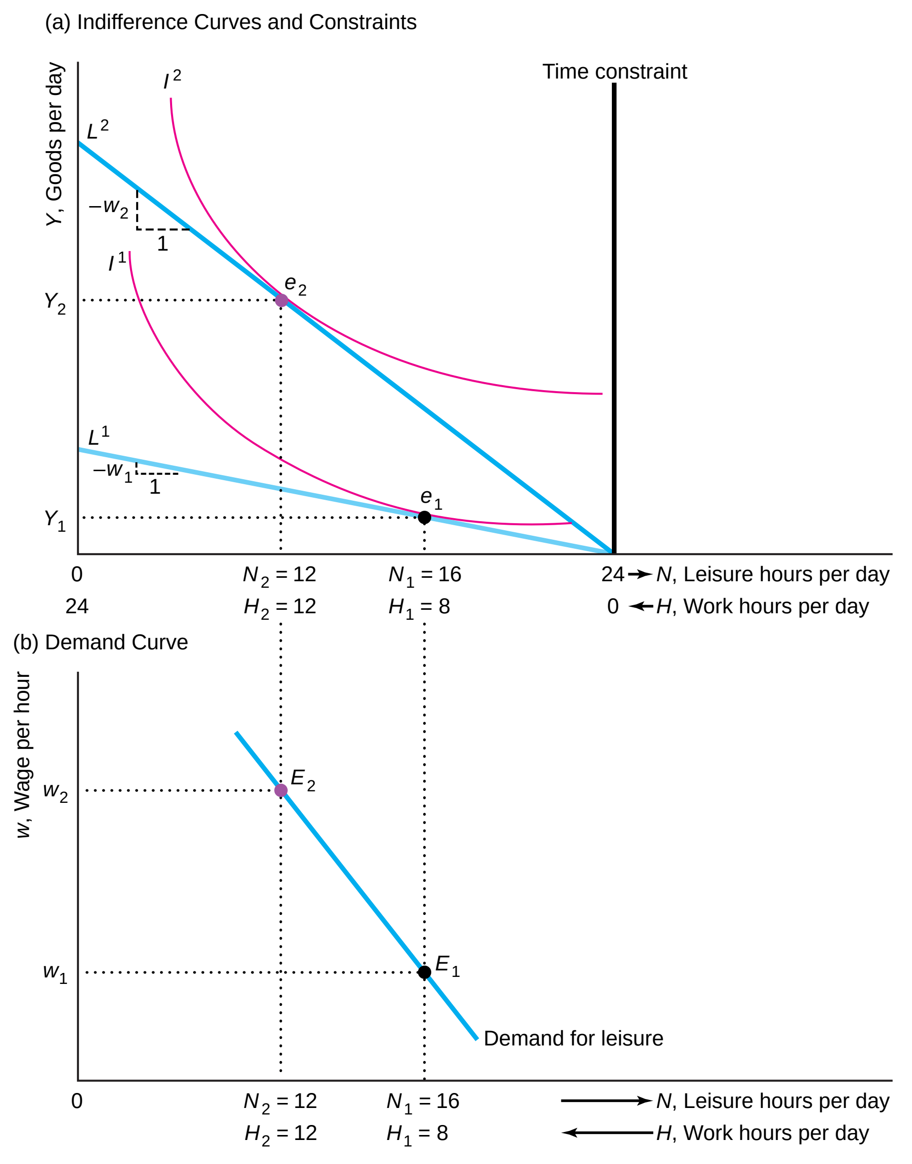


Figure 5.8 Demand for Leisure. (a) Jackie chooses between leisure, N, and other goods, Y, subject to a time constraint (vertical line at 24 hours) and a budget constraint, L^1, which is $Y = w_1 H = w_1(24 - N)$, with a slope of $-w_1$. The tangency of her indifference curve, I^1, with her budget constraint, L^1, determines her optimal bundle, e_1, where she has $N_1 = 16$ hours of leisure and works $H_1 = 24 - N_1 = 8$ hours. If her wage rises from w_1 to w_2, Jackie shifts from optimal bundle e_1 to e_2. (b) Bundles e_1 and e_2 correspond to E_1 and E_2 on her leisure demand curve.

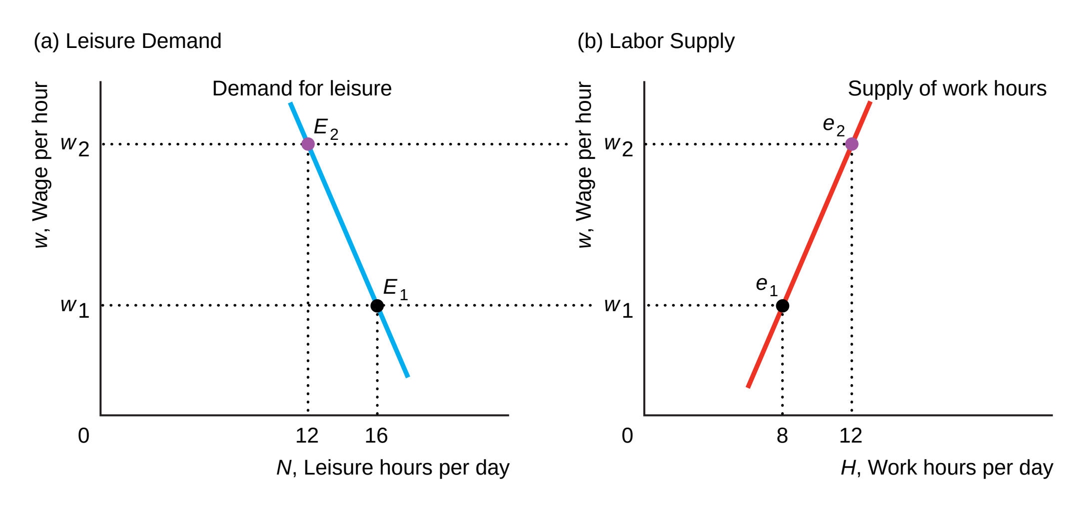


Figure 5.9 Supply Curve of Labor. (a) Jackie's demand for leisure is downward sloping. (b) At any given wage, the number of hours that Jackie works, H, and the number of hours of leisure, N, that she consumes add to 24. Thus her supply curve for hours worked, which equals 24 hours minus the number of hours of leisure she demands, is upward sloping.

Jackie picks her optimal hours of leisure, $N_1 = 16$, so that she is on the highest indifference curve, I^1, that touches her budget constraint. She works $H_1 = 24 - N_1 = 8$ hours per day and earns an income of $Y_1 = w_1 H_1 = 8w_1$.

We derive Jackie's demand curve for leisure using the same method that we used to derive Mimi's demand curve for beer. We raise the price of leisure—the wage—in panel a of Figure 5.8 to trace out Jackie's demand curve for leisure in panel b. As the wage increases from w_1 to w_2, leisure becomes more expensive, and Jackie demands less of it.

By subtracting her demand for leisure at each wage—her demand curve for leisure in panel a of Figure 5.9—from the 24, we construct her labor supply curve—the hours she is willing to work as a function of the wage—in panel b.[13] Her supply curve for hours worked is the mirror image of the demand curve for leisure: For every extra hour of leisure that Jackie consumes, she works one hour less.

Income and Substitution Effects

An increase in the wage causes both income and substitution effects, which alter an individual's demand for leisure and supply of hours worked. The *total effect* of an increase in Jackie's wage from w_1 to w_2 is the movement from e_1 to e_2 in Figure 5.10. Jackie works $H_2 - H_1$ fewer hours and consumes $N_2 - N_1$ more hours of leisure.

By drawing an imaginary budget constraint, L^*, that is tangent to her original indifference curve with the slope of the new wage, we can divide the total effect into

[13]Appendix 5B shows how to derive the labor supply curve using calculus.

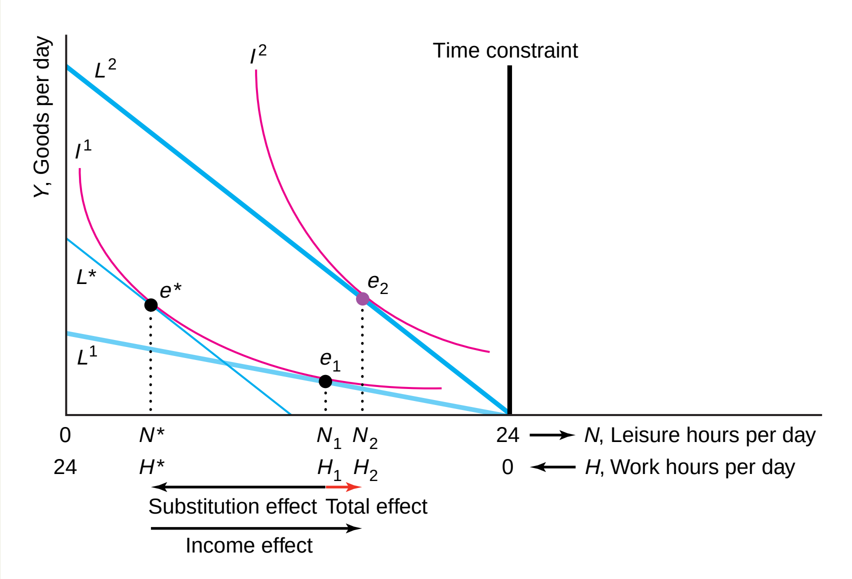


Figure 5.10 Income and Substitution Effects of a Wage Change. A wage change causes both a substitution and an income effect. The movement from e_1 to e^* is the substitution effect, the movement from e^* to e_2 is the income effect, and the movement from e_1 to e_2 is the total effect.

substitution and income effects. The *substitution effect*, the movement from e_1 to e^*, must be negative: A compensated wage increase causes Jackie to consume fewer hours of leisure, N^*, and work more hours, H^*.

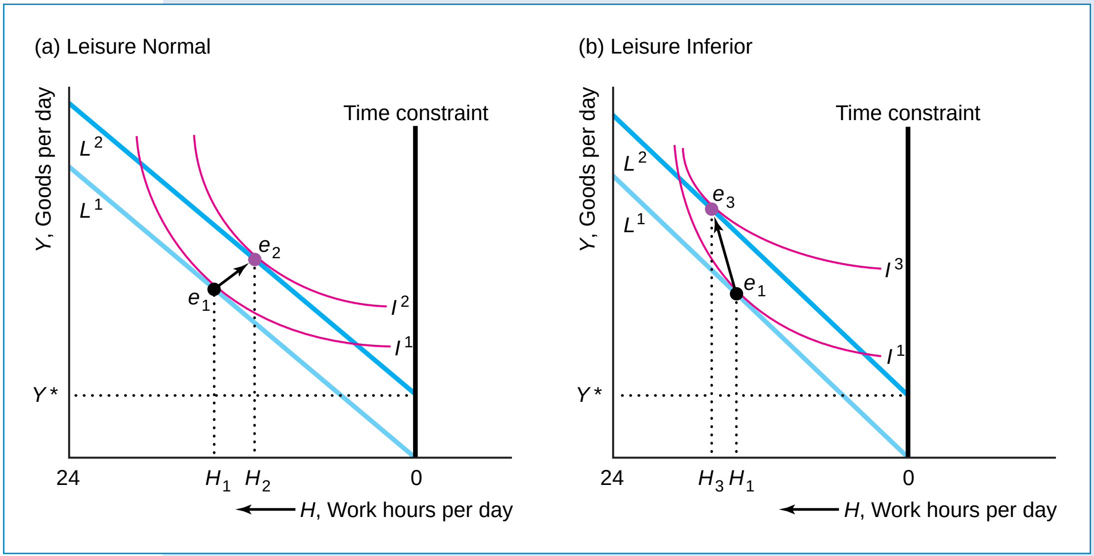
As the wage rises, if Jackie works the same number of hours as before, she has a higher income. The *income effect* is the movement from e^* to e_2. Because leisure is a normal good for Jackie, as her income rises, she consumes more leisure. When leisure is a normal good, the substitution and income effects work in opposite directions, so whether leisure demand increases or not depends on which effect is larger. Jackie's income effect dominates the substitution effect, so the total effect for leisure is positive: $N_2 > N_1$. Jackie works fewer hours as the wage rises, so her labor supply curve is backward bending.

If leisure is an inferior good, both the substitution effect and the income effect work in the same direction, and hours of leisure definitely fall. As a result, if leisure is an inferior good, a wage increase unambiguously causes the hours worked to rise.

5.3 **Enrico receives a no-strings-attached scholarship that pays him an extra *Y** per day. How does this scholarship affect the number of hours he wants to work? Does his utility increase?**

Answer

1. *Show his consumer equilibrium without unearned income:* When Enrico had no unearned income, his budget constraint, L^1 in the graphs, hit the hours-leisure axis at 0 hours and had a slope of $-w$.

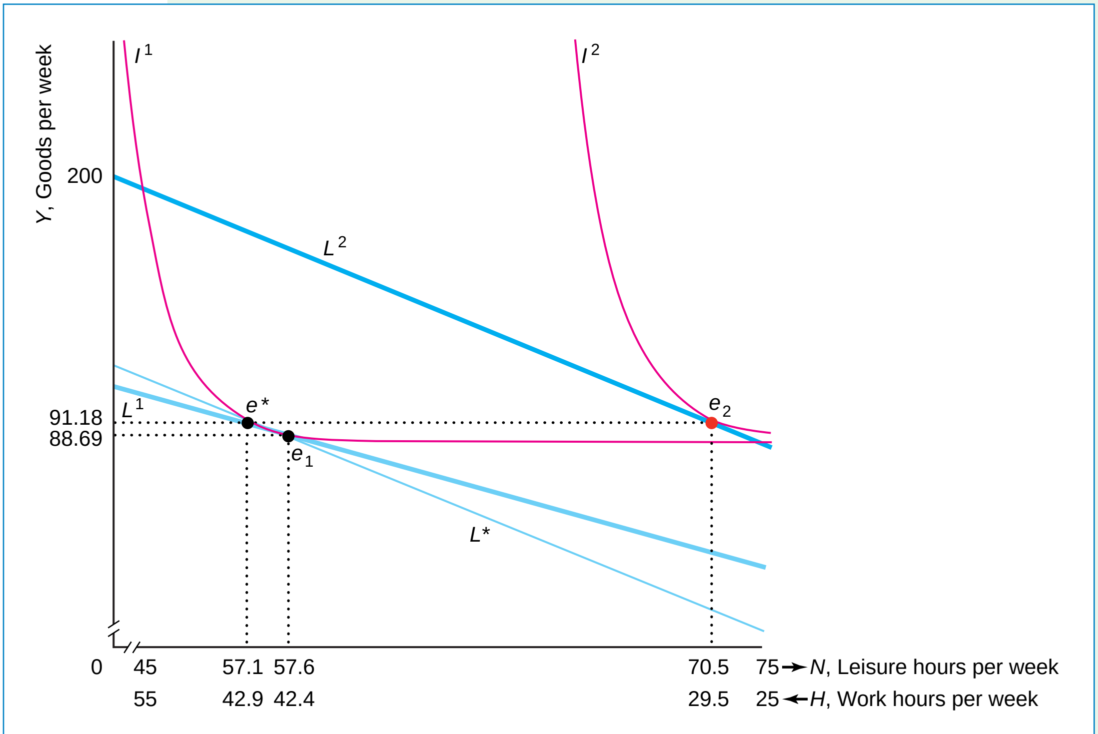


2. *Show how the unearned income affects his budget constraint:* The extra income causes a parallel upward shift of Y^*. His new budget constraint, L^2, has the same slope as before because his wage does not change. The extra income cannot buy Enrico more time, of course, so L^2 cannot extend to the right of the time constraint. As a result, L^2 is vertical at 0 hours up to Y^*: His income is Y^* if he works no hours. Above Y^*, L^2 slants toward the goods axis with a slope of $-w$.
3. *Show that the relative position of the new to the original equilibrium depends on his tastes:* The change in the number of hours he works depends on Enrico's tastes. Panels a and b show two possible sets of indifference curves. In both diagrams, when facing budget constraint L^1, Enrico chooses to work H_1 hours. In panel a, leisure is a normal good, so as his income rises, Enrico consumes more leisure than originally: He moves from Bundle e_1 to Bundle e_2. In panel b, he views leisure as an inferior good and consumes fewer hours of leisure than originally: He moves from e_1 to e_3. (Another possibility is that the number of hours he works is unaffected by the extra unearned income.)
4. *Discuss how his utility changes:* Regardless of his tastes, Enrico has more income in the new equilibrium and is on a higher indifference curve after receiving the scholarship. In short, he feels that more money is better than less.

Application

LEISURE-INCOME CHOICES OF TEXTILE WORKERS

Dunn (1977, 1978, 1979), using data obtained by questioning Southern cotton mill workers and examining their behavior, determined their indifference curves, which we can use to examine income and substitution effects. A typical worker's indifference curves are close to right angles (see the graph), indicating that leisure and all other goods are nearly perfect complements: The worker is relatively unwilling to substitute goods for leisure. (Workers' indifference curves vary only slightly by race and gender.)



At the original wage, \$2.09 per hour, the budget constraint is L^1 and a typical worker chooses to work 42.4 hours per week (assuming that there are 100 total hours to be allocated between work and leisure), Bundle e_1. An increase in the wage of \$1 per hour causes the budget constraint to rotate outward to L^2. An uncompensated increase in the wage increases the demand for leisure and reduces the hours worked to 29.5 per week, Bundle e_2. Thus workers' labor supply curves are backward bending: Workers decrease their hours as their wage rises. An increase in the wage from \$2.09 to \$3.09 leads to weekly earnings rising only from \$88.69 to \$91.18 because of the offsetting reduction in the hours worked.

What would happen if, when the wage increased, workers' incomes were reduced so that they remained on the original indifference curve, I^1? That is, what is the substitution effect for this \$1 wage increase? The imaginary budget constraint L^* is parallel to L^2 but tangent to indifference curve I^1 at e^*. Thus the substitution effect—the movement from e_1 to e^*—due to a compensated wage increase is an increase in weekly hours by half an hour a week to 42.9 hours. The income effect (the movement from e^* to e_2) is to work 13.4 (= 29.5 – 42.9) fewer hours a week.

Shape of the Labor Supply Curve

Whether the labor supply curve slopes upward, bends backward, or has sections with both properties depends on the income elasticity of leisure. Suppose that a worker views leisure as an inferior good at low wages and a normal good at high wages. As the wage increases, the demand for leisure first falls and then rises, and the hours supplied to the market first rise and then fall.

The budget line rotates upward from L^1 to L^2 as the wage rises in panel a of Figure 5.11. Because leisure is an inferior good at low incomes, in the new optimal bundle, e_2, this worker consumes less leisure and more goods than at the original bundle, e_1.

At higher incomes, however, leisure is a normal good. At an even higher wage, the new equilibrium is e_3, on budget line L^3, where the quantity of leisure demanded is higher and the number of hours worked is lower. Thus the corresponding supply curve for labor slopes upward at low wages and bends backward at higher wages in panel b.

Do labor supply curves slope upward or backward? Economic theory alone cannot answer this question: Both forward-sloping and backward-bending supply curves are *theoretically* possible. Empirical research is necessary to resolve this question.

Most studies (Killingsworth 1983, MaCurdy, Green, and Paarsch 1990) find that the labor supply curves for British and American men are virtually vertical because both the income and substitution effects are about zero. Studies find that wives' labor supply curves are also virtually vertical: slightly backward bending in Canada

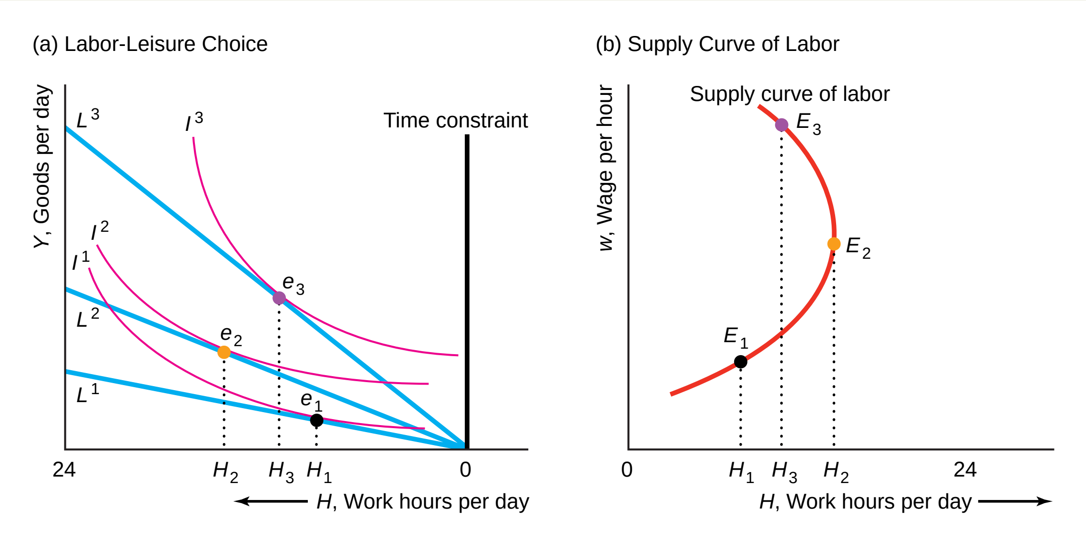


Figure 5.11 Labor Supply Curve That Slopes Upward and Then Bends Backward. At low incomes, an increase in the wage causes the worker to work more: the movement from e_1 to e_2 in panel a or from E_1 to E_2 in panel b. At higher incomes, an increase in the wage causes the worker to work fewer hours: the movement from e_2 to e_3 or from E_2 to E_3.

and the United States and slightly forward sloping in the United Kingdom and Germany. In contrast, studies of the labor supply of single women find relatively large positive supply elasticities of 4.0 and even higher. Thus, only single women tend to work substantially more hours when their wages rise.

Income Tax Rates and Labor Supply

Why do we care about the shape of labor supply curves? One reason is that we can tell from the shape of the labor supply curve whether an increase in the income tax rate—a percent of earnings—will cause a substantial reduction in the hours of work. Taxes on earnings are an unattractive way of collecting money for the government if supply curves are upward sloping because the taxes cause people to work fewer hours, reducing the amount of goods society produces and raising less tax revenue than if the supply curve were vertical or backward bending. On the other hand, if supply curves are backward bending, a small increase in the tax rate increases tax revenue *and* boosts total production (but reduces leisure).

Presidents John Kennedy Ronald Reagan, and George W. Bush argued that cutting the marginal tax rate (the percentage of the last dollar earned that the government takes in taxes) would stimulate people to work longer and produce more, both desirable effects. President Reagan claimed that tax receipts would increase due to the additional work.

Because tax rates have changed substantially over time, we have a natural experiment to test this hypothesis. The Kennedy tax cuts lowered the top personal marginal tax rate from 91% to 70%. Due to the Reagan tax cuts, the maximum rate fell to 50% from 1982 to 1986, 38.5% in 1987, and 28% in 1988–1990. The rate rose to 31% in 1991–1992 and 39.6% from 1993 to 2000. The Bush administration's Tax Relief Act of 2001 tax cut reduces this rate to 38.6% for 2001–2003, 37.6% for 2004–2005, and 35% for 2006 and thereafter.

Many other countries' central governments also lowered their top marginal tax rates in recent years. For example, Japan's rate fell from 88% in 1986 to 65% in 1994 and to 50% in 1999.

By 2001, according to the Organization for Economic Cooperation and Development (OECD), the highest marginal tax rate including both central (federal) and subcentral government taxes (state and local) in OECD (relatively developed) countries ranged from 35.6% in Turkey to 65.2% in Belgium. The top rate in the United States was 47.5%; in other countries the rates were New Zealand 39.0%, the United Kingdom 40.0, Iceland 43.1%, Canada 43.2%, Australia 48.5%, Japan 49.5%, the Netherlands 52.0%, and Denmark 63.3%.

The effect of a tax rate of $\tau = 0.28$ is to reduce the effective wage from w to $(1 - \tau)w = 0.72w$.[14] The tax reduces the after-tax wage by 28%, so a worker's budget constraint rotates downward, similar to rotating the budget constraint downward from L^2 to L^1, in Figure 5.11.

As we discussed, if the budget constraint rotates downward, the hours of work may increase or decrease, depending on whether leisure is a normal or an inferior good. The worker in panel b has a labor supply curve that at first slopes upward and then bends backward, as in panel b. If the worker's wage is very high, the worker is in the backward-bending section of the labor supply curve.

If so, the relationship between the marginal tax rate, τ, and tax revenue, τwH, is bell-shaped, as in Figure 5.12. At a zero tax rate, a small increase in the tax rate *must* increase the tax revenue, because no revenue was collected when the tax rate was zero. However, if the tax rate rises a little more, tax revenue must rise even higher, for two reasons. First, the government collects a larger percentage of every dollar earned because the tax rate is higher. Second, employees work more hours as the tax rate rises because workers are in the backward-bending section of their labor supply curves.

As the tax rate rises far enough, however, the workers are in the upward-sloping section of their labor supply curves. In this section, an increase in the tax rate reduces the number of hours worked. When the tax rate rises high enough, the reduction in hours worked more than offsets the gain from the higher rate, so tax revenue falls.

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[14]Under a progressive income tax system, the marginal tax rate increases with income. The average tax rate differs from the marginal tax rate. Suppose that the marginal tax rate is 20% on the first \$10,000 earned and 30% on the second \$10,000. Someone who earned \$20,000 would pay \$2,000 (= 0.2 × \$10,000) on the first \$10,000 of earnings and \$3,000 on the next \$10,000. That taxpayer's average tax rate is 25% (= [\$2,000 + \$3,000]/\$20,000). For simplicity in the following analysis, we assume that the marginal tax rate is a constant, τ, so that the average tax rate is also τ.

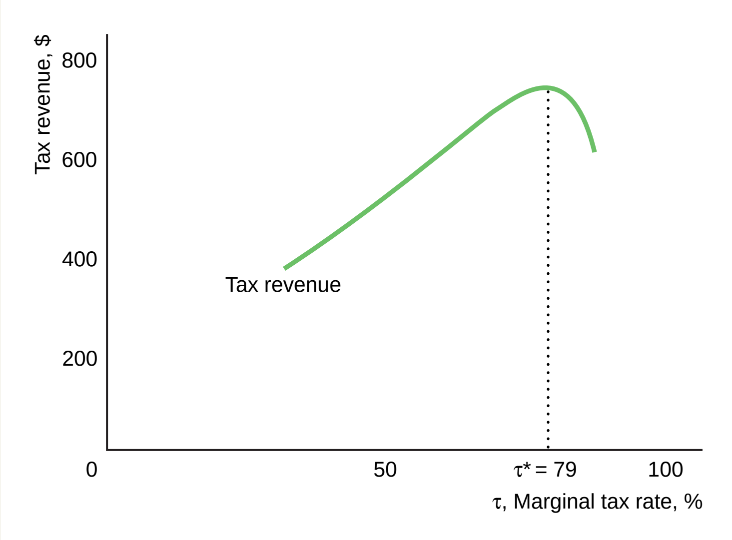

Figure 5.12 Relationship of Tax Revenue to Tax Rates. At marginal tax rates below τ^*, an increase in the rate leads to larger tax collections. At rates above τ^*, however, an increase in the marginal rate decreases tax revenue. These calculations (Fullerton, 1982, Table 1, p. 15) are based on the assumption that the labor supply elasticity with respect to the after-tax wage is 0.15 and that the labor demand curve is horizontal.

It makes little sense for a government to operate at very high marginal tax rates in the downward-sloping portion of this bell-shaped curve. The government could get more output *and* more tax revenue by cutting the marginal tax rate.

The marginal tax rate, t^*, that maximizes tax revenue is very high for the United States: Estimates range from 79% (Fullerton 1982) to 85% (Stuart 1984). Thus, the Kennedy era tax cuts from 91% to 70% raised tax revenue and increased work effort of top-income-bracket workers, but the Reagan era tax cut (in which the actual rate was only about half that of τ^*) had the opposite effect. Goolsbee (2000) examined the effect of higher taxes on corporate executives and found that even this extremely high-income group has little long-run response to tax changes.

WINNING THE GOOD LIFE

Would you stop working if you won a lottery jackpot or inherited a large sum? Economists want to know how unearned income affects labor supply because this question plays a crucial role in many government debates on taxes and welfare. For example, some legislators oppose negative income tax and welfare programs because they claim that giving money to poor people will stop them from working. Is that assertion true?

We could clearly answer this question if we could observe the behavior of a large group of people only some of whom were randomly selected to receive varying large payments of unearned income each year for decades. Luckily for us, governments conduct such experiments by running lotteries.

Imbens, Rubin, and Sacerdote (2001) compared the winners of major prizes and others who played the Massachusetts Megabucks lottery. Major prizes ranged from $22,000 to $9.7 million with an average of $1.1 million and were paid in yearly installments over two decades.

A typical player in this lottery earned $16,100. The average winner received $55,200 in prize money per year and chose to work slightly fewer hours so that his or her labor earnings fell by $1,877 per year. That is, winners increased their consumption and savings but did not substantially decrease how much they worked.

For every dollar of unearned income, winners reduced their work effort and hence their labor earnings by 11¢ on average. Men and women, big and very big prize winners, and people of all education levels behaved the same. However, there were differences by age of the winner and by income groups. People 55 to 65 reduced their effort by about a third more than younger people, presumably because they decided to retire early. Most important, people with no earnings in the year before winning the lottery tended to increase their labor earnings after winning.

Summary

1. **Deriving demand curves:** Individual demand curves can be derived by using the information about tastes contained in a consumer's indifference curve map. Varying the price of one good, holding other prices and income constant, we find how the quantity demanded varies with that price, which is the information we need to draw the demand curve. Consumers' tastes, which are captured by the indifference curves, determine the shape of the demand curve.
2. **How changes in income shift demand curves:** The entire demand curve shifts as a consumer's income rises. By varying income, holding prices constant, we show how quantity demanded shifts with income. An Engel curve summarizes the relationship between income and quantity demanded, holding prices constant.
3. **Effects of a price change:** An increase in the price of a good causes both a substitution effect and an income effect. The *substitution effect* is the amount by which a consumer's demand for the good changes as a result of a price increase when we compensate the consumer for the price increase by raising the individual's income by enough that his or her utility does not change. The substitution effect is unambiguous: A compensated rise in a good's price *always* causes consumers to buy less of that good. The *income effect* shows how a consumer's demand for a good changes as the consumer's income falls. The price rise lowers the consumer's opportunities, because the consumer can now buy less than before with the same income. The income effect can be positive or negative. If a good is normal (income elasticity is positive), the income effect is negative.
4. **Cost-of-living adjustments:** The government's major index of inflation, the Consumer Price

Index, overestimates inflation by ignoring the substitution effect. Though on average small, the substitution bias may be substantial for particular individuals or firms.

5. **Deriving labor supply curves:** Using consumer theory, we can derive the daily demand curve for leisure, which is time spent on activities other than work. By subtracting the demand curve for leisure from 24 hours, we obtain the labor supply curve, which shows how the number of hours worked varies with the wage. Depending on whether leisure is an inferior good or a normal good, the supply curve of labor may be upward sloping or backward bending. The shape of the supply curve for labor determines the effect of a tax cut. Empirical evidence based on this theory shows why tax cuts in the 1980s did not increase the tax revenue of individuals as predicted by the Reagan administration.

QUIZ

Questions

1. Derive the demand curve for Coke for a person who views Coke and Pepsi as perfect substitutes.
2. Derive the demand curve for pie for Barbara, who eats pie only à la mode and does not eat either pie or ice cream alone (pie and ice cream are complements).
3. Miguel views donuts and coffee as perfect complements: He always eats one donut with a cup of coffee and will not eat a donut without coffee or drink coffee without a donut. What does Miguel's Engel curve for donuts look like? How much does his weekly budget have to rise for Miguel to buy one more donut per week?
4. Don spends his money on food and on operas. Food is an inferior good for Don. Does he view an opera performance as an inferior or a normal good? Why? In a diagram, show a possible income-consumption curve for Don.
5. Under what conditions does the income effect reinforce the substitution effect? Under what conditions does it have an offsetting effect? If the income effect more than offsets the substitution effect for a good, what do we call that good?
6. Michelle spends all her money on food and clothing. When the price of clothing decreases, she buys more clothing.
   a. Does the substitution effect cause her to buy more or less clothing? Explain. (If the direction of the effect is ambiguous, say so.)
   b. Does the income effect cause her to buy more or less clothing? Explain. (If the direction of the effect is ambiguous, say so.)
7. Sofia consumes only coffee and coffee cake and consumes them only together (they are complements). By how much will a CPI over these two goods differ from the true cost-of-living index?
8. Do you expect that relatively more high-quality navel oranges are sold in California or New York? Why?
9. Draw a figure to illustrate the verbal answer given in Solved Problem 5.2. Use math and a figure to show how adding an *ad valorem* tax changes the analysis. [See the application "Shipping the Good Stuff Away."]
10. During his first year at school, Ximing buys eight new college textbooks at a cost of $50 each. Used books cost $30 each. When the bookstore announces a 20% price increase in new texts and a 10% increase in used texts for the next year, Ximing's father offers him $80 extra. Is Ximing better off, the same, or worse off after the price change? Why?
11. Under a welfare plan, poor people are given a lump-sum payment of $*L*. If they accept this welfare payment, they must pay a high tax, $\tau = \frac{1}{2}$, on anything they earn. If they do not accept the welfare payment, they do not have to pay a tax on their earnings. Show that whether an individual accepts welfare depends on the individual's tastes.
12. If an individual's labor supply curve slopes forward at low wages and bends backward at high wages, is leisure a Giffen good? If so, at high or low wage rates?
13. Suppose that Roy could choose how many hours to work at a wage of w and chose to work seven hours a day. The employer now offers him time-and-a-half wages ($1.5w$) for every hour he works

beyond a minimum of eight hours per day. Show how his budget constraint changes. Will he choose to work more than seven hours a day?

14. Jerome moonlights: He holds down two jobs. The higher-paying job pays w, but he can work at most eight hours. The other job pays w^*, but he can work as many hours as he wants. Show how Jerome determines how many hours to work.

15. Suppose that the job in Question 14 that had no restriction on hours was the higher-paying job. How do Jerome's budget constraint and behavior change?

16. Suppose that Joe's wage varies with the hours he works: $w(H) = \alpha H$, $\alpha > 0$. Show how the number of hours he chooses to work depends on his tastes.

17. David consumes only cookies and books. At his current consumption bundle, his marginal utility from books is 10 and from cookies is 5. Each book costs him $10, and each cookie costs $2. Is he maximizing his utility? Explain. If he is not, how can he increase his utility while keeping his total expenditure constant?

18. Illustrate that the Paasche cost-of-living index (see the application "Fixing the CPI Substitution Bias") overestimates the rate of inflation when compared to the true cost-of-living index.

19. *Review* (Chapter 4): Is a wealthy person more likely than a poor person to prefer a government payment of $100 in cash to $100 worth of food stamps? Why or why not?

Problems

20. Nadia likes spare ribs, R, and fried chicken, C. Her utility function is

$$U = 10R^2C.$$

What is her marginal utility of spare ribs function? She pays $10 for a slab of ribs and $5 for a chicken. What is her optimal consumption bundle? Show her optimal bundle in a diagram.

21. Steve's utility function is $U = BC$, where B = veggie burgers per week and C = packs of cigarettes per week. What is his marginal rate of substitution if veggie burgers are on the vertical axis and cigarettes are on the horizontal axis? Steve's income is $120, the price of a veggie burger is $2, and that of a pack of cigarettes is $1. How many burgers and how many packs of cigarette does Steve consume to maximize his utility? When a new tax raises the price of a burger to $3, what is his new optimal bundle? Illustrate your answers in a graph.

22. Roger's utility function is Cobb-Douglas, $U = B^{1/4}Z^{3/4}$, his income is Y, the price of B is p_B, and the price of Z is p_Z. Derive his demand curves. (*Hint*: See Appendixes 4A and 4B.)

23. Derive Roger's Engel curve for B for the utility given in Problem 22.

★24. Using calculus, show that not all goods can be inferior.

25. Using calculus, show the effect of a change in the wage on the amount of leisure an individual wants to consume. (*Hint*: See Appendix 5A.)

26. Answer the same question as in Problem 25 when the utility function is $U = Y^{\alpha}L^{1-\alpha}$.