APPENDIX

2A Graphs in Economics

Many students try to understand economics without taking the time to learn how to read and interpret graphs. This approach is shortsighted. You can "think" your way to the correct answer in a few cases, but the models we build and illustrate with graphs are designed to help analyze the tough questions, where your intuition can lead you astray.

Economics is fundamentally a quantitative science. That is, economists often solve problems by finding a numerical answer. For instance, economists determine the unemployment rate, the inflation rate, the growth rate of the economy, prices, costs, and much more. Economists also like to compare present-day numbers with numbers from the immediate past and historical data. Throughout your study of economics, you will find that many data-driven topics—for example, financial trends, transactions, the stock market, and other business-related variables—naturally lend themselves to graphic display. You will also find that many theoretical concepts are easier to understand when depicted visually in graphs and charts.

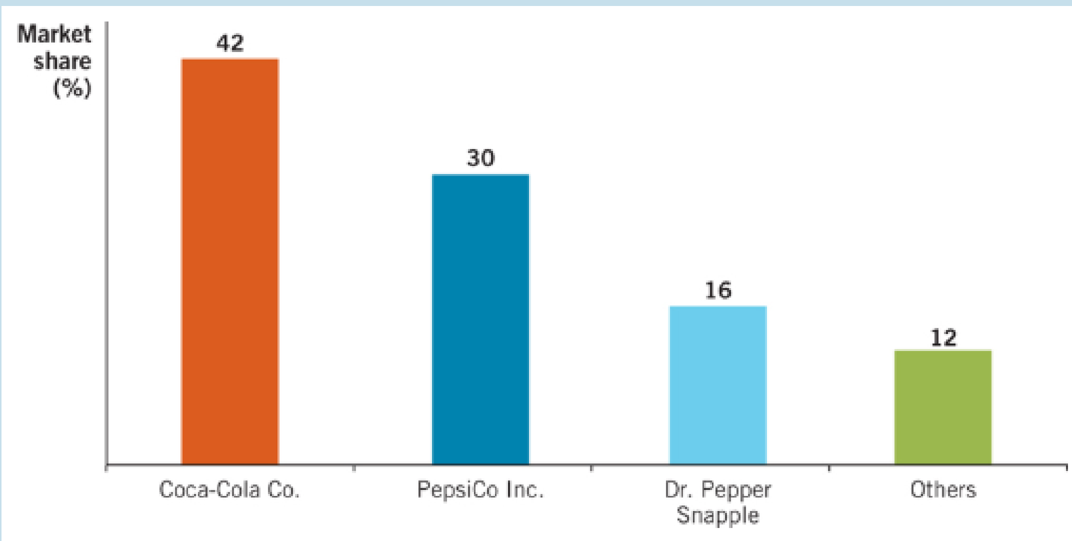
Economists also find that graphing can be a powerful tool when attempting to find relationships between different sets of observations. For example, the production possibilities frontier model presented in this chapter involves the relationship between the production of pizza and the production of chicken wings. The graphical presentations make this relationship, the trade-off between pizza and wings, much more vivid.

In this appendix, we begin with simple graphs involving a single variable. We then move to graphs that consist of two variables.

Graphs That Consist of One Variable

There are two common ways to display data with one variable: bar graphs and pie charts. A **variable** is a quantity that can take on more than one value. Let's look at the market share of the largest carbonated-beverage companies. Figure 2A.1 shows the data in a bar graph. On the vertical (*y*) axis is the market share held by each firm. On the horizontal (*x*) axis are the three largest firms (Coca-Cola, PepsiCo, and Dr. Pepper Snapple) and a separate category for the remaining firms, called "Others." Coca-Cola Co. has the largest market share at 42%, followed by PepsiCo Inc. at 30% and Dr. Pepper Snapple at 16%. The height of each firm's bar represents its market-share percentage. The combined market share of the other firms in the market is 12%.

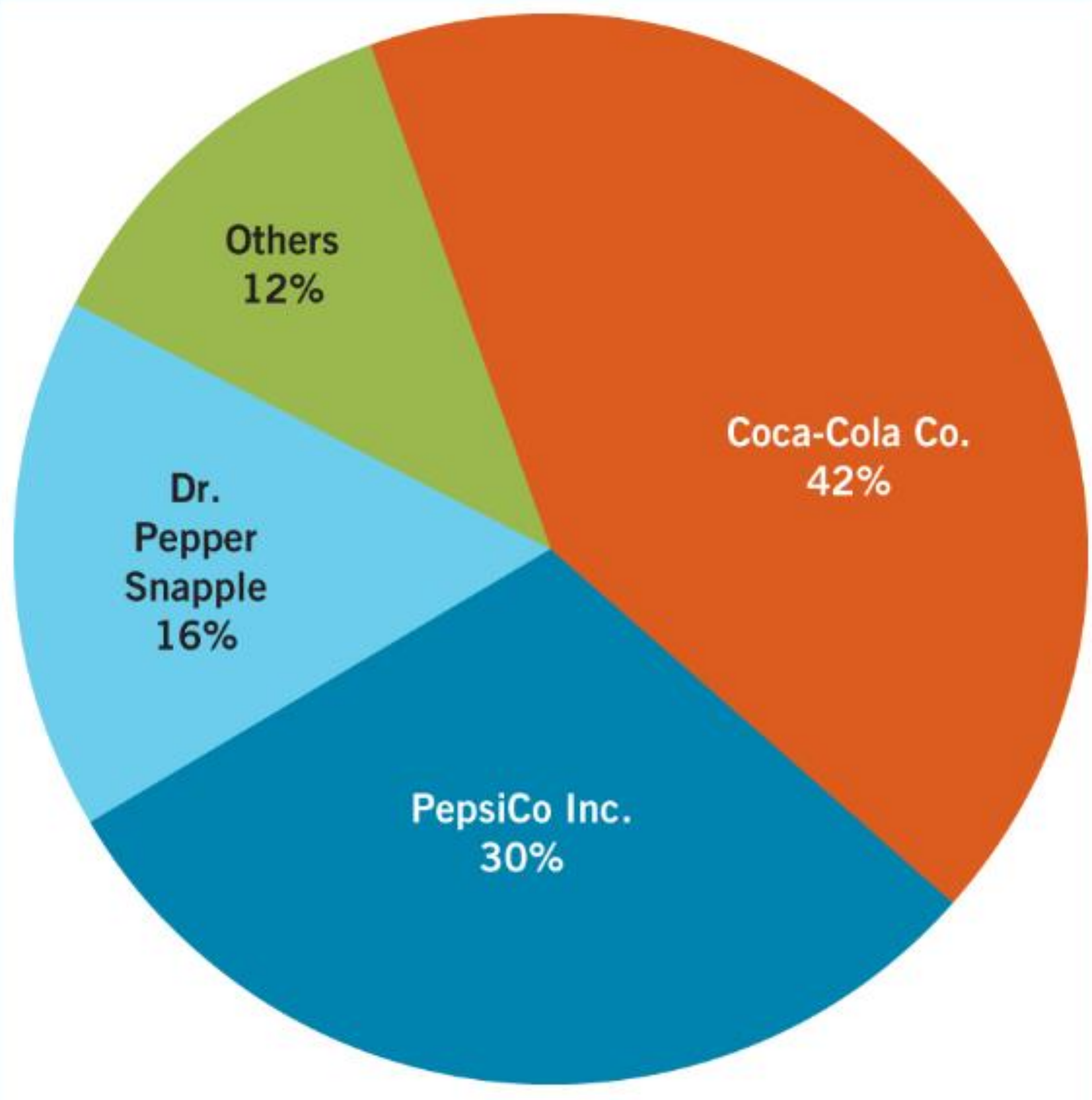
FIGURE 2A.1



Bar Graphs

Each firm's market share in the beverage industry is represented by the height of the bar.

FIGURE 2A.2



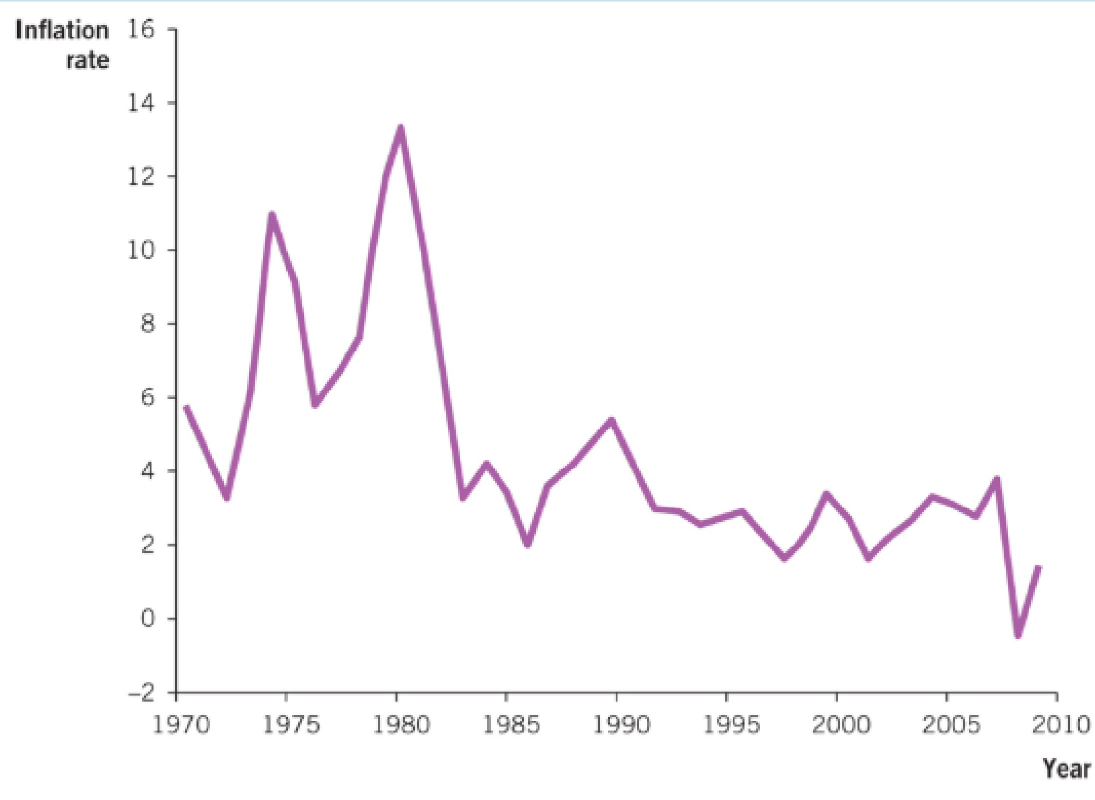
Pie Chart

Each firm's market share in the beverage industry is represented by the size of the pie slice.

Time-Series Graphs

A time-series graph displays information about a single variable across time. For instance, if you want to show how the inflation rate has varied over a certain period of time, you could list the annual inflation rates in a lengthy table or you could illustrate each point as part of a time series in a graph. Graphing the points makes it possible to quickly determine when inflation was highest and lowest without having to scan through the entire table. Figure 2A.3 illustrates this point.

FIGURE 2A.3



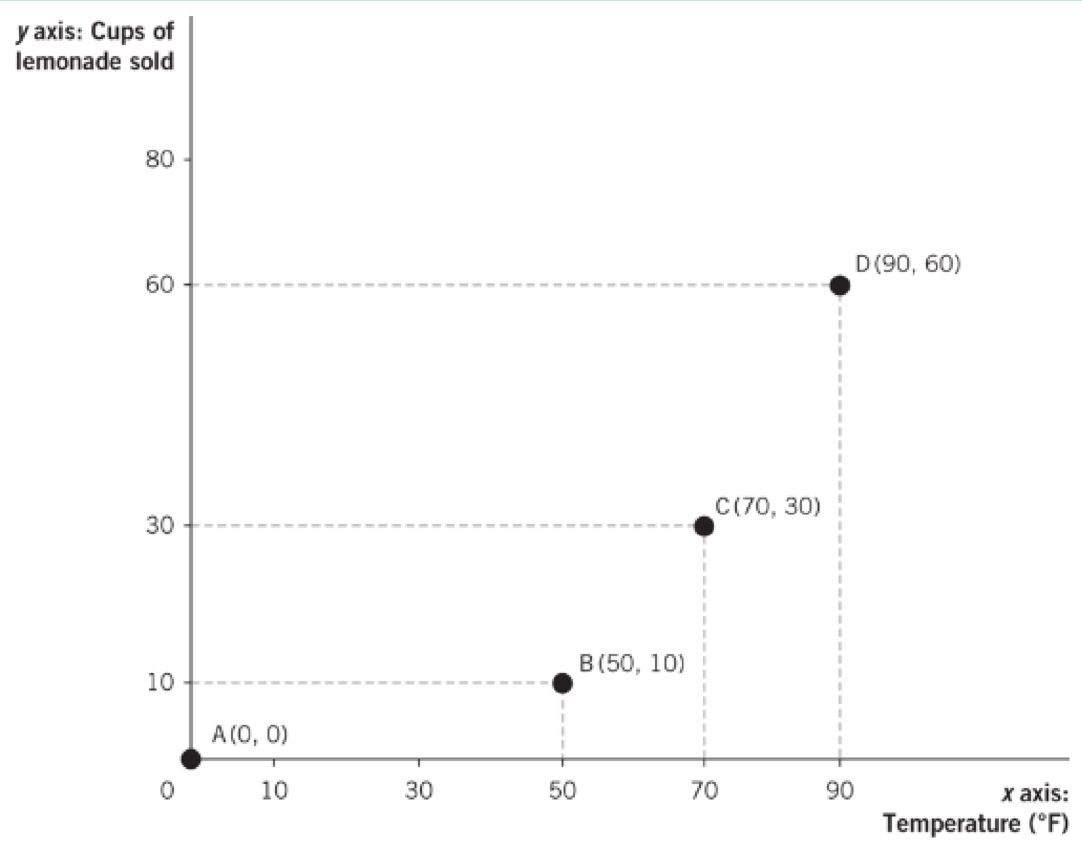
Time-Series Graph

In a time-series graph, you immediately get a sense of when the inflation rate was highest and lowest, the trend through time, and the amount of volatility in the data.

Graphs That Consist of Two Variables

Sometimes, understanding graphs requires you to visualize relationships between two economic variables. Each variable is plotted on a coordinate system, or two-dimensional grid. The coordinate system allows us to map a series of ordered pairs that show how the two variables relate to each other. For instance, suppose that we examine the relationship between the amount of lemonade sold and the air temperature, as shown in Figure 2A.4.

FIGURE 2A.4



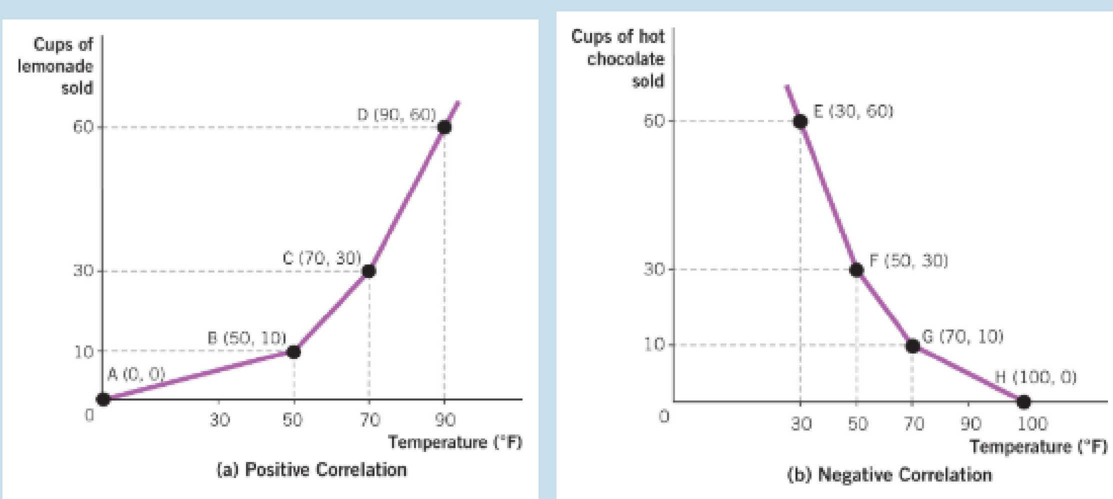
Plotting Points in a Coordinate System

Within each ordered pair (*x*, *y*), the first value, *x*, represents the value along the *x* axis, and the second value, *y*, represents the value along the *y* axis. The combination of all the (*x*, *y*) pairs is known as a scatterplot.

The air temperature is graphed on the *x* axis (horizontal) and cups of lemonade sold on the *y* axis (vertical). Within each ordered pair (*x*, *y*), the first value, *x*, represents the value along the *x* axis and the second value, *y*, represents the value along the *y* axis. For example, at point A, the value of *x*, or the temperature, is 0 and the value of *y*, or the amount of lemonade sold, is also 0. No one would want to buy lemonade when the temperature is that low. At point B, the value of *x*, the air temperature, is 50°F, and the value of *y*, the number of cups of lemonade sold, is 10. By the time we reach point C, the temperature is 70°F and the amount of lemonade sold is 30 cups. Finally, at point D, the temperature has reached 90°F, and 60 cups of lemonade are sold.

The graph you see in Figure 2A.4 is known as a **scatterplot**; it shows the individual (*x*, *y*) points in a coordinate system. Note that in this example, the amount of lemonade sold rises as the temperature increases. When the two variables move together in the same direction, we say that there is a **positive correlation** between them (see Figure 2A.5a). Conversely, if we graph the relationship between hot chocolate sales and temperature, we find that they move in opposite directions; as the temperature rises, hot chocolate consumption goes down (see Figure 2A.5b). This data set reveals a **negative correlation**, which occurs when two variables, such as cups of hot chocolate sold and temperature, move in opposite directions. Economists are ultimately interested in using models and graphs to make predictions and test theories, and the coordinate system makes both positive and negative correlations easy to observe.

FIGURE 2A.5



Positive and Negative Correlations

(a) This graph displays the positive relationship, or correlation, between lemonade sales and higher temperatures.

(b) This graph displays the negative relationship, or correlation, between hot chocolate sales and higher temperatures.

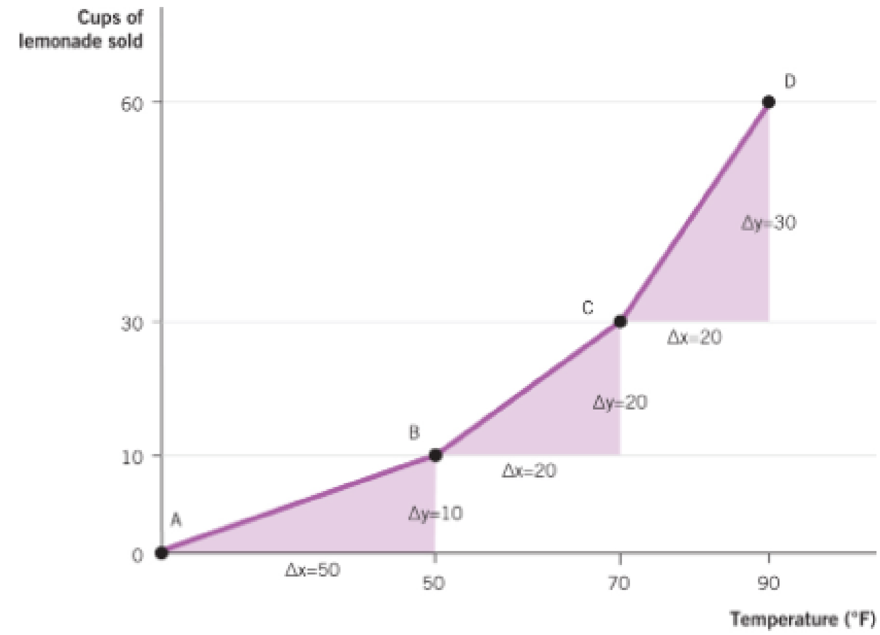
Figure 2A.5 illustrates the difference between a positive correlation and a negative correlation. Figure 2A.5a shows the same information as Figure 2A.4. When the temperature increases, the quantity of lemonade sold increases as well. However, in Figure 2A.5b we have a very different set of ordered pairs. As the temperature increases, the quantity of hot chocolate sold falls. We can see this relationship by starting with point E, where the temperature is 32°F and hot chocolate sales are 60 cups. At point F, the temperature rises to 50°F, but hot chocolate sales fall to 30 cups. At point G, the temperature is 70°F and hot chocolate sales are down to 10 cups. The purple line connecting points E–H illustrates the negative correlation between hot chocolate sales and temperature, because the line is downward sloping. This relationship contrasts with the positive correlation in Figure 2A.5a, where lemonade sales rise from point A to point D and the line is upward sloping. But what exactly is slope?

The Slope of a Curve

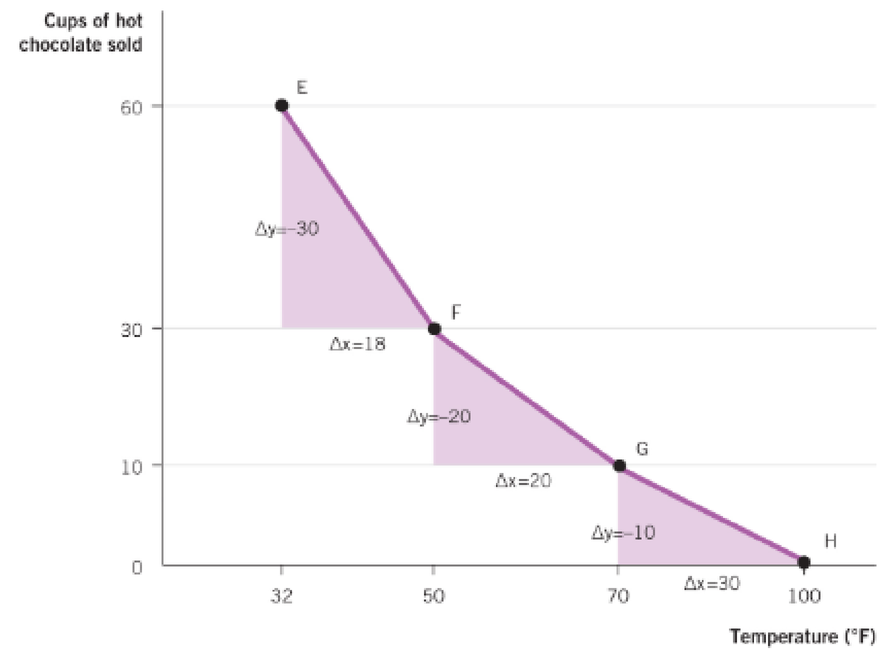
A key element in any graph is the **slope**, or the rise along the *y* axis (vertical) divided by the run along the *x* axis (horizontal). The *rise* is the amount that the vertical distance changes. The *run* is the amount that the horizontal distance changes.

$$\text{slope} = \frac{\text{change in } y}{\text{change in } x}$$

A slope can have a positive, negative, or zero value. A slope of zero—a straight horizontal line—indicates that there is no change in *y* for a given change in *x*. The slope can be positive, as it is in Figure 2A.5a, or negative, as it is in Figure 2A.5b. Figure 2A.6 highlights the changes in *x* and *y* between the points on Figure 2A.5. (The change in a variable is often notated with a Greek delta symbol, Δ, which is read "change in.")



(a) Positive Slope



(b) Negative Slope

Positive and Negative Slopes

Notice that in both panels the slope changes value from point to point. Because of this changing slope value, we say that the relationships are nonlinear. In (a), the slopes are positive as you move along the curve from point A to point D. In (b), the slopes are negative as you move along the curve from point E to point H. An upward, or positive, slope indicates a positive correlation, while a negative, or downward, slope indicates a negative correlation.

In Figure 2A.6a, the slope from point B to point C is

$$\text{Slope} = \frac{\text{change in } y}{\text{change in } x} = \frac{(30 - 10) \text{ or } 20}{(70 - 50) \text{ or } 20} = 1$$

All of the slopes in Figure 2A.6 are tabulated in Table 2A.1.

TABLE 2A.1

Positive and Negative Slopes

(a)		(b)	
Points	**Slope**	**Points**	**Slope**
A to B	0.2	E to F	-1.7
B to C	1.0	F to G	-1.0
C to D	1.5	G to H	-0.3

Each of the slopes in Figure 2A.6a is positive, and the values slowly increase from 0.2 to 1.5 as you move along the curve from point A to point D. However, in Figure 2A.6b, the slopes are negative as you move along the curve from point E to point H. An upward, or positive, slope indicates a positive correlation, while a downward, or negative, slope indicates a negative correlation.

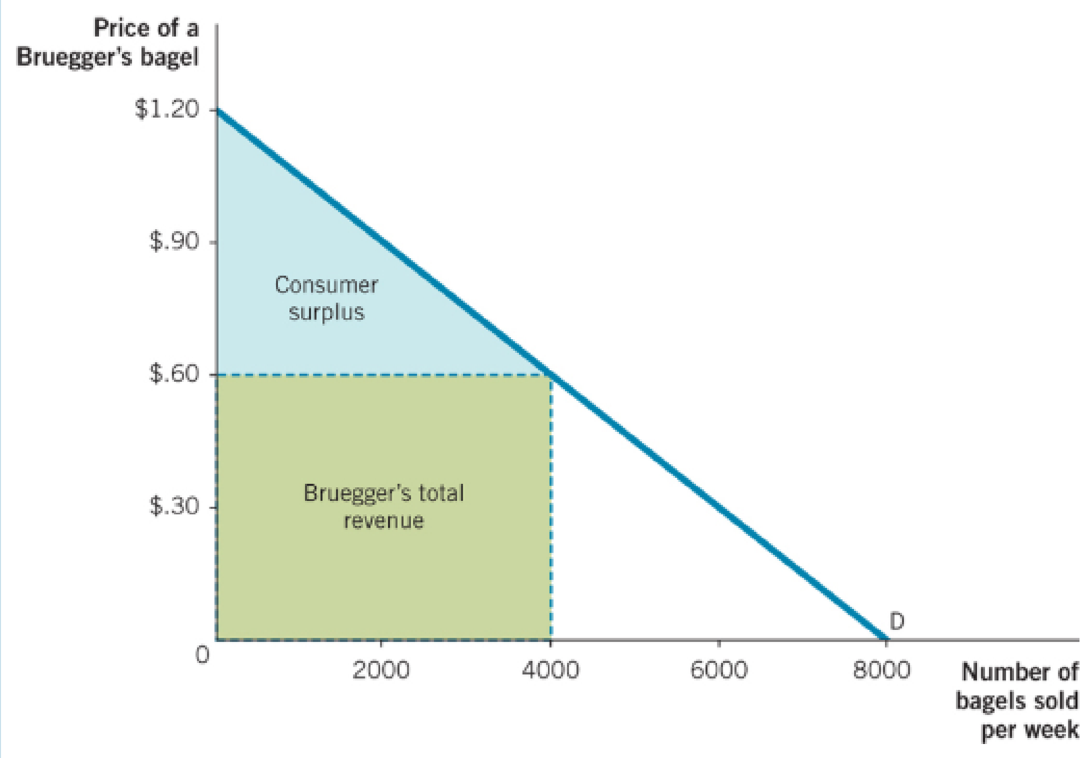
Notice that in both panels of Figure 2A.6, the slope changes values from point to point. Because of this changing slope, we say that the relationships are *nonlinear*. (In contrast, the relationship is *linear* when slope does not change along the line.) The slope tells us something about how responsive consumers are to changes in temperature. Consider the movement from point A to point B in Figure 2A.6a. The change in y is 10, while the change in x is 50, and the slope (10/50) is 0.2. Because zero indicates no change and 0.2 is close to zero, we can say that lemonade customers are not very responsive as the temperature rises from 0°F to 50°F. However, they are much more responsive from point C to point D, when the temperature rises from 70°F to 90°F. At point D, lemonade consumption—the change in y—rises from 30 to 60 cups, and the slope is now 1.5. The strength of the positive relationship is much stronger, and as a result, the curve is much steeper, or more vertical. This part of the curve contrasts with the movement from point A to point B, where the curve is flatter, or more horizontal.

We can apply the same analysis to Figure 2A.6b. Consider the movement from point E to point F. The change in y is –30, the change in x is 18, and the slope is –1.7. This value represents a strong negative relationship, so we would say that hot chocolate customers were quite responsive; as the temperature rose from 32°F to 50°F, they cut their consumption of hot chocolate by 30 cups. However, hot chocolate customers are not very responsive from point G to point H, where the temperature rises from 70°F to 100°F. In this case, consumption falls from 10 cups to 0 cups and the slope is –0.3. The strength of the negative relationship is much weaker (closer to zero), and as a result, the line is much flatter, or more horizontal. This part of the curve contrasts with the movement from point E to point F, where the curve is steeper, or more vertical.

Formulas for the Area of a Rectangle and a Triangle

Sometimes, economists interpret graphs by examining the area of different sections below a curve. Consider the demand for Bruegger's bagels shown in Figure 2A.7. The demand curve (labeled D) has a downward slope, which tells us that when the price of bagels falls, consumers will buy more bagels. (We will learn more about demand curves in Chapter 3.) But this curve also can tell us about the revenue the seller receives—one of the most important considerations for the firm. In this case, let's assume that the price of each bagel is $0.60 and Bruegger's sells 4,000 bagels each week. We can illustrate the total amount of Bruegger's revenue by shading the area bounded by the number of sales and the price—the green rectangle in the figure. In addition, we can identify the surplus benefit consumers receive from purchasing bagels; the blue triangle shows this amount. Because many buyers are willing to pay more than $0.60 per bagel, we can visualize the "surplus" that consumers get from Bruegger's Bagels by highlighting the blue triangular area under the demand curve and above the price of $0.60.

FIGURE 2A.7



Working with Rectangles and Triangles

We can determine the area of the green rectangle by multiplying the height by the base. This gives us $0.60 × 4,000, or $2,400 for the total revenue earned by Brueggerâs Bagels. We can determine the area of a triangle by using the formula $\frac{1}{2}$ × height × base. This gives us $\frac{1}{2}$ × $0.60 × 4,000, or $1,200 for the area of consumer surplus.

To calculate the area of a rectangle, we use the formula

$$\text{Area of a rectangle} = \text{height} \times \text{base}$$

In Figure 2A.7, the green rectangle is the amount of revenue that Brueggerâs Bagels receives when it charges $0.60 per bagel. The total revenue is $0.60 × 4,000, or $2,400.

To calculate the area of a triangle, we use the formula

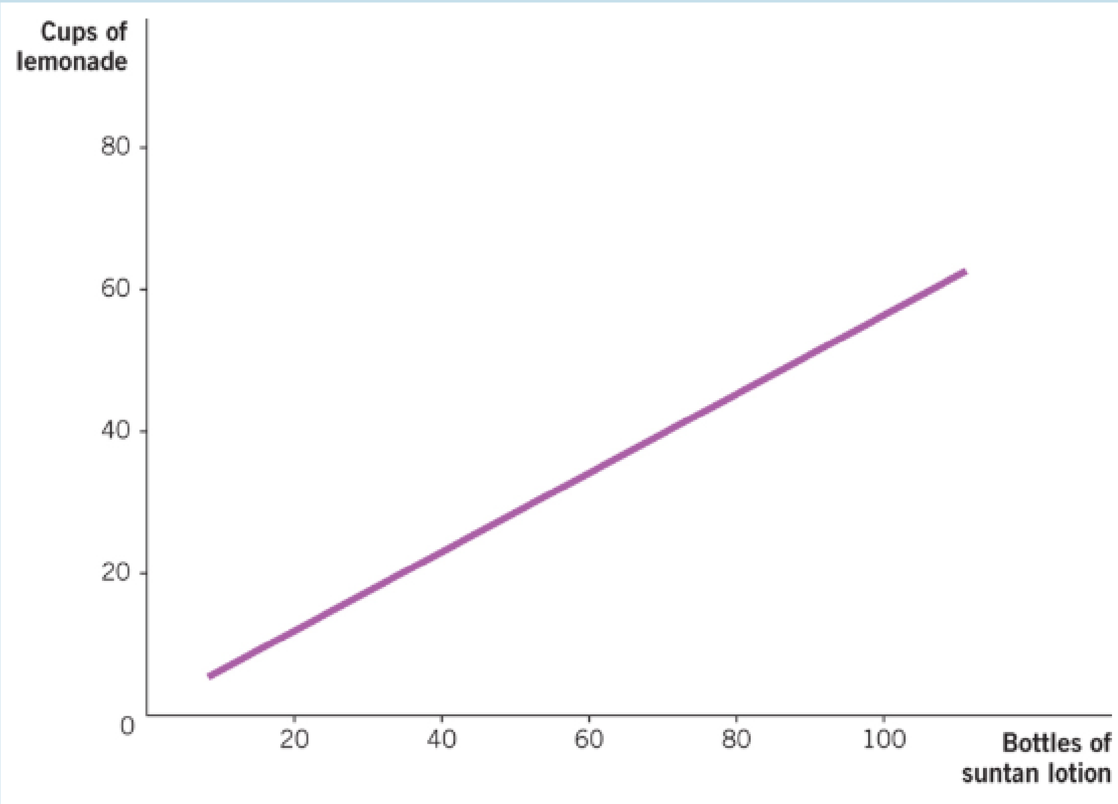
$$\text{Area of a triangle} = \frac{1}{2} \times \text{height} \times \text{base}$$

In Figure 2A.7, the blue triangle represents the amount of surplus consumers get from buying bagels. The amount of consumer surplus is $\frac{1}{2}$ × $0.60 × 4,000. Note that the value of the height, $0.60, comes from reading the y axis: $1.20 at the top of the triangle â $0.60 at the bottom of the triangle = $0.60.

Cautions in Interpreting Numerical Graphs

In Chapter 2, we utilized *ceteris paribus*, which entails holding everything else around us constant (unchanged) while analyzing a specific relationship. Suppose that you omitted an important part of the relationship. What effect would this omission have on your ability to use graphs as an illustrative tool? Consider the relationship between sales of lemonade and sales of bottles of suntan lotion. The graph of the two variables would look something like Figure 2A.8.

FIGURE 2A.8



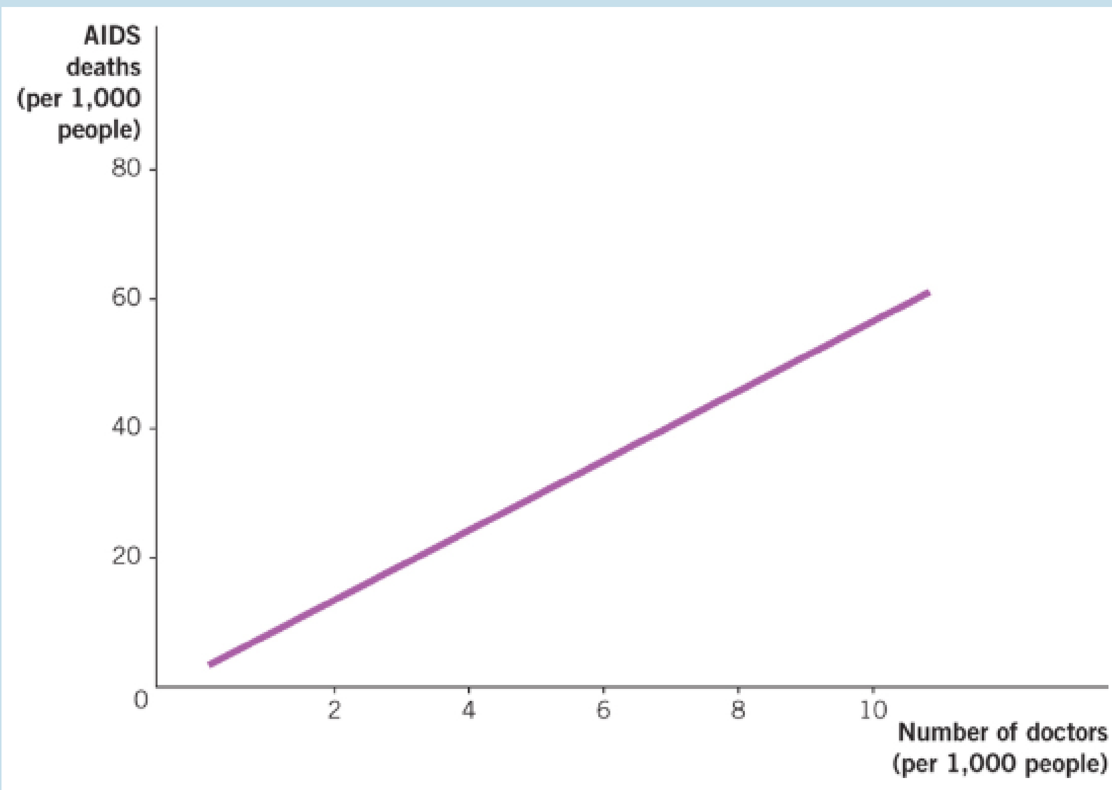
Graph with an Omitted Variable

What looks like a strongly positive correlation is misleading. What underlying variable is causing lemonade and suntan lotion sales to rise? The demand for both lemonade and suntan lotion rises because the temperature rises.

Looking at Figure 2A.8, you would not necessarily know that it is misleading. However, when you stop to think about the relationship, you quickly recognize that the graph is deceptive. Because the slope is positive, the graph indicates a positive correlation between the number of bottles of suntan lotion sold and the amount of lemonade sold. At first glance this relationship seems reasonable, because we associate suntan lotion and lemonade with summer activities. But the association does not imply **causality**, which occurs when one variable influences the other. Using more suntan lotion does not cause people to drink more lemonade. It just so happens that when it is hot outside, more suntan lotion is used and more lemonade is consumed. In this case, the causal factor is heat! The graph makes it look like the number of people using suntan lotion affects the amount of lemonade being consumed, when in fact the two variables are not directly related.

Another possible mistake is **reverse causation**, which occurs when causation is incorrectly assigned among associated events. Suppose that in an effort to fight the AIDS epidemic in Africa, a research organization notes the correlation shown in Figure 2A.9.

FIGURE 2A.9



Reverse Causation and an Omitted Variable

As you look at this graph, you should quickly realize that important information is missing. AIDS deaths are associated with having more doctors in the area. But the doctors are there to help and treat people, not harm them. Suggesting that more doctors in an area causes more deaths from AIDS would be a mistake—an example of reverse causation.

After looking at the data, it is clear that as the number of doctors per 1,000 people goes up, so do death rates from AIDS. The research organization puts out a press release claiming that doctors are responsible for increasing AIDS deaths, and the media hypes the discovery. But hold on! Maybe there happen to be more doctors in areas with high incidences of AIDS because that's where they are most needed. Coming to the correct conclusion about the data requires that we do more than simply look at the correlation.

CONCEPTS YOU SHOULD KNOW

causality (p. 65)
negative correlation (p. 60)
positive correlation (p. 60)
reverse causation (p. 66)
scatterplot (p. 60)
slope (p. 61)
variable (p. 57)

STUDY PROBLEMS

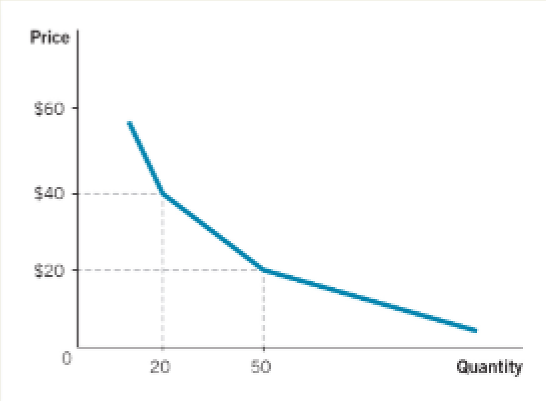
1. The following table shows the price and the quantity demanded of apples (per week).

Price per Apple	Quantity Demanded
$0.25	10
$0.50	7
$0.75	4
$1.00	2
$1.25	1
$1.50	0

a. Plot the data provided in the table into a graph.

b. Is the relationship between the price of apples and the quantity demanded negative or positive?

* **2.** In the following graph, calculate the value of the slope if the price rises from $20 to $40.



2. The slope is calculated by using the formula:

$$\text{Slope} = \frac{\text{change in } y}{\text{change in } x} = \frac{\$40 - \$20}{20 - 50} - \frac{\$20}{-30} = -0.6667$$

3. Explain the logical error in the following sentence: "As ice cream sales increase, the number of people who drown increases sharply. Therefore, ice cream causes drowning."