# Consumers in the Marketplace

In Chapter 1, we told a simple but powerful story about demand, summarized in a single phrase: *When the price goes up, the quantity demanded goes down.*

In Chapter 3, we told a far more sophisticated story about demand: *When the price goes up, the budget line pivots inward and the consumer moves from one tangency to another.*

Our next task is to understand how these stories fit together. Do they always make the same predictions? If so, why? If not, which should we believe?

This chapter will tackle those questions. We will use the indifference curves and budget lines of Chapter 3 to reach a deeper understanding of the law of demand from Chapter 1.

Along the way, we'll learn a lot about how consumers respond to changing market conditions. It turns out that *income* changes are a little easier to analyze than *price* changes, so we'll start by studying income changes in Section 4.1. In Sections 4.2 and 4.3, we'll turn to the effects of price changes. Finally, in Section 4.4, we'll talk about some numerical measures of all these effects.

## 4.1 Changes in Income

In this section, we consider the effects of a change in income. In order to focus on a single good—call it *X,* which might stand for soft drinks or coffee or eggs—we will use the composite-good convention, lumping together everything except *X* into a single category called *all other goods.* This allows us to maintain the useful fiction that there are only two goods in the economy: There is *X,* and there is "all other goods," which we label *Y.*

### Changes in Income and Changes in the Budget Line

Let's think about how your budget line moves when your income rises.

Suppose you start with the *Original* budget line in Exhibit 4.1. You can afford any basket on this budget line, including, for example, the illustrated basket *G.*

If your income rises by $5, you can now afford to buy basket *G plus* $5 worth of good *Y.* That is, you can afford point *H.* So point *H* is on your new budget line.

**EXHIBIT 4.1**     **A Rise in Income**
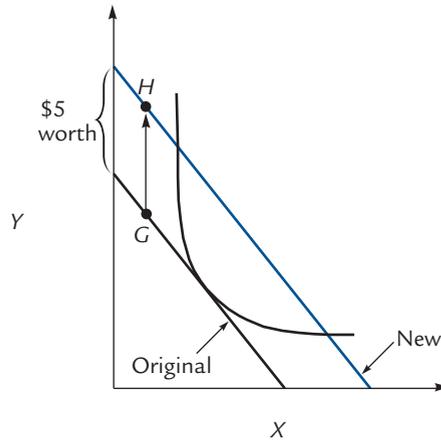


When your income increases by $5, the budget line shifts out parallel to itself. For each point on the original budget line (like *G*), there is a point on the new budget line (like *H*) which consists of basket *G* plus an additional $5 worth of *Y.*

(If the price of *Y* is $1 per unit, then the vertical arrow in Exhibit 4.1 has length 5; if the price of *Y* is $2 per unit, then the vertical arrow has length 2½; if the price of *Y* is 1¢ per unit, then the vertical arrow has length 500.)

More generally, given *any* point on your old budget line, you can add $5 worth of *Y* and get a point on your new budget line. So the vertical distance between the two budget lines is always the same "$5 worth." Because this distance is always the same, it follows that the new budget line is parallel to the original.

A change in income causes a parallel shift of the budget line.

**Exercise 4.1** Draw the new budget line that would result from a $5 fall in income.

There is another way to see that a change in income causes a parallel shift of the budget line. Recall from Section 3.2 that the equation of the budget line can be written

$$y = \frac{P_X}{P_Y} \cdot x + \frac{I}{P_Y}$$

so that a change in income (*I*) does not affect the slope ($-P_X/P_Y$). A change in income affects only the *Y*-intercept of the budget line, which is another way of saying that a change in income causes a parallel shift.
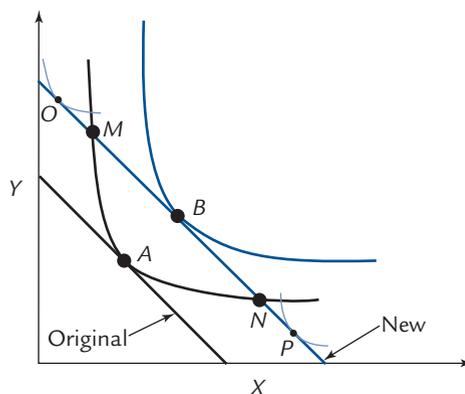
## Changes in Income and Changes in the Optimum Point

When your income rises by $5, your budget line shifts out as in Exhibit 4.1. What happens to your optimum point?

In Exhibit 4.2, we suppose that your original optimum point is *A,* where the original budget line (in black) is tangent to the black indifference curve. Now your income

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| EXHIBIT **4.2** | **A Rise in Income** |
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An increase in income causes the budget line to shift outward. If the original tangency is at *A,* then the new tangency cannot be at *O* or *P,* as either possibility would require two indifference curves to cross. (The curves that are shown tangent at these points cannot be indifference curves because they must cross the original black indifference curve.) Instead, the new tangency is at a point like *B.*

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rises by $5, causing your budget line to shift out; the new budget line is shown in color. Where can the new tangency be?

The tangency *cannot* be at point *O.* Here's why: If an indifference curve were tangent at *O,* it would be forced to cross the black indifference curve, which cannot happen. (The lightly colored curve shown tangent at *O cannot* be an indifference curve, because it crosses the black indifference curve that is tangent at *A.*) Likewise, the tangency cannot be at point *P.* Instead, the tangency must occur somewhere between points *M* and *N* on the new budget line, at a point like *B.*

## Normal and Inferior Goods

If point *B* is located as in Exhibit 4.2, then a rise in income causes your consumption of *X* to rise. This is because point *B* is to the right of point *A,* so it corresponds to a basket with more *X.*

But alternative pictures are possible. Exhibit 4.3 shows two possibilities. Point *B* could be to the right of *A,* as in the first panel, or point *B* could be to the left of *A,* as in the second panel. In the first case, a rise in income leads you to consume more *X,* and we say that *X* is a **normal good.** In the second case, a rise in income leads you to consume *less X,* and we say that *X* is an **inferior good.**

For example, it is entirely likely that if your income rises, you will consume less Hamburger Helper. That makes Hamburger Helper an inferior good.

**Normal good**

A good that you consume more of when your income rises.

**Inferior good**

A good that you consume less of when your income rises.

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The word *inferior* is used differently here than in ordinary English. In ordinary English, *inferior* is a term of comparison; you can't call something inferior without saying what it is inferior to; as a student, you can be inferior to some of your classmates and superior to others. But in economics, a good either is or is not inferior, and inferiority does not have the negative connotations that it has in everyday speech.

Dangerous Curve

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**EXHIBIT 4.3**  **Normal and Inferior Goods**
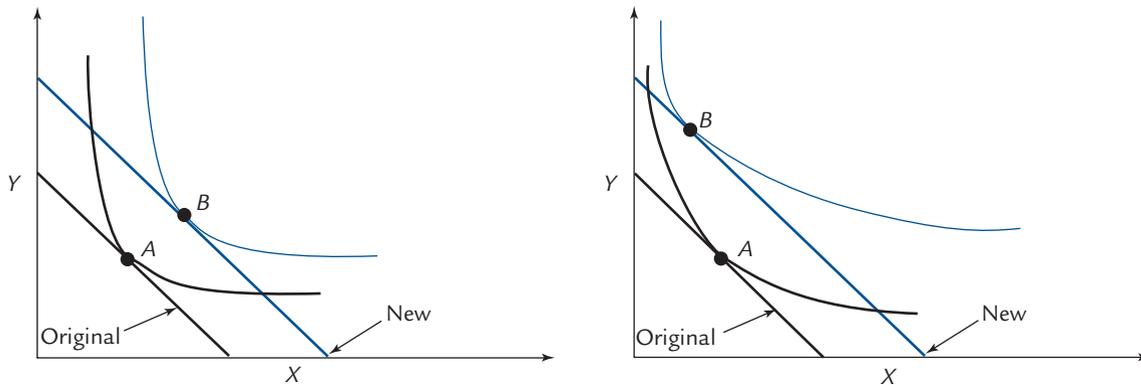
Suppose your original tangency is at *A* and your income increases. Then your new tangency *B* could be either to the right of *A* (as in the first panel) or to the left of *A* (as in the second panel). In the first case, a rise in income leads you to consume more *X* and we call *X* a normal good. In the second case, a rise in income leads you to consume less *X* and we call *X* an inferior good.

**Exercise 4.2** In the first panel of Exhibit 4.3, is *Y* an inferior good? What about in the second panel? Where must the tangency *B* be located if *Y* is an inferior good?

## The Engel Curve

**Engel curve**

A curve showing, for fixed prices, the relationship between income and the quantity of a good consumed.

Beth is a consumer who buys eggs and root beer. Her **Engel curve** for eggs is a graph that shows how many eggs she'll consume at each level of income. You can see her Engel curve in the second panel of Exhibit 4.4. When her income is $4, she consumes 3 eggs; when her income is $8, she consumes 6 eggs, and so on.

It turns out that if we know the prices of eggs and root beer, and if we know Beth's indifference curves, then we can *figure out* the coordinates of the points on her Engel curve. For example, suppose we know that the price of an egg is 50¢, the price of a root beer is $1, and Beth's indifference curves are the curves shown in Exhibit 4.4A.

To construct a point on Beth's Engel curve, we follow a five-step process:

1. Imagine an income for Beth—say, $4.

2. Draw the corresponding budget line. In this case, given our assumptions about the prices of eggs and root beer, Beth can afford up to 8 eggs (with no root beer) or 4 root beers (with no eggs). Therefore, her budget line is the one labeled "$4 income" in Exhibit 4.4A.

3. Find the tangency between this budget line and an indifference curve. (We can do this because we've assumed that we *know* Beth's indifference curves.) In this case, the tangency occurs at point A.

4. Read off the corresponding quantity of eggs—in this case, 3.

5. Plot the point on the Engel curve, relating the income in step 1 to the quantity in step 4. In this case, we get the point A′ = ($4, 3), illustrated in Exhibit 4.4B.

To get *another* point on Beth's Engel curve, repeat the entire five-step process, beginning with a different income. If you imagine the income $8 in step 1, you'll be led to the quantity 6 in step 4, and you'll plot the point *B′* in step 5.

EXHIBIT **4.4**    **Constructing the Engel Curve**

A. Beth's indifference curve

B. Beth's Engel curve
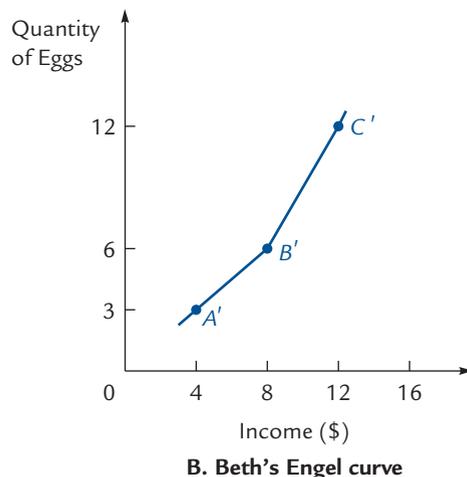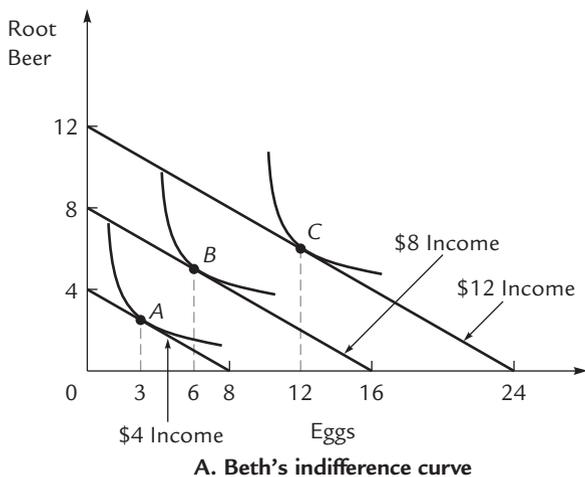
Points *A, B,* and *C* in the first panel show Beth's optima at a variety of incomes. (The prices of eggs and root beer are held fixed at 50¢ and $1, respectively.) Points *A', B',* and *C'* in the second panel record the quantity of eggs that Beth consumes for each of three incomes; these quantities are the horizontal coordinates of points *A, B,* and *C.* The curve through *A', B',* and *C'* is Beth's Engel curve for eggs.

**Exercise 4.3** Explain how to derive the coordinates of point *C'* in Exhibit 4.4B.

The moral of this story is that *the Engel curve contains no information that is not already encoded in the indifference curve diagram.* Once we know the indifference curves, we can generate the Engel curve by a purely mechanical process.

## The Shape of the Engel Curve

The Engel curve in Exhibit 4.4B is upward sloping. In other words, when Beth's income rises, she consumes more eggs. Thus, eggs are a normal good for Beth.

In general, the Engel curve will slope upward for a normal good and downward for an inferior good. If eggs were an inferior good for Beth, then the tangency *B* in Exhibit 4.4A would occur somewhere to the *left* of the tangency *A*—say, with a horizontal coordinate of 2. This would yield the point *B'* = ($8, 2) in Exhibit 4.4B, and the curve through *A'* and *B'* would slope downward.
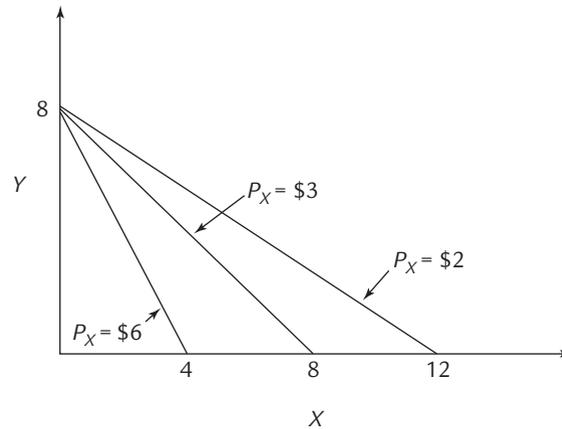
# 4.2 Changes in Price

We now shift our attention from changes in income to changes in the price of *X*.

## Changes in Price and Changes in the Budget Line

To focus attention on changes in the price of *X*, we assume that your income and the price of *Y* remain fixed. For example, suppose the price of *Y* remains fixed at $3 per unit

EXHIBIT **4.5**    **Changes in the Price of _X_**

The price of _Y_ is fixed at $3 and income is fixed at $24. A rise in the price of _X_ causes the budget line to pivot inward around its _Y_-intercept, and a fall in price causes the budget line to pivot outward around its _Y_-intercept.

and your income remains fixed at $24. Exhibit 4.5 shows the budget lines that result when the price of _X_ is $2, $3, and $6.

**Exercise 4.4** Verify that the budget lines have been drawn correctly.

There are two important things to notice in Exhibit 4.5. First, a change in the price of _X_ has no effect on the _Y_-intercept of the budget line. When you buy zero _X_s, you can always afford exactly 8 _Y_s, regardless of what happens to the price of _X_. Thus:

A change in the price of _X_ causes the budget line to pivot around its _Y_-intercept.

The second important thing to notice is the direction in which the budget line pivots. When the price of _X_ is low (like $2), the budget line extends out to a high quantity of _X_ (in this case, 12); when the price of _X_ is high (like $6), the budget line extends out only to a low quantity of _X_ (in this case, 4). Thus:

A rise in the price of _X_ causes the budget line to pivot inward. A fall in the price of _X_ causes the budget line to pivot outward.

## Changes in Price and Changes in the Optimum Point

When the price of _X_ rises, your budget line pivots inward, as shown in Exhibit 4.6.
The geometry of Exhibit 4.6 places no restrictions on the location of the new optimum point; it could be anywhere at all on the new budget line. Now we're going to think a little more deeply about the location of that new optimum.

### Giffen and Ordinary Goods

Exhibit 4.7 illustrates two possibilities. In both cases, a rise in the price of _X_ causes the optimum point to shift from _A_ to _B_. In the first panel, _B_ lies to the left of _A;_ in the second panel, _B_ lies to the right of _A_.

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EXHIBIT **4.6**    **A Price Increase**
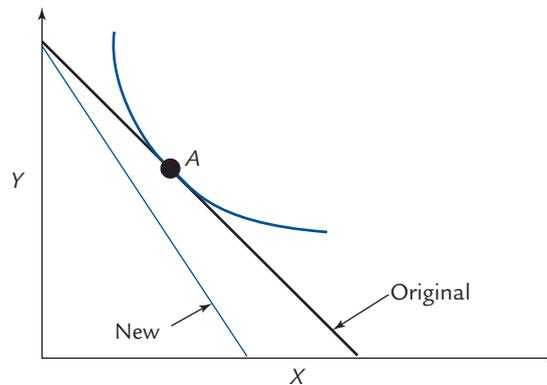
A rise in price causes the budget line to pivot inward. The original optimum is at *A,* and the new optimum could be anywhere at all on the new (brown) budget line.

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In the first panel, you can see that when the price of *X* goes up, the quantity demanded goes down (from $Q_A$ to $Q_B$). That statement should sound familiar; it is the same law of demand that we met in Chapter 1.

In the second panel, you can see that when the price of *X* goes up, the quantity demanded goes *up*! In this case, *X* violates the law of demand.

Goods that violate the law of demand (like good *X* in the second panel of Exhibit 4.7) are called **Giffen goods.** Goods that obey the law of demand (like good *X* in the first panel of Exhibit 4.7) are called **ordinary goods.**

**Giffen good**

A good that violates the law of demand, so that when the price goes up, the quantity demanded goes up.

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Do not confuse the question "Is *X* Giffen?" with the question "Is *X* inferior?" To determine whether *X* is inferior, you must ask what happens when *income* changes, so that the budget line undergoes a parallel shift (as in the two panels of Exhibit 4.3). To determine whether *X* is Giffen, you must ask what happens when the price of *X* changes, so that the budget line pivots around its *Y*-intercept, as in the two panels of Exhibit 4.7.

Dangerous Curve

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In the panels of Exhibit 4.7, it is not possible to tell by inspection whether *Y* is a Giffen good. To determine whether *Y* is Giffen, we have to ask what happens to the consumption of *Y* when there is a change in the price of *Y*. But the graphs in Exhibit 4.7 illustrate a change in the price of *X,* not a change in the price of *Y.*

Dangerous Curve

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**Exercise 4.5** Draw a graph illustrating how the budget line shifts when the price of *Y* rises. Draw the original optimum. Where is the new optimum located if *Y* is not a Giffen good? Where is the new optimum located if *Y* is a Giffen good?

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## A Puzzle: Why Are Giffen Goods so Rare?

Giffen goods are extremely uncommon; in fact, they are so uncommon that the author of your textbook does not know of a single actual instance. That's why the law of demand is called a *law*—it is virtually always obeyed.
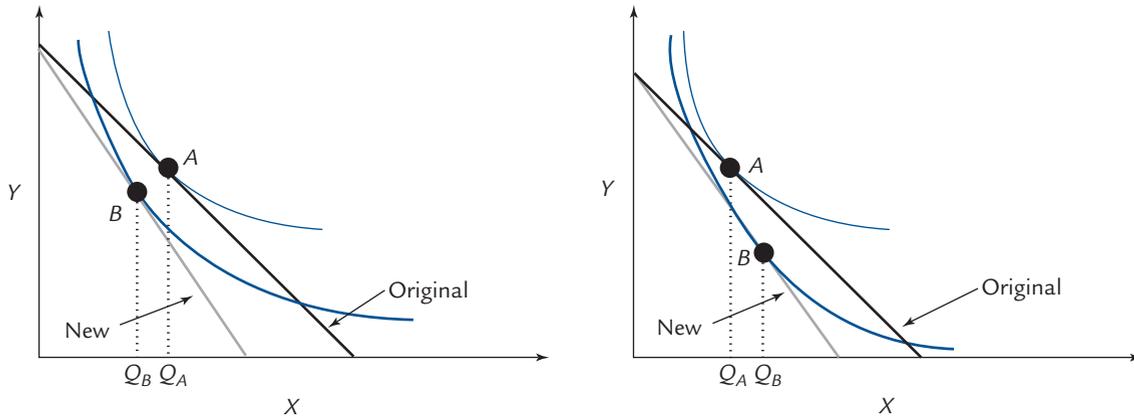
**Ordinary good**

A good that obeys the law of demand: When the price goes up, the quantity demanded goes down.

EXHIBIT **4.7**   **Ordinary Goods and Giffen Goods**

When the price of *X* goes up, the budget line pivots inward. The optimum moves from point *A* to point *B* and the quantity of *X* that you demand changes from $Q_A$ to $Q_B$. In the first panel, $Q_B$ is less than $Q_A$; in other words "when the price goes up the quantity demanded goes down," as required by the law of demand. In the second panel, $Q_B$ is greater than $Q_A$, so that "when the price goes up the quantity demanded goes *up*," in violation of the law of demand. When the law of demand is violated, *X* is called a Giffen good.

The theory of indifference curves tells us that there *can* be exceptions to the law of demand—in other words, it is possible to draw a picture like the second panel of Exhibit 4.7. But experience tells us that although such exceptions are possible, they are either extremely rare or completely nonexistent. And therein lies a puzzle. If the theory allows Giffen goods to exist, why don't they?

We will return to this puzzle—and solve it—near the end of Section 4.3.

## The Demand Curve

Let us return our attention to Beth, who buys eggs and root beer. Just as Beth's Engel curve shows the relation between her income and her egg consumption, so her demand curve shows the relation between the price of eggs and her egg consumption.

**Dangerous Curve**

The Engel curve plots income on the horizontal axis versus egg consumption on the vertical; the demand curve plots the price of eggs on the vertical axis versus egg consumption on the horizontal.

Like the Engel curve, the demand curve can be derived from the indifference curve diagram. If we know Beth's income, the price of root beer, and her indifference curves, then we can construct her demand curve for eggs.

The process is illustrated in Exhibit 4.8, where we assume that the price of root beer is $3 and Beth's income is $24; thus, the vertical intercept of her budget line is at 8 root beers.

To construct a point on Beth's demand curve, we follow a five-step process:

1. Imagine a price for eggs—say, $2.

2. Draw the corresponding budget line. Given our assumption that Beth's income is $24, she can afford up to 12 eggs (with no root beer). Thus, her budget line has horizontal intercept 12, as illustrated in Exhibit 4.8A.

## EXHIBIT 4.8 — Constructing the Demand Curve
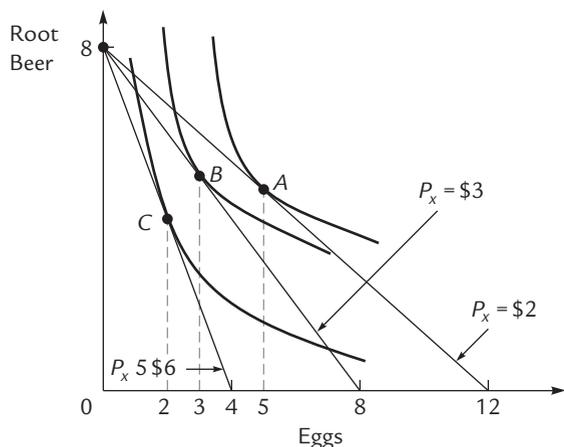


**A. Beth's influence curves**

**B. Beth's demand curve**

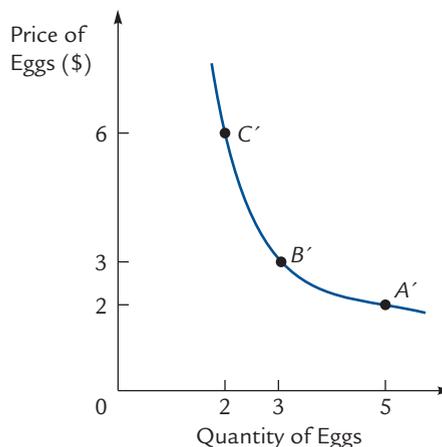When the price of eggs is $2 apiece, Beth chooses basket *A,* with 5 eggs. This information is recorded by point *A′* in the second panel. Points *B′* and *C′* are derived similarly. The curve through *A′*, *B′*, and *C′* is Beth's demand curve for eggs.

3.  Find the tangency between this budget line and an indifference curve. In this case, the tangency occurs at point *A.*

4.  Read off the corresponding quantity of eggs—in this case, 5.

5.  Plot a point on the demand curve relating the price in step 1 to the quantity in step 4. In this case we get the point *A′* in Exhibit 4.8B.

To get *another* point on Beth's demand curve, repeat the entire five-step process, beginning with a different price for eggs. If you imagine the price $3 in step 1, you'll be led to the quantity 3 in step 4, and you'll plot the point *B′* in step 5.

**Exercise 4.6** Explain how to derive the coordinates of point *C′* in Exhibit 4.8B.

As with the Engel curve, we now know that *the demand curve contains no information that is not already encoded in the indifference curve diagram.* Once we know the indifference curves, we can generate the demand curve by a purely mechanical process.

Students sometimes attempt to draw the demand curve and the indifference curves on the same graph. This cannot be done correctly because the two diagrams require different axes (quantities of goods *X* and *Y* for the indifference curves; quantity and price of good *X* for the demand curve).

Other students sometimes think that the labeled points in Exhibit 4.8A illustrate the shape of the demand curve. This is also incorrect. It is true that each point on the demand curve arises from a point in the indifference curve diagram, but translating from one diagram to the other is not simply a matter of copying points. The only way to go from one diagram to the other is via the five-step process just described.

Dangerous
Curve

### The Shape of the Demand Curve

In Exhibit 4.8, eggs obey the law of demand; therefore, the demand curve for eggs slopes down. If eggs were a Giffen good, then the tangency *B* would be to the *right* of *A,* say, at a quantity of 7. Then the point *B′* on the demand curve would have horizontal coordinate 7 and the demand curve would slope upward.

# 4.3  Income and Substitution Effects

We have a puzzle to solve: Why, in the real world, do there seem to be essentially no Giffen goods? It would be very satisfying to answer this question by saying that the geometry of indifference curves makes Giffen goods impossible. Unfortunately, that is not the case. Exhibit 4.7 showed that there is no geometric obstruction to the existence of a Giffen good.

So the solution to our puzzle will require an argument that goes beyond geometry. We will start with a purely verbal discussion of two distinct reasons why the law of demand "ought" to hold. After we've understood these effects in words, we will translate our words into geometry and then tie the two approaches together.

## Two Effects of a Price Increase

When the price of a good goes up, we typically expect the quantity demanded to fall. There are two separate, good reasons for this expectation, called the *substitution effect* and the *income effect*.

### The Substitution Effect

Suppose you're in the habit of buying 5 hamburgers a day at $2 apiece. If the price goes up to $3 apiece, you might decide that fifth hamburger is simply not worth the money, and therefore cut back to 4 hamburgers a day. That's the **substitution effect of a price increase.**

**Substitution effect of a price increase**

A change in consumption due to the fact that you won't buy goods whose marginal value is below the new price.

To put this a little more precisely: We know that each of your five hamburgers must have a marginal value (to you) of at least $2; otherwise you wouldn't have been buying them all along. But their marginal values are not all identical; the second hamburger is worth less than the first, and the third is worth less than the second. So it's entirely possible that the first four hamburgers are worth more than $3 each (to you) and the fifth hamburger is worth less than $3. That's why you still eat some hamburgers, but not as many as before.

So the substitution effect comes down to this: When the price of a good rises, you adjust your consumption downward so as to avoid buying goods whose price is now above their marginal value.

When the price of a good goes up, the substitution effect leads you to consume less of it.

### The Income Effect

Now we will describe the income effect of a price increase.

Suppose the price of hamburgers rises. Then, because you can't spend more than your entire income, you'll have to consume less of *something.* (Another way to say this is that your old basket is outside your new budget line, so you'll have to choose a new

basket.) It's then quite likely—though not certain—that hamburgers themselves will be among the goods you cut back on.

We can be more precise about this: The fact that you can no longer afford your original basket is tantamount to a change in *income;* in a very real sense, a price increase makes you *poorer.* When you become poorer, you reduce your consumption of all normal goods, though you increase your consumption of inferior goods.

That's the **income effect of a price increase:** When the price of hamburgers rises, you are effectively poorer and therefore consume either fewer hamburgers (if hamburgers are a normal good) or more hamburgers (if hamburgers are an inferior good).

When the price of a good goes up, the income effect leads you to consume either less of it (this happens if the good is normal) or more of it (this happens if the good is inferior).

## Isolating the Substitution Effect: An Imaginary Experiment

When the price of candy bars goes up, Albert buys fewer candy bars. At the old (low) price, he might have bought 8, but at the new (high) price, he buys only 3. Question: How much of that reduction is due to the income effect and how much to the substitution effect?

So far, we have no way to tell. As soon as the price rises, Albert feels both effects simultaneously and responds to both of them simultaneously. All we see is the combined response. Of the 5 candy bars he gave up, were 2 due to the income effect and 3 to the substitution effect? Or 3 and 2? Or 1 and 4? Anything is possible.

So let's try a little experiment. Our goal is to *make the income effect go away* so that we can observe the substitution effect in isolation. How can we do this?

Well, why is there an income effect in the first place? It's because Albert, faced with higher prices, feels poorer. How can we make that effect go away? Obviously, by making him feel richer. How can we do that? Obviously, by giving him money.

So let's arrange the following experiment. We raise the price of candy bars. At the same time, we leave a few quarters on the ground for Albert to find. When he pushes his shopping cart down the candy aisle, he gets two surprises at once: The price has risen (which makes him feel poorer) and he's found some money (which makes him feel richer). If we leave him *exactly the right amount* of money, those effects will cancel, and he'll feel just as rich as he felt an hour ago. He'll feel no income effect. Now whatever he does is due to the pure substitution effect. If he puts, say, 5 candy bars in his cart instead of his usual 8, then we can conclude that the substitution effect causes him to give up exactly 3 candy bars.

At this point, we can walk up to Albert, tap him on the shoulder, and say: "Excuse me, but I believe those are my quarters." He returns the money, goes back to feeling poorer, and returns 2 of his 5 candy bars to the shelf, keeping 3. This movement is entirely a result of his feeling poorer, so we're seeing the pure income effect, which we now know is responsible for his giving up exactly 2 candy bars.

## Visualizing the Imaginary Experiment

Exhibit 4.9 illustrates our imaginary experiment. In panel A, Albert enters the grocery store expecting to find candy bars on sale at their traditional price. He therefore expects to have the *Original* budget line, where his tangency is at point *A* and he buys 8 candy bars. But when he arrives at the candy aisle, he sees that the price has risen. This causes his budget line to pivot in to the location of the *New* budget line, where his tangency is at *B.* He therefore buys 3 candy bars. *The reduction from 8 to 3 is due to the income and substitution effects combined.*

**Income effect of a price increase**

A change in consumption due to the fact that you can no longer afford your original basket and are therefore effectively poorer.

That didn't help us distinguish one effect from the other, so we start all over again. This time, we leave some quarters for Albert to find just at the moment when he notices the price increase. The price increase still pivots his budget line in to the *New* location, but then the cash windfall shifts that budget line outward, parallel to itself.

How far out does the budget line shift? That depends on how much cash we give him. How much cash should we give him? Enough to just cancel the income effect. How much is that? Enough to leave him feeling neither richer nor poorer than he was an hour ago. What exactly does that mean? The notion of "feeling richer" is a little vague, but we can interpret it to mean that Albert should be *exactly as happy* as he was an hour ago. In other words, we give him *just enough cash so that he can reach a tangency on his* Original *budget line.*

In panel B of Exhibit 4.9, this means that we give him just enough cash to shift his *New* budget line until it's tangent to his original indifference curve. Think of the *New* line as gradually shifting outward as we leave more and more money for Albert to find; we stop adding to the pile when the budget line just touches the upper indifference curve at a tangency which we label *C.* The resulting budget line is called Albert's *Compensated* budget line, because the additional income exactly compensates for the price increase (in the sense that it leaves him just as happy as he was an hour ago).

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**Dangerous Curve**

When they shift the *New* budget line outward, students sometimes try to make it tangent to the upper indifference curve at point *A.* This can't be correct, because the *Original* budget line is already tangent there. Two different lines cannot be tangent to the same curve at the same point.

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Having discovered both the price increase *and* the cash, Albert is now on his *Compensated* budget line, where he chooses point *C,* with 5 candy bars. The movement from *A* to *C*—that is, the movement from 8 candy bars to 5—is a pure substitution effect.

Now is when we give Albert the bad news that he doesn't get to keep the cash he found. This shifts his budget line back from the *Compensated* location to the *New* location. He shifts from point *C* to point *B,* or in other words from 5 candy bars to 3. This is the pure income effect.

## Sorting It All Out

In ordinary circumstances, Albert does his shopping without a mad experimenter following in his wake. Therefore, in ordinary circumstances, panel A of Exhibit 4.9 tells the whole story. The price of candy rises, Albert feels two effects at once, and he moves to point *B* because of the two effects combined—as indicated by the horizontal arrow in panel C of the exhibit.

But even though Albert moves directly from *A* to *B,* we can always *imagine* that for a brief moment he received some additional cash, moving him to *C,* and then the additional cash was taken away from him, moving him back to *B* again. The first move is the pure substitution effect and the second move is the pure income effect, as indicated by the other two arrows in panel C.
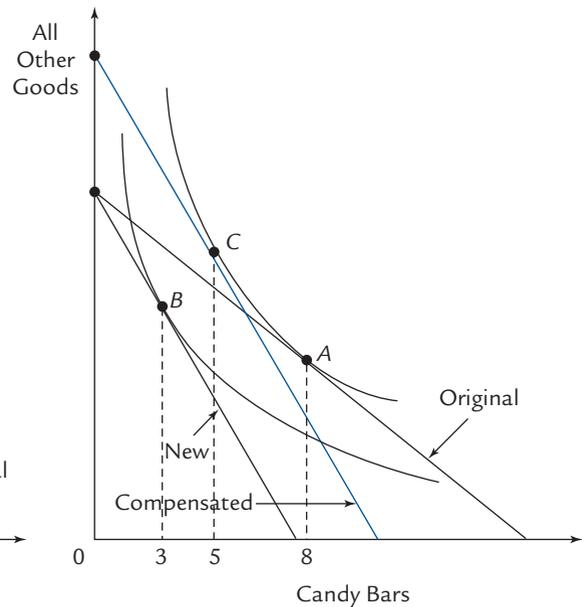
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**Dangerous Curve**

Notice that a price change causes *two* effects whereas a price change accompanied by an offsetting income increase causes *one* effect.
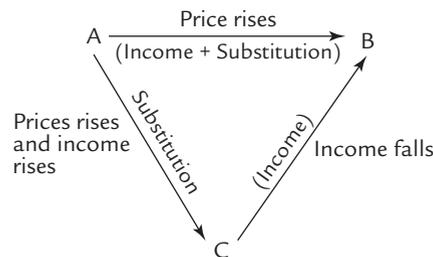
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## EXHIBIT 4.9    Income and Substitution Effects



**A.  A price increase**



**B.  Income compensation**



**C.  Schematic**

Albert starts with the *Original* budget line and chooses tangency A. If the price of candy bars increases, the budget line pivots in to the *New* location and he chooses tangency B. The move from A to B is caused by the income and substitution effects together, as indicated by the horizontal arrow in panel C.

In panel B, we imagine that Albert's income rises at the same moment that he discovers the candy price increase. This shifts his *New* budget line out parallel to itself. The more his income rises, the further the budget line shifts.

We assume that either by coincidence or through the design of a mad experimenter, Albert's budget line shifts until it *just touches* his original indifference curve, giving him a new tangency at point C. The resulting budget line is labeled *Compensated* because the income increase just compensates him for the price increase, leaving him just as happy as he was an hour ago. The movement from A to C is a pure substitution effect, as indicated by the downward sloping arrow in panel C.

If Albert then loses his newfound income, he returns to the *New* budget line and point B; this move from C to B is a pure income effect.

In reality, Albert is not compensated for price changes, so he moves directly from A to B. But to separate the substitution and income effects, we can always *imagine* that he moves first to C and then to B.

**Exercise 4.7** Suppose the price of candy bars were to fall. Draw a diagram analogous to Exhibit 4.9 showing how Albert's consumption changes and separating the change into a substitution effect and an income effect. (*Hint:* When the price of candy bars falls, Albert feels happier than before. To eliminate the income effect, you have to "compensate" him negatively, by taking income away until he is no happier than before.)
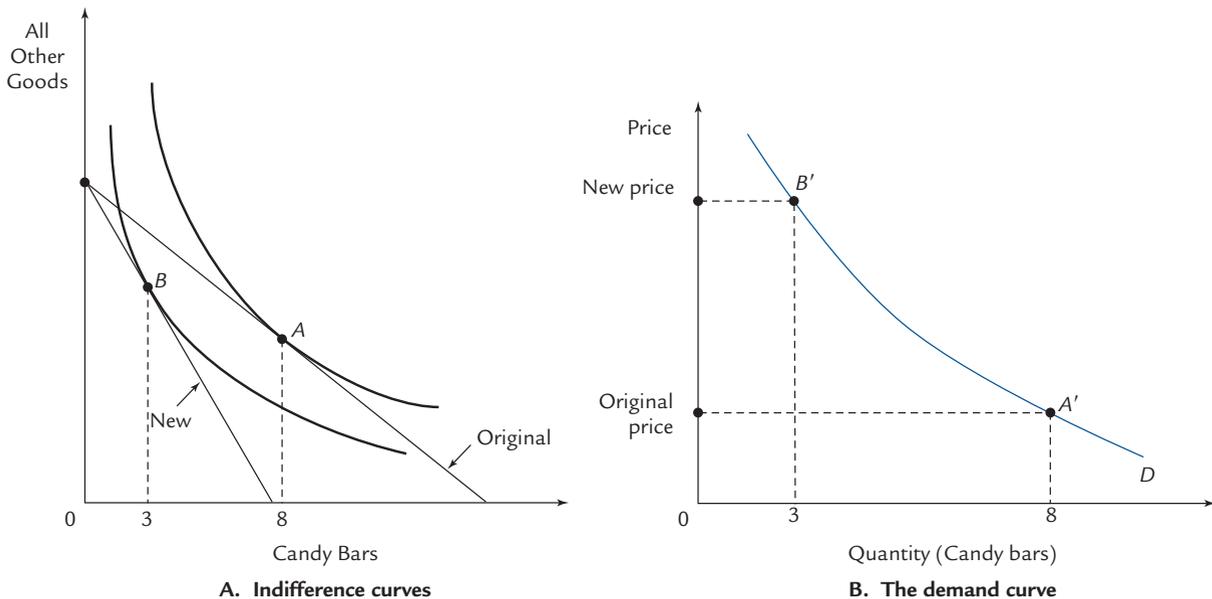
## Why Demand Curves Slope Downward

Exhibit 4.10 is a reminder that the shape of the demand curve depends on the configuration of the indifference curves. At the *original* price of candy bars, Albert chooses tangency *A* and buys 8 candy bars; this is recorded by point *A′* on the demand curve. At the higher *new* price of candy bars, Albert chooses tangency *B* and buys 3 candy bars. This is recorded by point *B′* on the demand curve.

Why does the demand curve slope downward? Because point *B′* (corresponding to the higher price) is to the *left* of point *A′*. (That is, higher prices go with lower quantities.) Why is *B′* to the left of *A′*? Because *B* is left of *A* on the indifference curve diagram.

So, if you want to know why demand curves slope downward, you've got to ask: Why is *B* to the left of *A*? Here's where we can use what we've learned about income and substitution effects.

EXHIBIT **4.10**     **Why Demand Curves Slope Downward**



A.  **Indifference curves**          B.  **The demand curve**

Points *A* and *B* on the indifference curve diagram give rise to points *A′* and *B′* on the demand curve diagram. The demand curve slopes downward because *B′* is to the left of *A′*. In turn, *B′* is to the left of *A′* because *B* is to the left of *A*. So asking "Why do demand curves slope downward?" is the same as asking "Why is *B* to the left of *A*?"
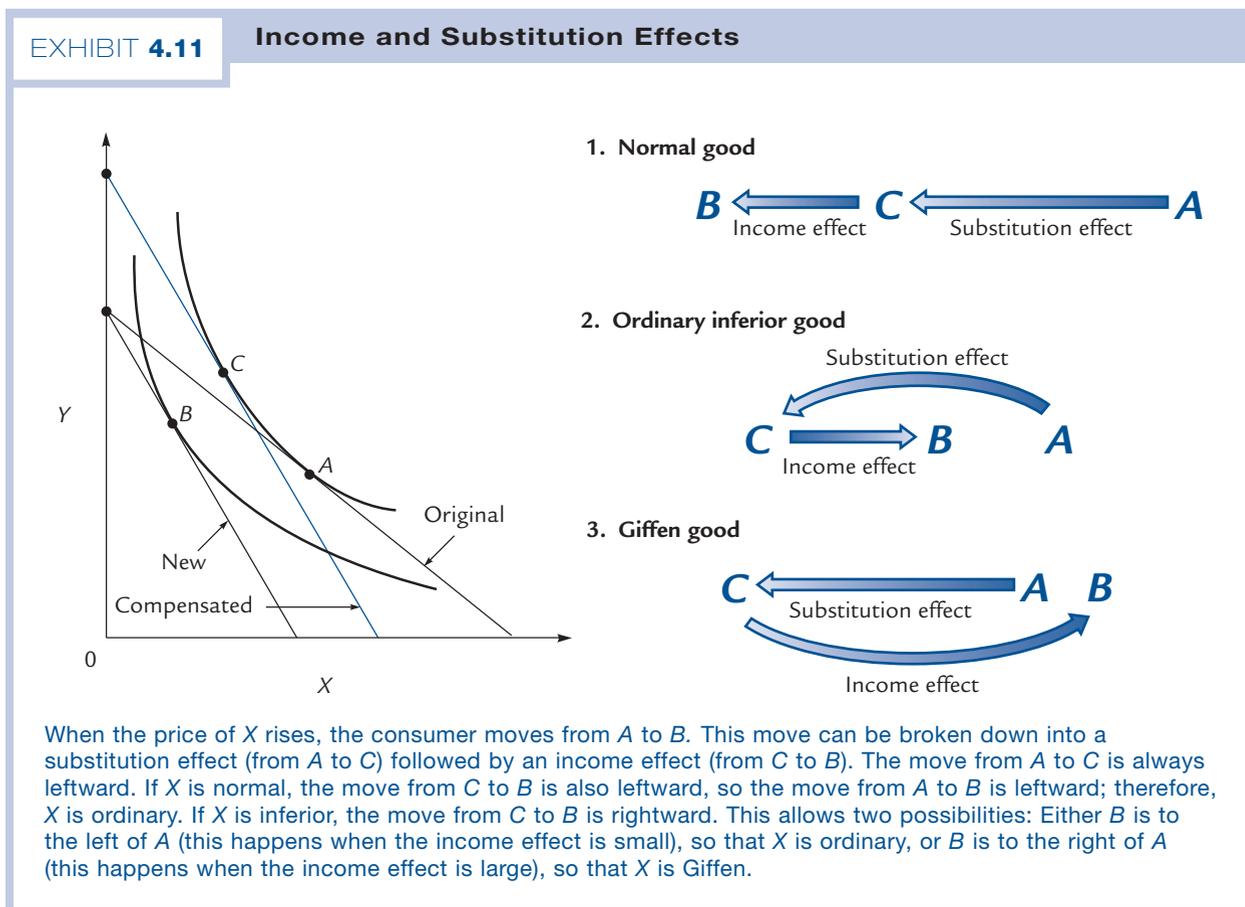
The first panel of Exhibit 4.11 reproduces the income and substitution effects that were illustrated in Exhibit 4.9. Remember that when the price of good $X$ rises, the substitution effect is the move from $A$ to $C$ and the income effect is the move from $C$ to $B$. Now let's do some geometry.

## Some Geometric Observations

Here are three key observations about the points in Exhibit 4.11:

1.  $C$ is always to the left of $A$. Here's why: $C$ and $A$ are on the same indifference curve, but $C$ is the tangency with a steeper line, so $C$ must be on a steeper part of the curve. Steeper parts of the curve are always to the left. (Notice that this purely geometric observation is equivalent to something we observed earlier: When the price of a good goes up, the substitution effect always leads you to consume less of it.)

2.  If $X$ is a normal good, then $B$ is to the left of $C$. Here's why: The move from $C$ to $B$ represents a pure change in income ($C$ and $B$ are tangencies with parallel budget lines). When you move from the *Compensated* line to the *New* line, income falls, so you consume less $X$; that is, you move to the left.

3.  If $X$ is an inferior good, then $B$ is to the right of $C$. In other words, when income falls, you consume *more* of the inferior good $X$.

(In Exhibit 4.11, $B$ is drawn to the left of $C$, so in this case $X$ is a normal good.)



**EXHIBIT 4.11**     **Income and Substitution Effects**

When the price of $X$ rises, the consumer moves from $A$ to $B$. This move can be broken down into a substitution effect (from $A$ to $C$) followed by an income effect (from $C$ to $B$). The move from $A$ to $C$ is always leftward. If $X$ is normal, the move from $C$ to $B$ is also leftward, so the move from $A$ to $B$ is leftward; therefore, $X$ is ordinary. If $X$ is inferior, the move from $C$ to $B$ is rightward. This allows two possibilities: Either $B$ is to the left of $A$ (this happens when the income effect is small), so that $X$ is ordinary, or $B$ is to the right of $A$ (this happens when the income effect is large), so that $X$ is Giffen.

## The Demand Curve for a Normal Good

Suppose that *X* is a normal good. When the price of *X* goes up, the consumer in Exhibit 4.11 moves from *A* to *B*. What is the direction of that move?

We know from the first of our geometric observations that *C* is to the left of *A*. Because we've assumed that *X* is normal, we know from the second observation that *B* is to the left of *C*. Using your best IQ-test skills, what can you conclude about the relative positions of *A* and *B*?

The answer is revealed in the top row of the right-hand panel in Exhibit 4.11, where you can see that *B* must be to the left of *A*. In other words, when the price of *X* goes up, the quantity demanded goes down. In still other words, *X* is an ordinary (i.e., non-Giffen) good. Because this argument applies whenever *X* is normal, we can summarize our conclusion as follows:

A normal good cannot be Giffen.

We've just discovered something truly remarkable. To say that a good is normal is to say something about the response to an *income* change. To say that a good is Giffen is to say something about the response to a *price* change. There is no obvious reason why these conditions should have anything to do with one another. But our analysis reveals that they are closely related nevertheless: No normal good can ever be Giffen. The demand curve for a normal good is sure to slope downward.

Although we've phrased the argument in terms of geometry, we can translate it into economics. When the price of *X* goes up, the substitution effect (from *A* to *C*) must cause the quantity demanded to fall. At the same time, the income effect (from *C* to *B*) *also* causes the quantity demanded to fall. These effects reinforce each other, and the quantity demanded certainly falls.

## The Demand Curve for an Inferior Good

Now suppose that *X* is an inferior good. When the price of *X* goes up, the consumer in Exhibit 4.11 moves from *A* to *B*. What is the direction of that move?

We know from the first geometric observation that *C* is to the left of *A*. Because we've assumed that *X* is inferior, we know from the second observation that *B* is to the right of *C*.

Bringing your IQ-test skills to bear on this problem, you'll quickly discover that you can draw no certain conclusion about the relative locations of points *A* and *B*. There are two possibilities, illustrated in the second and third rows of the right-hand panel in Exhibit 4.11. When the substitution effect is larger than the income effect, *B* is to the left of *A* (so that *X* is ordinary) but when the income effect is larger than the substitution effect, *B* is to the right of *A* (so that *X* is Giffen).

The two panels of Exhibit 4.12 show that each of these possibilities can occur. Therefore:

An inferior good is ordinary if the substitution effect exceeds the income effect, but Giffen if the income effect exceeds the substitution effect.

The economic interpretation is straightforward: When the price of *X* goes up, the substitution effect (from *A* to *C*) causes the quantity demanded to fall. At the same time, the income effect (from *C* to *B*) causes the quantity demanded to *rise* (because *X* is an inferior good). These effects work in opposite directions, so the quantity demanded of *X* can fall or rise, depending on which effect is bigger.

| EXHIBIT **4.12** | **Income and Substitution Effects for an Inferior Good** |
|---|---|
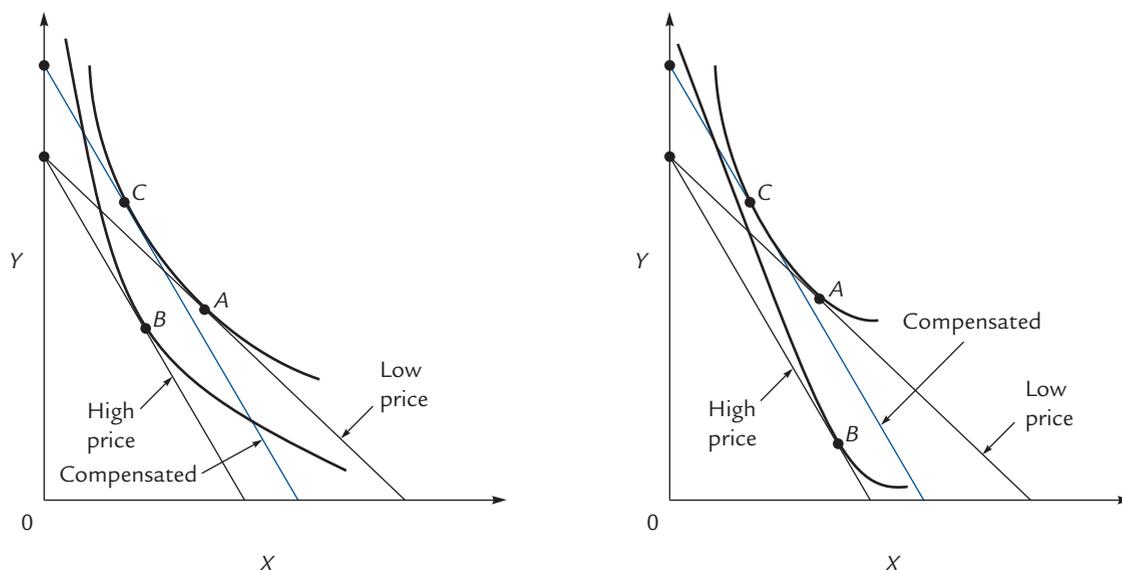


In both panels, *X* is an inferior good; that is, *B* is to the right of *C*. In the first panel, *X* is ordinary (i.e., not Giffen); that is, *B* is to the left of *A*. In the second panel, *X* is Giffen; that is, *B* is to the right of *A*.

## The Size of the Income Effect

Suppose the price of bubble gum rises. Will you feel slightly poorer or a lot poorer? Unless you are a very unusual person—that is, unless you spend a very substantial portion of your income on bubble gum—you will feel only slightly poorer. Therefore, the income effect, which is caused by that sense of being poorer, is likely to be small.

On the other hand, suppose the price of college tuition rises. Depending on who's paying for your education, there's a good chance you'll now feel quite substantially poorer. If tuition expenses account for a substantial fraction of your income, the income effect might be considerable.

In general, the income effect of a price change is large only for goods that account for a large fraction of your expenditure. The laws of arithmetic dictate that there can't be very many such goods (for example, there can be no more than 3 goods that account for at least ⅓ of your expenditure). So large income effects are relatively rare.

## Giffen Goods Revisited

A Giffen good must satisfy two conditions. First, it must be inferior (because a normal good cannot be Giffen). Second, it must account for a substantial fraction of your expenditure (because an inferior good is Giffen only when the income effect exceeds the substitution effect).

Each of these conditions is unusual. Many goods are inferior, but most are not. And only very few goods can account for substantial fractions of your expenditure. Thus, in order to be Giffen, a good must satisfy *two* unusual conditions at once. This explains why Giffen goods are rare.

In fact, one can make an even stronger argument. We've said that a randomly chosen good is likely to be normal. But we can also say that if the randomly chosen good accounts for a large fraction of your expenditure, then it's *particularly* likely to be normal. Here's why: When your income increases, you have to spend the excess on something, and the goods on which you spend relatively little are unlikely to soak up much of that excess. For example, if your income rises by $100 per week, it is unlikely that you'll devote the entire $100 to bubble gum—to do so would require an implausibly large percentage increase in your bubble gum expenditures. Instead, some of the $100 will probably go toward the goods that account for the bulk of your expenditure— which means that those goods are probably normal. So not only do Giffen goods have to satisfy two improbable conditions but one of those improbable conditions causes the other to become even *more* improbable.

*Dangerous Curve*

Here's a hypothetical example. Suppose you eat hamburger six days a week and steak on Sunday; suppose also that hamburger is an inferior good. One day the price of hamburger rises. Because you eat so much hamburger, this makes you feel a lot poorer. Because you are now so much poorer, you decide to cut out steak entirely and eat hamburgers seven days a week. When the price of hamburgers goes up, the quantity demanded goes *up.* In this case, hamburgers are a Giffen good.

For this story to work, hamburgers must be inferior *and* you must spend so much on hamburger that the price increase has a major impact on your lifestyle. The moral of Exhibit 4.11 is that this story about hamburgers is essentially the *only* story that could ever produce a Giffen good.

### Example: "Bad" Cigarettes as Giffen Goods

In the real world, big income effects are rare, which is part of why Giffen goods are rare. But in the laboratory, big income effects are easy to create, so the laboratory is where we should look for Giffen goods.

In one experiment,[1] a group of heavy smokers were given incomes of $6 each. They could purchase puffs on either "good" cigarettes (that is, brands they liked a lot) or "bad" cigarettes (brands they liked less). At a price of 25¢ per good puff and 5¢ per bad puff, a typical subject chose 20 puffs of each.

For the duration of the experiment, subjects couldn't buy anything but cigarette puffs. Therefore, both good and bad puffs accounted for substantial fractions of their spending. (One sixth of their spending went to bad cigarettes; by contrast, very few of us spend anywhere close to one sixth of our incomes on any one thing.) All income effects were therefore large. Also, it's reasonable to expect that bad puffs should be an inferior good. This makes the conditions exactly right for bad puffs to be not just inferior, but also Giffen.

And that's exactly what happens. When the price of a bad puff is increased to 12.5¢, our typical subject chooses 24 bad puffs instead of 20. This is exactly what we'd expect based on the logic of the hypothetical hamburger/steak example above. That example remains hypothetical because in the real world, the income effect associated with hamburger is unlikely to be extremely large. Thus, the cigarette experiment confirms our conclusion that Giffen goods arise from large income effects, which reinforces our explanation of why they're rarely observed.

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[1] R.J. DeGrandpre, Warren Bickel, S. Abu Turab Rizvi, and John Hughes, "Effects of Income on Drug Choice in Humans," *Journal of the Experimental Analysis of Behavior* 59 (1993): 483–500.

## The Compensated Demand Curve

When the price of lettuce rises from $1 to $3, Bugs reduces his consumption from 7 heads of lettuce per day to 1 head of lettuce per day. You can see in the first panel of Exhibit 4.13 that his consumption is reduced from 7 to 3 by the substitution effect and from 3 to 1 by the income effect. Bugs's demand curve, shown in the third panel, records the combined effect by showing that his consumption falls from 7 to 1.

But for some applications, it is useful to keep track of the substitution effect independent of the income effect. (We will meet some of these applications in Chapter 8.) In order to do that, we can draw Bugs's **compensated demand curve,** which shows that at a price of $3, he would consume 3 heads of lettuce—in the hypothetical circumstance where he feels no income effect.

You can imagine Bugs as the subject of an imaginary experiment, where every time the price of lettuce changes, experimenters adjust his income to keep him on his original indifference curve; we summarize this condition by saying that Bugs is income-compensated for all price changes. The compensated demand curve shows how much lettuce Bugs would consume if he were the subject of that experiment.

Because the substitution effect of a price increase always reduces the quantity demanded, it follows that the compensated demand curve must slope down. In terms of Exhibit 4.13, point *C* in the first panel is always to the left of point *A;* therefore, point *C′* in the second panel is always to the left of point *A′*. Again, the conclusion is that the compensated demand curve slopes downward. This is in contrast to the ordinary (uncompensated) demand curve, which slopes upward in the case of a Giffen good.

**Compensated demand curve**

A curve showing, for each price, what the quantity demanded would be if the consumer were income-compensated for all price changes.
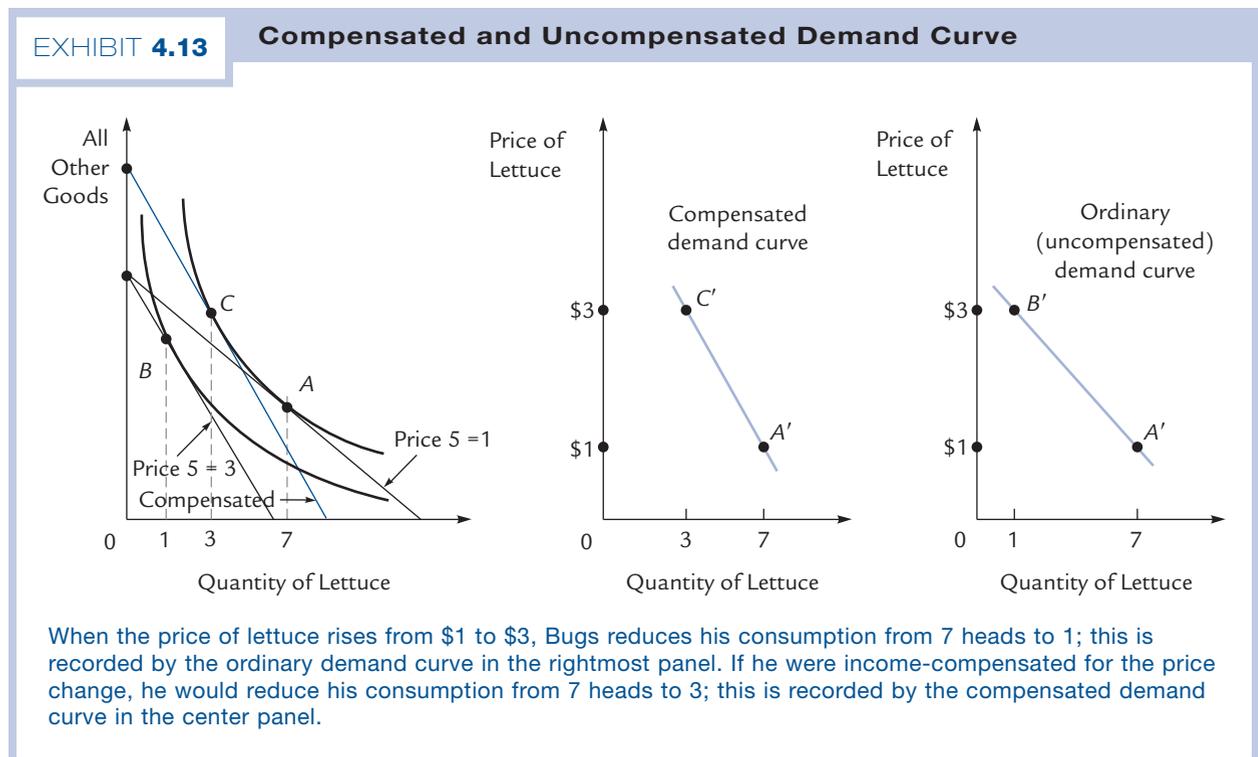
The ordinary (uncompensated) demand curve describes the behavior of actual consumers in actual markets. *Whenever we use the unqualified phrase "demand curve," we always mean the ordinary (uncompensated) demand curve.*

Dangerous Curve

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**EXHIBIT 4.13**   **Compensated and Uncompensated Demand Curve**



When the price of lettuce rises from $1 to $3, Bugs reduces his consumption from 7 heads to 1; this is recorded by the ordinary demand curve in the rightmost panel. If he were income-compensated for the price change, he would reduce his consumption from 7 heads to 3; this is recorded by the compensated demand curve in the center panel.

# 4.4 Elasticities

If you owned a clothing store, you'd want to be able to anticipate changes in your customers' buying habits. From the material we have developed so far, you'd be able to draw two general conclusions. First, if their income increases, your customers will probably buy more clothes. Second, if the price of clothing falls, your customers will almost surely buy more clothes.

As the owner of a business who is trying to foresee market conditions, you might find these revelations unsatisfying. Although they predict the *directions* of change, they say nothing about the *magnitude* of change. What you really want to know is: If my customers' incomes increase by a certain amount, by *how much* will they increase their expenditures on clothing? If the price falls by a certain amount, by *how much* will the quantity demanded increase?

Elasticities are numbers that answer these questions. In this section, we will learn what elasticities are and see some sample estimates.

## Income Elasticity of Demand

First we will consider the response to a change in income. This response is depicted by the Engel curve, and one way to measure it is by the *slope* of that curve. We ask: If your income increased by $1, by how many units would you increase your consumption of *X?* That number is the slope of your Engel curve.

Unfortunately, this slope is arbitrary. For one thing, it depends on the units in which *X* is measured. When your income goes up by $1, your yearly coffee consumption might go up by 6 cups, which is the same as 1 pot. If coffee is measured in cups, your Engel curve has slope 6; if coffee is measured in pots, it has slope 1. For another thing, the slope depends on the units in which your income is measured. Your coffee consumption will respond differently if your income increases by one Italian lira instead of one U.S. dollar.

Therefore, we adopt a different measure, one that does not depend on the choice of units. Instead of asking, "If your income increased by *one dollar,* by how many *units* would you increase your consumption of *X?*" we ask, "If your income increased by 1%, by what *percent* would you increase your consumption of *X?*" The answer to this question is a number that does not depend on the choice of units. That number is called the elasticity of your Engel curve, or your **income elasticity of demand.**

**Income elasticity of demand**

The percent change in consumption that results from a 1% increase in income.

If your income *I* changes by an amount $\Delta I$, then the percent change in your income is given by $100 \times \Delta I/I$. If the quantity of *X* that you consume, *Q*, changes by an amount $\Delta Q$, then the percent change in consumption is $100 \times \Delta Q/Q$. The formula for income elasticity is

$$\text{Income elasticity} = \frac{\text{Percent change in quantity}}{\text{Percent change in income}}$$

$$= \frac{100 \cdot \Delta Q/Q}{100 \cdot \Delta I/I}$$

$$= \frac{I \cdot \Delta Q}{Q \cdot \Delta I}$$

Suppose, for example, that your Engel curve for *X* is the one depicted in panel B of Exhibit 4.4. When your income increases from $8 to $12 (a 50% increase), your consumption of *X* increases from 6 to 12 (a 100% increase). In this region, your income elasticity of demand is 100%/50% $=2$.

On the other hand, when your income increases from $4 to $8, your consumption of X increases from 3 to 6; a 100% increase in income yields a 100% increase in quantity, so your income elasticity of demand in this region is 1.

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**Exercise 4.8** What would it mean for your income elasticity of demand for X to be negative?

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## Applications

Suppose again that you own a clothing store, you foresee an increase in your customers' incomes, and you want to anticipate the change in their clothing expenditures. The critical bit of information is the income elasticity of demand for clothing. In fact, that elasticity has been estimated at about .95.[2] If your customers' incomes increase by 10%, you may expect them to increase their expenditures on clothing by about 9.5%.

Following an increase in income, it usually takes time for people to fully adjust their spending patterns. Thus, we can estimate both a short-run and a long-run income elasticity, reflecting an initial partial response to an income increase and the ultimate full response. We expect the long-run elasticity to exceed the short-run elasticity, and for clothing this is indeed the case. Although the short-run elasticity is .95, the long-run elasticity is 1.17. Following a 10% increase in income, people initially increase expenditures on clothing by 9.5%, but ultimately increase expenditures by 11.7%.

Income elasticities take a wide range of values. The income elasticity of demand for an inferior good is negative. The income elasticity of demand for alcoholic beverages is only about .29. (A 10% increase in income leads to a 2.9% increase in expenditure on alcohol.) The income elasticity of demand for jewelry is about 1, so that expenditure on jewelry increases roughly in proportion with income. The income elasticity of demand for household appliances is 2.72. When income increases 10%, expenditure on appliances increases 27.2%. (The estimates in this paragraph are all short-run elasticities.)

## The Demand for Quality

When people get wealthier, they not only buy *more* goods, they also buy *better* goods. If your income goes up by 10 percent, you might replace your microwave or your stereo with a better microwave or a better stereo.

When economists estimate income elasticities, they usually count a $2,000 stereo system as the equivalent of two $1,000 stereo systems. So when we say that a 10% increase in income yields a 27.2% increase in expenditure on appliances, that might mean a 27.2% increase in the *number* of appliances, or a 27.2% increase in the *quality* of the appliances, or both. (Here we are using price to measure quality, so that by definition a stereo that costs 27.2% more is 27.2% better.)

On average over all goods, economists Mark Bils and Pete Klenow estimate that as people become wealthier, quality grows a little more rapidly than quantity. But the ratio of quality changes to quantity changes is very different for different goods. If you're rich enough to own two microwaves instead of one, they'll cost, on average, about 25% more than your poorer neighbor's single unit. The poor family pays (say) $200 for one microwave; the rich family pays $250 apiece for two (presumably better) microwaves.

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[2] H. Houthakker and L. Taylor, *Consumer Demand in the United States,* Cambridge: Harvard University Press, 1970. All further elasticity estimates in this chapter are taken from this source.

But if you're rich enough to own two living room tables instead of one, the 25% rule no longer holds; now you'll pay, on average, about 100% more per table. The poor family pays $500 for one living room table while the rich family pays $1,000 apiece for two. A family with twice as many vacuums pays (on average) about 22% more per vacuum; a family with twice as many trucks pays about 140% more per truck.[3]

These numbers suggest that over time, as families on average become richer, the average quality of living room tables should rise faster than the average quality of microwaves, and the average quality of trucks should rise faster than the average quality of vacuums. Of course, it's possible that technological consideration will undercut some of these predictions—we could, in principle, reach a point where it's very hard to make better trucks but still very easy to make better vacuums.

## Price Elasticity of Demand

When the price of salt goes up, people buy less salt. When the price of fresh tomatoes goes up, people buy fewer tomatoes. But the responses are of very different magnitudes. A 10% increase in the price of salt typically leads to about a 1% decrease in the quantity bought. A 10% increase in the price of fresh tomatoes typically leads to about a 46% decrease in the quantity bought.

**Price elasticity of demand**

The percent change in consumption that results from a 1% increase in price.

We express this contrast by saying that the **price elasticity of demand** for tomatoes is 46 times as great as the price elasticity of demand for salt.

More formally, your price elasticity of demand for a good $X$ (also called the elasticity of your demand curve for $X$) is defined by the formula:

$$\text{Price elasticity} = \frac{\text{Percent change in quantity}}{\text{Percent change in price}}$$

$$= \frac{100 \cdot \Delta Q/Q}{100 \cdot \Delta P/P}$$

$$= \frac{P \cdot \Delta Q}{Q \cdot \Delta P}$$

If your demand curve for $X$ slopes downward, then the price elasticity is negative, because an increase (that is, a positive change) in price is associated with a decrease (that is, a negative change) in quantity. For example, suppose that a price of $2 corresponds to a quantity of 5 and a price of $3 corresponds to a quantity of 4. Then a 50% price increase yields a 20% quantity decrease, so the price elasticity of demand is $(-20\%)/50\% = -.4$.

Just as we can talk about your personal price elasticity of demand for $X$, so we can talk about the market's price elasticity of demand for $X$. Again, we divide the percent change in quantity by the percent change in price, only now we take our quantities from the market demand curve instead of your personal demand curve.

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**Exercise 4.9** Use the formula for price elasticity and the information given at the beginning of this subsection to show that the price elasticities of demand for salt and for fresh tomatoes are −.1 and −4.6.

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We say that the demand for a good is highly elastic when the price elasticity of demand for that good has a large absolute value. Thus the demand for tomatoes is

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[3] The numbers in this paragraph, and the idea of estimating elasticities for "quality Engel curves," come from M. Bils and P. Klenow, "Quantifying Quality Growth," *American Economic Review,* September 2001.

highly elastic when compared with the demand for salt. We also say that the demand for tomatoes is *more elastic* than the demand for salt.

The next question is: why? Why are tomato buyers so much more price-sensitive than salt buyers? One key factor is the availability of substitutes. If the price of tomatoes goes up, you can substitute any of a dozen other vegetables in your salad. Whenever a good has many substitutes, the demand tends to be highly elastic. That's why the elasticity of demand for Chevrolets is about −4.0 even though the elasticity of demand for cars is around −1.3. There are many good substitutes for a Chevrolet (like a Ford) but not so many good substitutes for a car. Likewise, most soft drinks (like Coke, Diet Coke, or Pepsi) have highly elastic demand curves with elasticities in the range of −3 to −4.

For the same reason, we expect that the demand for Hostess Twinkies is more elastic than the demand for packaged cakes; the demand for packaged cakes is more elastic than the demand for snack foods; and the demand for snack foods is more elastic than the demand for food generally.

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For a given income and quantity of *X,* high income elasticity is reflected in a relatively steep Engel curve. For a given price and quantity of *X,* high price elasticity is reflected in a relatively flat demand curve. The apparent paradox occurs because the quantity of *X* is plotted on the vertical axis for an Engel curve and on the horizontal axis for a demand curve.

Dangerous
Curve

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The price elasticity of demand for electricity is −.13, for water −.20, for jewelry −.41, for shoes −.73, and for tobacco −1.4. If the price of electricity rises by 10%, the quantity demanded falls by 1.3%. If the price of water rises by 10%, the quantity demanded falls by 2%.

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**Exercise 4.10** If the price of jewelry rises by 10%, by how much does the quantity demanded fall? How about for shoes? For tobacco?

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## The Relationship between Price Elasticity and Income Elasticity

When the price goes up, the quantity demanded goes down, usually for two reasons: a substitution effect and an income effect. So the price elasticity of demand depends both on the size of the substitution effect and on the size and direction of the income effect.

The income effect is larger for goods that consume a larger fraction of your income. The income effect is also larger for goods with high income elasticities of demand.

The direction of the income effect depends on whether the good is normal or inferior. For normal goods, a larger income effect means a larger price elasticity of demand; for inferior goods the opposite is true.

For example, suppose you go to the movies once a week and spend $10 per movie, while you go to the live theater twice a year and spend $50 each time. Then over the course of a year, you're spending about five times as much on movies as on the theater. This suggests that changes in the price of movies should have larger income effects than changes in the price of live theater performances. So it's a good guess that your price elasticity of demand is higher for the movies.

Similarly, if you eat out at McDonald's 300 nights a year, spending $5 each time for a total of $1,500, and at the 21 Club once a year, spending $200, then your price elasticity of demand for McDonald's hamburgers is probably higher than your price elasticity of demand for dinners at the 21 Club. If the 21 Club raises its prices by 10%, it will lose

some fraction of your business, but if McDonald's raises its prices by 10%, it will lose a larger fraction of your business.

## Cross Elasticities

One other circumstance that can affect your demand for *X* is a change in the price of some other good *Y*. The **cross elasticity of demand** for *X* with respect to *Y* is a measure of the size of this effect; it is the percent change in consumption of *X* divided by the percent change in the price of *Y*.

A change in the price of *Y* could cause your consumption of *X* to either rise or fall. In the first case, your cross elasticity of demand is positive, and in the second it is negative. If *X* is coffee and *Y* is tea, the cross elasticity is likely to be positive: When the price of tea increases by 1%, your coffee consumption is likely to increase. The percent by which it increases (a positive number) is the cross elasticity of demand. But if *X* is coffee and *Y* is cream, a 1% increase in the price of cream is likely to lead to a *decrease* (that is, a *negative* percentage change) in the price of coffee, and so in this case the cross elasticity of demand is negative.

When the cross elasticity of demand for *X* with respect to *Y* is positive, we say that *X* and *Y* are **substitutes.** When it is negative, we say that they are **complements.** Substitutes, as the name indicates, tend to be goods that can be substituted for each other, as in our example of tea and coffee. Other examples might be Coke and Pepsi, or train tickets and airline tickets. Complements tend to be goods that are used together— each complements the other. We have seen the example of coffee and cream. Other pairs of complements might be computers and floppy disks, or textbooks and college courses.

## Example: Is Coke the Same as Pepsi?

Coke is quite a good substitute for Pepsi; we know this because the cross elasticity of demand[4] is a relatively large .34, that is, when the price of Pepsi rises 1%, sales of Coke rise a hefty .34%.

That perhaps is not surprising. What's more surprising is that (regular) Coke is an even better substitute for *Diet* Pepsi; here the cross elasticity of demand is an even larger .45. But Coke is above all a close substitute for Diet Coke where the cross elasticity is an enormous 1.15.

By and large, Coke and Pepsi are good substitutes for most other soft drinks. When the price of Mountain Dew goes up, a lot of people switch to Pepsi (cross elasticity .77). But the reverse is false; when the price of Pepsi goes up, very few people switch to Mountain Dew (cross elasticity only .08).

## Elasticities and Monopoly Power

Does the McDonald's hamburger chain have a monopoly on the products it sells? If consumers think that there is no close substitute for a McDonald's hamburger, then the answer is yes. On the other hand, if consumers think that a Burger King hamburger and a McDonald's hamburger are indistinguishable, then McDonald's faces heavy competition.

When courts are called upon to decide whether a firm has monopoly power, they must ask whether competing firms offer products that are close substitutes in the

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[4] All the cross elasticities in this section are from Jean-Pierre Dube, "Product Differentiation and Mergers in the Carbonated Soft Drink Industry," *Journal of Economics and Management Strategy* 14 (2005): 879–904.

minds of consumers. But how is the court to tell whether an alternative product is viewed as a close substitute? A solution is to examine the cross elasticity of demand.

Suppose that the cross elasticity of demand between McDonald's and Burger King hamburgers is positive and large. Then the goods are close substitutes and Burger King competes in essentially the same market as McDonald's. The large cross elasticity means that if McDonald's tries to raise its prices, a lot of customers will switch to Burger King, so that McDonald's monopoly power is severely limited. On the other hand, if the cross elasticity is small, McDonald's needs to worry much less about this kind of competition. Large cross elasticities are evidence of competition and small cross elasticities are evidence of monopoly.

Because of the relatively large cross elasticities that are common between soft drinks, regulators have been reluctant to approve mergers between soft drink companies. In recent decades, Coke has been prohibited from acquiring Dr. Pepper, and Pepsi withdrew its interest in acquiring Mountain Dew in anticipation of a negative ruling.

## Summary

Changes in the consumer's opportunities lead to changes in the optimal consumption basket. Changes in opportunities arise from changes in income and changes in prices.

A change in income causes a parallel shift in the budget line. When income rises, consumption of the good $X$ can either rise (in which case $X$ is called a normal good) or fall (in which case $X$ is called an inferior good).

If we fix the prices of goods $X$ and $Y,$ we can draw budget lines corresponding to various levels of income. If we also know the consumer's indifference curves, we can find the optimal basket corresponding to each level of income and read off the quantity of $X$ associated with each level of income. We can plot this information on a graph, with income on the horizontal axis and quantity of $X$ on the vertical. The resulting curve is called an Engel curve. The Engel curve slopes upward for a normal good and downward for an inferior good.

A change in the price of $X$ causes the budget line to pivot around its $Y$-intercept—outward for a fall in price and inward for a rise in price. A rise in price can cause the quantity of $X$ demanded to fall (in which case $X$ is called an ordinary good) or rise (in which case $X$ is called a Giffen good).

If we fix the price of $Y$ and the consumer's income, we can draw budget lines corresponding to various prices of $X.$ If we also know the consumer's indifference curves, we can find the optimal basket associated with each price of $X$ and read off the quantity of $X$ associated with each price. We can plot this information on a graph, with price on the vertical axis and quantity on the horizontal. The resulting curve is the demand curve for $X.$ The demand curve slopes downward if $X$ is not Giffen and upward if $X$ is Giffen.

When the price of $X$ goes up, the consumer changes his consumption of $X$ for two reasons. First, there is the substitution effect: Consumers will not purchase goods whose marginal value is below the price. Second, there is the income effect: Consumers are made effectively poorer when a price goes up. The substitution effect always reduces consumption of $X.$ The income effect reduces consumption of $X$ if $X$ is a normal good, but increases consumption of $X$ if $X$ is an inferior good.

For a normal good, the substitution and income effects work in the same direction, ensuring that when the price goes up the quantity demanded goes down. Thus, a normal good cannot be Giffen. For an inferior good, the substitution and income effects work in opposite directions: If the substitution effect is greater, the good is not Giffen, but if the income effect is greater, the good is Giffen.

The compensated demand curve shows, for each price, the quantity of *X* the consumer would demand if he were income-compensated for every price change. Thus, the compensated demand curve shows only the substitution effect and so must slope downward.

# Author Commentary     www.cengage.com/economics/landsburg

**AC1.** Just as consumers demand *more* goods when their income rises, they also demand *higher quality* goods when their income rises. We can measure that demand for quality by starting with the formula for income elasticity and replacing "percentage change in quantity" with "percentage change in quality."

# Review Questions

**R1.** When income rises, how does the budget line move?

**R2.** What is the definition of an inferior good? What is the definition of a normal good?

**R3.** Suppose the price of *X* is $3 per unit and the price of *Y* is $5 per unit. Given the following indifference curve diagram, construct three points on the Engel curve for *X.*
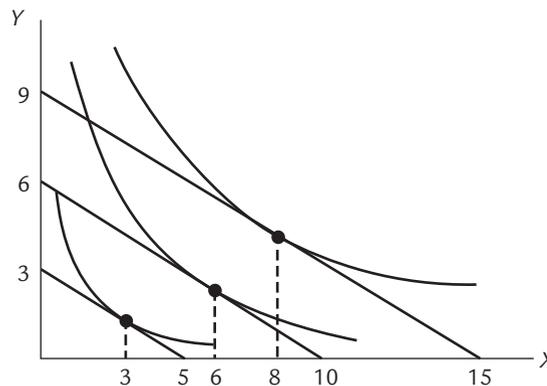


**R4.** When the price of *X* goes up, how does the budget line move?

**R5.** What is the definition of a Giffen good?

**R6.** Suppose the price of *Y* is $6 per unit and your income is $24. Given the following indifference curve diagram, construct three points on the demand curve for *X*.
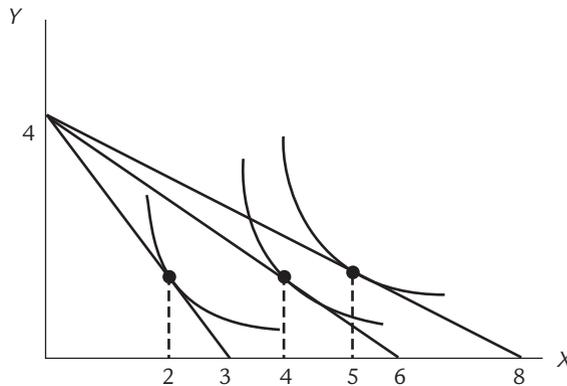


**R7.** Draw a diagram to illustrate the income and substitution effects of a price increase.

**R8.** When the price of a good increases, what is the direction of the substitution effect? Use the geometry of the indifference curves to justify your answer.

**R9.** When the price of a normal good increases, what is the direction of the income effect? When the price of an inferior good increases, what is the direction of the income effect?

**R10.** Are all Giffen goods inferior? Are all inferior goods Giffen? Justify your answer in terms of the directions of the income and substitution effects.

**R11.** What is the difference between a compensated demand curve and an ordinary demand curve?

**R12.** Must the compensated demand curve always slope downward? Why or why not?

**R13.** Give the formulas for the income elasticity of demand and price elasticity of demand.

**R14.** In review question 3, compute the income elasticity of demand for *X* as income rises from $15 to $30.

**R15.** In review question 6, compute the price elasticity of demand for *X* as the price rises from $4 to $8.

**R16.** The price elasticity of demand for coffee is about –.25. Suppose that when the price is 50¢ per cup, consumes demand 1,000 cups per day. If the price rises to 60¢ per cup, how many cups will be demanded?

# Numerical Exercises

**N1.** Suppose your indifference curves are all described by equations of the form $x\,y =$ constant, with a different constant for each indifference curve.

    **a.** Show that for any point $P = (x, y)$, the indifference curve through $P$ has slope $-y/x$ at $P$. (This requires calculus. If you don't know enough calculus, you can just pretend you've solved this part and go on to part (b).)

**b.** Suppose that your income is $40, the price of X is $1, and the price of Y is $1. How much X do you buy?

*Hint:* The problem is to find your optimal basket (x, y). First write down an equation that says (x, y) is on the budget line. Next write down an equation that says the slope of the indifference curve at (x, y) is equal to the slope of the budget line at (x, y). (Remember that you have a formula for the slope of the budget line from part (a), and that you can compute the slope of the budget line from the prices of X and Y.) Then solve these two equations simultaneously.

**c.** Suppose your income and the price of Y remain as above, but the price of X rises to $4. Now how much X do you consume? (Use the same hint as in part (b).)

**d.** Based on your answers to parts (b) and (c), draw two points on your demand curve for X.

**e.** After the price of X rises from $1 to $4, suppose that your income rises by just enough to bring you back to your original indifference curve. Now how much X do you buy? (*Hint:* The problem is to find the basket (x, y) where the compensated budget line is tangent to the original indifference curve.) First write down the equation of the original indifference curve (remember that it is of the form xy = constant, and you can figure out the constant because you already know the coordinates of one point on that curve). Next write down an equation that expresses the condition that the slope of the indifference curve must equal the slope of the compensated budget line. Then solve these two equations simultaneously.

**f.** When the price of X rises from $1 to $4, how much of the change in your consumption is due to the substitution effect? How much is due to the income effect?

**N2.** Suppose that your Engel curve for X is given by the equation

$$X = a + bI$$

where I is income and a and b are constants.

**a.** If your income increases from I to I + ΔI, by how much does X increase?

**b.** Write down a formula, in terms of X and I, for your income elasticity of demand for X.

**c.** Use the equation $X = a + bI$ to eliminate I from your formula, and write a formula for income elasticity in terms of X alone.

**d.** As your consumption of X increases, what happens to your income elasticity of demand for X?

**e.** If your Engel curve is a line through the origin, what is your income elasticity of demand for X?

**N3.** Suppose that your demand curve for X is given by the equation

$$X = c - dP$$

where P is price and c and d are positive constants.

**a.** Derive a formula for your price elasticity of demand for X, and write your formula in terms of X alone.

**b.** When you consume zero units of X, what is your price elasticity of demand? When the price of X is zero, what is your price elasticity of demand?

**N4.** Suppose that your demand curve for *X* is given by the equation

$$X = \frac{e}{P}$$

where *P* is price and *e* is a positive constant. Derive a formula for your price elasticity of demand for *X*.

# Problem Set

**1.** Suppose the only goods you buy are circus tickets and accounting textbooks. One day the price of circus tickets goes up, the price of accounting textbooks goes down, and you notice that you are exactly as happy as you were before the price changes.

   **a.** Are you now buying more or fewer circus tickets than before?

   **b.** Can you still afford your original market basket?

**2.** Suppose the only goods you consume are wine and roses. On Tuesday, the price of wine goes up, and at the same time your income increases by just enough so that you are equally as happy as you were on Monday.

   **a.** What happens to the quantity of wine that you consume? Illustrate your answer with indifference curves.

   **b.** On Tuesday would you still be able to afford the same basket that you were buying on Monday? How do you know?

   On Wednesday there are no new price changes (so the Tuesday prices are still in effect), but your income changes to the point where you can just exactly afford Monday's basket.

   **c.** Are you happier on Wednesday or on Monday?

   **d.** Is it possible to say with certainty whether you buy more wine on Wednesday than on Monday? If not, on what would your answer depend?

   **e.** Is it possible to say with certainty whether you buy more wine on Wednesday than on Tuesday? If not, on what would your answer depend?

**3.** The only goods you consume are wine and roses. Between Monday and Tuesday, your income falls. Between Tuesday and Wednesday, your income remains at the Tuesday level, but the price of roses falls. On Wednesday, you are exactly as happy as on Monday. **True or False:** If you consume more wine on Wednesday than Tuesday, then wine must be a normal good.

**4.** For Henry, eggs are inferior but not Giffen. On Henry's indifference curve diagram, illustrate the income and substitution effects when the price of eggs goes up. How does your diagram illustrate that eggs are inferior? How does it illustrate that eggs are not Giffen?

**5.** In the following diagrams, the black dots represent points where the illustrated lines are tangent to indifference curves.
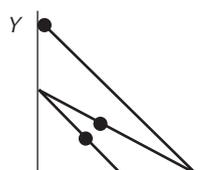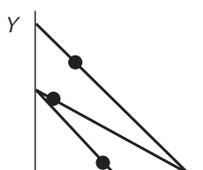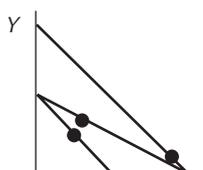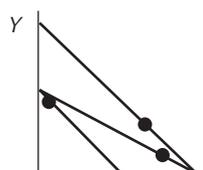


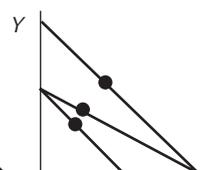Figure A      Figure B      Figure C      Figure D      Figure E

    **a.** In which figure(s) is *X* a normal good?

    **b.** In which figure(s) is *X* a Giffen good?

    **c.** In which figure(s) is *Y* an inferior good?

    **d.** In which figure(s) is *Y* a Giffen good?

**6.** Suppose that the only two goods you purchase are *X* and *Y.* One day the price of *X* goes down.

    **a.** Illustrate your old and new budget lines.

    **b.** Illustrate the substitution and income effects on your consumption of *X.*

    **c.** What is the direction of the substitution effect? Why?

    **d.** If *X* is a normal good, what is the direction of the income effect? Why?

    **e.** If *X* is an inferior good, what is the direction of the income effect? Why?

    **f.** **True or False:** If *X* is an inferior good, then a fall in price must lead to a rise in consumption, but if *X* is a normal good, then a fall in price might lead to a fall in consumption. Justify your answer carefully in terms of income and substitution effects.

**7.** Suppose the only goods you buy are wine and roses.

    **a.** Between Monday and Tuesday, the price of wine goes up (while your income remains fixed). Draw a diagram, with wine on the horizontal axis and roses on the vertical, to illustrate how your budget line moves. Illustrate your optimum points on the two budget lines, labeling Monday's optimum *M* and Tuesday's optimum *T.*

    **b.** On Wednesday, the price of wine returns to its Monday level, but at the same moment your income falls by just enough so that you are just as happy on Wednesday as on Tuesday. Draw Wednesday's optimum point and label it *W.*

In each of parts (c), (d), and (e), determine whether the statement is (1) true always, (2) false always, (3) true if wine is an inferior good, but otherwise false, (4) false if wine is an inferior good, but otherwise true, (5) true if wine is a Giffen good, but otherwise false, or (6) false if wine is a Giffen good but otherwise true.

    **c.** *M* is to the left of *T.*

    **d.** *T* is to the left of *W.*

    **e.** *M* is to the left of *W.*

    **f.** **True or False:** Every Giffen good is an inferior good. Justify your answers by **using the earlier parts of this problem,** *not* by using the argument given in the text.

**8.** Suppose the only two goods you consume are *X* and *Y.* On Tuesday, the price of *Y* (not *X!*) goes up. On Wednesday, there are no new price changes, but your income rises by just enough so that you can exactly afford Monday's basket.

    **a.** Use a diagram, with *X* on the horizontal axis and *Y* on the vertical, to illustrate your budget lines and optimum points on Monday, Tuesday, and Wednesday. Label the optimum points *M, T,* and *W.*

    **b.** In terms of the locations of points *M, T,* and *W,* what would it mean for *X* to be an inferior good?

    **c.** Is it true that *W* is always to the right of *M?* If so, how do you know? If not, what would your answer depend on?

     **d.** Call *X* a *Figgen good* if it is true that "when the price of *Y* goes up, the quantity demanded of *X* goes up." In terms of points *M, T,* and *W,* what would it mean for *X* to be a Figgen good?

     **e.** **True or False:** Every inferior good is a Figgen good.

     **f.** **True or False:** Every Giffen good is a Figgen good.

**9.** The only goods you consume are eggs and wine. Between Monday and Tuesday, your income rises. On Wednesday, the price of eggs goes up. On Wednesday, you are just as happy as you are on Monday. **True or False:** If wine is an inferior good, you certainly buy less wine on Tuesday than on Wednesday. Use your diagram to justify your answer. (*Note:* The price of *eggs* rises, but the question asks you about the quantity of *wine.*)

**10.** The only goods you consume are eggs and wine. On Tuesday, the price of *wine* increases. On Wednesday, the price of wine returns to its original level, but the price of *eggs* increases. You are equally happy on Tuesday and Wednesday.

     **a.** Draw a graph showing your budget lines on Monday (before either price changes), Tuesday, and Wednesday, and showing your optimum points. Label them *M, T,* and *W.*

     **b.** **True or False:** If eggs are a Giffen good, you will certainly consume more eggs on Tuesday than on Monday. Justify your answer by referring to the points on your graph.

**11.** The following diagram shows your indifference curves for goods *X* and *Y.*
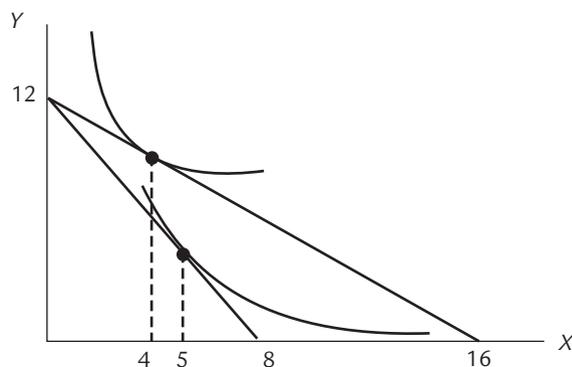


     **a.** Is *X* an ordinary good or a Giffen good? How do you know?

     **b.** Is *X* a normal good or an inferior good? How do you know?

     **c.** Suppose your income is $48 and the price of *Y* is $4 per unit. Give the coordinates of two points on your demand curve for *X.* (The coordinates of a point consist of a *price* and a *quantity.*)

**12.** Suppose you buy only *X* and *Y,* both of which are normal goods. Suppose also that almost all of your income is spent on *Y.* When the price of *X* goes up, does the quantity of *Y* go up or down?

**13.** When the price of shoes goes up, Tara goes right on buying just as many shoes as before. **True or False:** Shoes could not possibly be an inferior good for Tara.

**14.** Tara buys only shoes and socks. When the price of shoes goes up, Tara continues buying exactly the same number of socks as before. **True or False:** Socks could not possibly be an inferior good for Tara.

**15.** Sam consumes only green eggs and ham. Ham is an inferior good for Sam. One day the price of green eggs goes up.

   **a.** Illustrate Sam's old and new optimum points, and show both the substitution and the income effects. How does this graph reflect the fact that ham is an inferior good?

   **b.** **True or False:** When the price of green eggs goes up, Sam certainly buys more ham than before. Justify your answer carefully, by considering the directions of both the substitution and income effects.

**16.** Leopold consumes only kidneys and liver. When the price of kidneys rises, Leopold responds by eating less liver.

   **a.** Can you determine whether liver is an inferior good for Leopold?

   **b.** Can you determine whether liver is a Giffen good for Leopold?

   **c.** *Extra Credit:* what is Leopold's last name?

**17.** Bugs consumes carrots and lettuce, both of which are normal goods. Suppose the price of *carrots* rises.

   **a.** Illustrate the substitution and income effects.

   **b.** Does the substitution effect lead to an increase or a decrease in Bugs's lettuce consumption? Justify your answer. (*Note:* The price of *carrots* changed, but you are asked about the effect on the quantity of *lettuce.*)

   **c.** Does the income effect lead to an increase or a decrease in Bugs's lettuce consumption? Justify your answer.

   **d.** Assume Bugs spends very little of his income on carrots. When the price of carrots rises, do you expect his lettuce consumption to go up or down? Why?

**18.** In January, root beer and orange soda each cost $1 a bottle. Judith's income is $20. She buys 5 root beers and 15 orange sodas. In February, the price of root beer falls to 50¢, the price of orange soda rises to $2, Judith's income remains $20, and she still buys exactly 5 root beers. **True or False:** Root beer is a normal good for Judith.

**19.** In April, Frieda pays $2 apiece for eggs and $1 apiece for sodas. Her income is $40. She buys 18 eggs and 4 sodas. In May, Frieda pays $1 apiece for eggs and $2 apiece for sodas. Her income is $40. She buys 16 eggs and 12 sodas.

   **a.** In which month is Frieda happier?

   **b.** Are eggs a normal or an inferior good for Frieda?

**20.** Herman consumes Munster cheese and no other goods.

   **a.** Munster cheese could not possibly be an inferior good for Herman.

   **b.** Munster cheese could not possibly be a Giffen good for Herman.

**21.** Herman consumes Munster cheese and no other goods.

   **a.** What is the shape of Herman's ordinary (uncompensated) demand curve for Munster cheese?

   **b.** What is the shape of Herman's compensated demand curve for Munster cheese?

   **c.** What is Herman's price elasticity of demand for Munster cheese?

22. Suppose your indifference curves between *X* and *Y* are shaped as in Exhibit 3.10, page 59.

   a. What is the shape of your ordinary (uncompensated) demand curve for *X?*

   b. What is the shape of your compensated demand curve for *X?*

   c. What is your price elasticity of demand for *X?*

23. **True or False:** For a normal good, the compensated demand curve is steeper than the uncompensated demand curve, but for an inferior good the reverse is true.

24. **True or False:** Your compensated and uncompensated demand curves for bubble gum are likely to be very similar to each other, but your compensated and uncompensated demand curves for college tuition might be very different.

25. Suppose the only good you ever consume is Nestle's Crunch bars. What is your income elasticity of demand for Nestle's Crunch bars? What is your price elasticity of demand for Nestle's Crunch bars?

26. A *luxury* is defined to be a good with income elasticity greater than 1. Explain what this means without the technical jargon. Is it possible for all the goods you consume to be luxuries? Why or why not?

27. Which is likely to have a higher elasticity: The demand for gasoline from Gus's gas station or the demand for gasoline generally? Why?

28. In 2003, tolls were raised on seven bridges across the Delaware River, connecting Pennsylvania to New Jersey. In the first two months of the year, bridge traffic fell by 17%, but revenue increased by 123% because of the higher tolls. What is the price elasticity of demand for using these bridges to cross the Delaware River?

29. Suppose that without a seat belt, drivers who travel at 0 mph have a 100% chance of staying alive, while drivers who travel at 100 mph have 0% chance of staying alive. Suppose that with a seat belt, drivers who travel at 0 mph have a 100% chance of staying alive, drivers who travel at 100 mph have a 50% chance of staying alive, and drivers who travel at 200 mph have a 0% chance of staying alive.

   a. Draw an indifference curve diagram relating safety (measured by chance of staying alive) on the horizontal axis and speed (measured in mph) on the vertical. Draw the budget constraints of a driver with a seat belt and a driver without a seat belt. (You may assume these constraints are straight lines.)

   b. **True or False:** If speed and safety are both normal goods, then the invention of seat belts will certainly make people drive faster but might or might not save lives. Explain your answer in terms of substitution and income effects.

30. Suppose you have 24 hours per day that you can allocate between leisure and working at a wage of $2 per hour.

   a. Draw your budget constraint between "leisure hours" on the horizontal axis and "income" on the vertical.

   b. Draw in your optimum point. Keeping in mind that the number of hours you spend working is equal to 24 minus the number of hours that you spend at leisure, plot a corresponding point on your labor supply curve.

**c.** Now suppose that the wage rate rises to $3 per hour. Draw your new budget constraint, your new optimum, and a new point on your labor supply curve.

**d.** On your indifference curve diagram, decompose the effect of the wage increase into a substitution effect and an income effect. What is the direction of the substitution effect? What is the direction of the income effect if leisure is a normal good? What is the direction of the income effect if leisure is an inferior good?

**e.** **True or False:** If leisure is an inferior good, the labor supply curve must slope upward, but if leisure is a normal good, the labor supply curve could slope either direction.

**f.** Whose labor supply curve is likely to slope upward more steeply: somebody whose income is derived entirely from wages, or somebody who has a large nonwage income? Why?

**31.** Suppose you have $1,000 today and expect to receive another $1,000 one year from today. Your savings account pays an annual interest rate of 25%, and your bank is willing to lend you money at that same interest rate.

**a.** Suppose that you save all of your money to spend next year. How much will you be able to spend next year? How much will you be able to spend today?

**b.** Suppose you borrow $800 and spend $1,800 today. How much will you be able to spend next year?

**c.** Draw your budget constraint between "spending today" and "spending next year." What is its slope? How does the slope reflect the relative price of spending today in terms of spending next year?

**d.** How would your budget line shift in each of the following circumstances:

You find $400 that you'd forgotten was in your desk drawer.

Your boss informs you that you will receive a $500 bonus next year.

The interest rate rises to 50%.

**e.** Under which circumstance would you spend more today: finding a forgotten $400 in a desk drawer or being told that you will receive a $500 bonus next year? Under which circumstance would you spend more next year?

**f.** Returning to the assumption that you have $1,000 today and expect to receive $1,000 next year, suppose that you choose neither to borrow nor to lend. Illustrate the tangency of your budget line with an indifference curve.

**g.** In part (f), suppose that the interest rate rises to 50%. Show how your budget line shifts. Do you increase or decrease your current spending? Do you increase or decrease your future spending? Are you better off or worse off than before?

**h.** In part (g), decompose the change in your consumption into a substitution effect followed by an income effect. Can you determine the direction of the substitution effect? Can you determine the direction of the income effect?