If you are reading this book, there is a good chance that you are either in college or thinking about taking the plunge. As you know, college is a big investment. Tuition averages almost $2,500 per year at community colleges, almost $5,000 per year at public colleges, and almost $25,000 per year at private colleges. And that’s not the only cost. Your time, as we have seen, is worth $10 or more per hour—this time value adds at least $20,000 per year to the opportunity cost of a college education.

As with any other investment, you’d like to know how a college education is going to pay you back. What are the “returns to education,” and how would you measure them? In this chapter you’ll see that you can answer such questions with models and data.

**CHAPTER OUTLINE**

2.1 The Scientific Method

2.2 Causation and Correlation

2.3 Economic Questions and Answers

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**Is college worth it?**

How much more do workers with a college education earn?

How much do wages increase when an individual is compelled by law to get an extra year of schooling?
Recall that empiricism—using data to analyze the world—is the third key principle of economics. We explored the first two principles—optimization and equilibrium—in the previous chapter. Empiricism is the focus of this chapter.

Empiricism is at the heart of all scientific analysis. The **scientific method** is the name for the ongoing process that economists, other social scientists, and natural scientists use to:

1. Develop models of the world
2. Test those models with data—evaluating the match between the models and the data

Economists do not expect this process to reveal the “true” model of the world, since the world is vastly complex. However, economists do expect to identify models that are useful in understanding the world. Testing with data enables economists to separate the good models—those that approximately match the data—from the bad models. When a model is overwhelmingly inconsistent with the data, economists try to fix the model or replace it altogether. We believe that this process enables us to find more useful models that help to explain the past and to predict the future with some confidence. In this section, we explain what a model is and how a model can be tested with data.

### Models and Data

Everyone once believed that the earth was flat. We now know that it is more like a beach ball than a Frisbee. Yet the flat-earth model is still actively used. Go into a gas station and you’ll find only flat road maps for sale. Consult your GPS receiver and you’ll also see flat maps. Nobody keeps a globe in the glove compartment.

Flat maps and spherical globes are both models of the surface of the earth. A **model** is a simplified description, or representation, of the world. Because models are simplified, they are not perfect replicas of reality. Obviously, flat maps are not perfectly accurate models of the surface of the earth—they distort the curvature. If you are flying from New York to Tokyo, the curvature matters. But if you are touring around New York City, you don’t need to worry about the fact that the earth is shaped like a sphere.

Scientists—and commuters—use the model that is best suited to analyze the problem at hand. Even if a model/map is based on assumptions that are known to be false, like flatness of the earth, the model may still help us to make good predictions and good plans for the
2.1 Data are facts, measurements, or statistics that describe the world. 

Exhibit 2.1 Flying from New York to Tokyo Requires More Than a Flat Map

This flat map is a model of part of the earth’s surface. It treats the world as perfectly flat, which leads the map maker to exaggerate distances in the northern latitudes. It is useful for certain purposes—for instance, learning geography. But you wouldn’t want to use it to find the best air route across the Pacific Ocean. For example, the shortest flight path from New York to Tokyo is not a straight line through San Francisco. Instead, the shortest path goes through Northern Alaska! The flat-earth model is well suited for some tasks (geography lessons) and ill-suited for others (intercontinental flight navigation).

Exhibit 2.2 New York City Subway Map

This is a model of the subway system in New York City. It is highly simplified—for example, it treats New York City as a perfectly flat surface and it also distorts the shape of the city—but it is nevertheless very useful for commuters and tourists.

Future. It is more important for a model to be simple and useful than it is for a model to be precisely accurate.

All scientific models make predictions that can be checked with data—facts, measurements, or statistics that describe the world. Recall from Chapter 1 that economists often describe themselves as empiricists, or say that we practice empiricism, because we use data
to create **empirical evidence**. These terms all boil down to the same basic idea: using data to answer questions about the world and using data to test models. For example, we could test the New York City subway map by actually riding the subway and checking the map’s accuracy.

When conducting empirical analysis, economists refer to a model’s predictions as **hypotheses**. Whenever such hypotheses are contradicted by the available data, economists return to the drawing board and try to come up with a better model that yields new hypotheses.

## An Economic Model

Let’s consider an example of an economic model. We’re going to study an extremely simple model to get the ball rolling. But even economic models that are far more complicated than this example are also highly simplified descriptions of reality.

All economic models begin with assumptions. Consider the following assumption about the returns to education: *Investing in one extra year of education increases your future wages by 10 percent*. Let’s put the assumption to work to generate a model that relates a person’s level of education to her wages.

Increasing a wage by 10 percent is the same as multiplying the wage by $1 + 0.10 = 1.10$. The returns-to-education assumption implies that someone with an extra year of education earns 1.10 times as much as she would have earned without the extra year of education. For example, if someone would earn $15 per hour with 13 years of education, then a 14th year of education will cause her hourly wage to rise to $15 \times 1.10 = 16.50$.

Economists use assumptions to derive other implications. For example, the returns-to-education assumption implies that *two* additional years of education will increase earnings by 10 percent twice over—once for each extra year of education—producing a 21 percent total increase.

$$1.10 \times 1.10 = 1.21.$$  

Consider another example. *Four* additional years of education will increase earnings by 10 percent four times over, implying a 46 percent total increase.

$$1.10 \times 1.10 \times 1.10 \times 1.10 = (1.10)^4 = 1.46.$$  

This implies that going to college would increase a college graduate’s income by 46 percent compared to what she would have been paid if she had ended her education after finishing high school. In other words, a prediction—or hypothesis—of the model is that college graduates will earn 46 percent more than high school graduates.

In principle, we can apply this analysis to *any* number of years of education. We therefore have a general model that relates people’s educational attainment to their income. The model that we have derived is referred to as the returns-to-education model. It describes the economic payoff of more education—in other words, the “return” on your educational investment. Most economic models are much, much more complex than this. In most economic models, it takes pages of mathematical analysis to derive the implications of the assumptions. Nevertheless, this simple model is a good starting point for our discussion. It illustrates two important properties of all models.

First, a model is an approximation. The model does not predict that everyone would increase their future wages by exactly 10 percent if they obtained an extra year of education. The predicted relationship between education and future wages is an average relationship—it is an approximation for what is predicted to happen for most people in most circumstances. The model overlooks lots of special considerations. For example, the final year of college probably does much more to increase your wages than the second-to-last year of college, because that final year earns you the official degree, which is a key item on your resumé. Likewise, your college major importantly impacts how much you will earn after college. Those who major in economics, for example, tend to earn more than graduates in most other majors. Our simple model overlooks many such subtleties. Just as a flat subway map is only an approximation of the features of a city, the returns-to-education model is only an approximation of the mapping from years of education to wages.

Second, a model makes predictions that can be tested with data—in this case, data on people’s education and earnings. We are now ready to use some data to actually evaluate the predictions of the returns-to-education model.
Q: How much more do workers with a college education earn?

To put the model to the test we need data, which we obtain from the Current Population Survey (CPS), a government data source. This survey collects data on wages, education, and many other characteristics of the general population and is available to anyone who wants to use it. When data are available to the general public, they are called “public-use data.”

Exhibit 2.3 summarizes the average annual earnings for our test. The returns-to-education model does not match the data perfectly. The exhibit shows that for 30-year-old U.S. workers with 12 years of education, which is equivalent to a high school diploma, the average yearly salary is $32,941. For 30-year-old U.S. workers with 16 years of education, which is equivalent to graduation from a four-year college, the average salary is $51,780.

If we simply divide these two average wages—college wage over high school wage—the ratio is 1.57.

\[
\frac{\text{average salary of 30-year-olds with 16 years of education}}{\text{average salary of 30-year-olds with 12 years of education}} = \frac{\$51,780}{\$32,941} = 1.57.
\]

Recall that the returns-to-education model says that each additional year of education raises the wage by 10 percent, so four extra years of education should raise the wage by a factor of \((1.10)^4 = 1.46\).

We can see that the model does not exactly match the data. Going from 12 years of education to 16 years is associated with a 57 percent increase in income. However, the model is not far off—the model predicted a 46 percent increase.
You may wonder how the data from the CPS can be used to calculate the wages reported above. We used the concept of the mean, or average. The mean (or average) is the sum of all the different values divided by the number of values and is a commonly used technique for summarizing data. Statisticians and other scientists use the terms mean and average interchangeably.

We can quickly show how the mean works in a small example. Say that there are five people: Mr. Kwon, Ms. Littleton, Mr. Locke, Ms. Reye, and Mr. Shephard, each with a different hourly wage:

- Kwon = $26 per hour,
- Littleton = $24 per hour,
- Locke = $8 per hour,
- Reye = $35 per hour,
- Shephard = $57 per hour.

If we add the five wages together and divide by 5, we calculate a mean wage of $30 per hour.

\[
\frac{26 + 24 + 8 + 35 + 57}{5} = 30.
\]

This analysis of a small sample illustrates the idea of calculating a mean, but convincing data analysis in economics relies on using a large sample. For example, a typical economic research paper uses data gathered from thousands of individuals. So a key strength of economic analysis is the amount of data used. Earlier we didn’t rely on a handful of observations to argue that education raises earnings. Instead, we used data from more than thousands of surveyed 30-year-olds. Using lots of data—economists call them observations—strengthens the force of an empirical argument because the researcher can make more precise statements.

To show you how to make convincing empirical arguments, this course uses lots of real data from large groups of people. Credible empirical arguments, based on many observations, are a key component of the scientific method.

**Argument by Anecdote**

Education is not destiny. There are some people with lots of education who earn very little. There are some people with little education who earn a lot. When we wrote this book, Bill Gates, a Harvard dropout who founded Microsoft, was the richest man in the world. Mark Zuckerberg, the Facebook CEO, also dropped out of Harvard.

With these two examples in mind, it is tempting to conclude that dropping out of college is a great path to success. However, it is a mistake to use two anecdotes, or any small sample of people, to try to judge a statistical relationship.

Here’s another example of how the amount of data can make a big difference. Exhibit 2.4 plots data from just two people. They are both 30-years-old. As you can see, the exhibit does not reproduce the positive relationship between education and earnings that is plotted in Exhibit 2.3. Instead, it looks as though rising education is associated with falling earnings. But the pattern in Exhibit 2.4 is far from shocking given that it plots only two people. Indeed, if you study two randomly chosen 30-year-olds, there is a 25 percent chance that the person with only a high school diploma has higher earnings than the person with a four-year college degree. This fact highlights that there is much more than education that determines your earnings, although getting a college degree will usually help make you money.

When you look at only a small amount of data, it is easy to jump to the wrong conclusion. Keep this warning in mind the next time a newspaper columnist tries to convince you of something by using a few anecdotes. If the columnist backs up her story with data reflecting the experiences of thousands of people, then she has done her job and may deserve to win the argument. But if she rests her case after sharing a handful of anecdotes, remain skeptical. Be doubly skeptical if you suspect that the anecdotes have been carefully
selected to prove the columnist’s point. Argument by anecdote should not be taken too seriously.

There is one exception to this rule. Argument by example is appropriate when you are contradicting a blanket statement. For example, if someone asserts that every National Basketball Association (NBA) player has to be tall, just one counterexample is enough to prove this statement wrong. In this case, your proof would be Tyrone Bogues, a 5-foot 3-inch dynamo who played in the NBA for 14 years.

2.2 Causation and Correlation

Using our large data set on wages and years of education, we’ve seen that on average wages rise roughly 10 percent for every year of additional education. Does this mean that if we could encourage a student to stay in school one extra year, that would cause that individual’s future wages to rise 10 percent? Not necessarily. Let’s think about why this is not always the case with an example.

The Red Ad Campaign Blues

Assume that Walmart has hired you as a consultant. You have developed a hypothesis about ad campaigns: you believe that campaigns using the color red are good at catching people’s attention. To test your hypothesis, you assemble empirical evidence from historical ad campaigns, including the color of the ad campaign and how revenue at Walmart changed during the campaign.

Your empirical research confirms your hypothesis! Sales go up 25 percent during campaigns with lots of red images. Sales go up only 5 percent during campaigns with lots of blue images. You race to the chief executive officer (CEO) to report this remarkable result. You are a genius! Unfortunately, the CEO instantly fires you.

What did the CEO notice that you missed?

The red-themed campaigns were mostly concentrated during the Christmas season. The blue-themed campaigns were mostly spread out over the rest of the year. In the CEO’s words,

The red colors in our advertising don’t cause an increase in our revenue. Christmas causes an increase in our revenue. Christmas also causes an increase in the use of red in our ads. If we ran blue ads in December our holiday season revenue would still rise by about 25 percent.
Unfortunately, this is actually a true story, though we’ve changed the details—including the name of the firm—to protect our friends. We return, in the appendix, to a related story where the CEO was not as sharp as the CEO in this story.

**Causation versus Correlation**

People often mistake *causation* for *correlation*. *Causation* occurs when one thing directly affects another. You can think of it as the path from cause to effect: putting a snowball in a hot oven causes it to melt.

*Correlation* means that there is a mutual relationship between two things. When Correlation Does Not Imply Causality

There are two reasons why we should not jump to the conclusion that a correlation between two variables implies a particular causal relationship:

1. **Omitted variables**
2. **Reverse causality**

An omitted variable is something that has been left out of a study that, if included, would explain why two variables that are in the study are correlated.

Reverse causality occurs when we mix up the direction of cause and effect.

Think of causation as the path from cause to effect.

**Causation** occurs when one thing directly affects another through a cause-and-effect relationship.

A correlation means that there is a mutual relationship between two things.

A variable is a factor that is likely to change or vary.

Positive correlation implies that two variables tend to move in the same direction.

Negative correlation implies that two variables tend to move in opposite directions. When the variables have movements that are not related, we say that the variables have zero correlation.

An omitted variable is something that has been left out of a study that, if included, would explain why two variables that are in the study are correlated.

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Chapter 2  |  Economic Methods and Economic Questions

2.1

2.3

2.2

An experiment is a controlled method of investigating causal relationships among variables.

Randomization is the assignment of subjects by chance, rather than by choice, to a treatment group or control group.

Exhibit 2.5 An Example of an Omitted Variable

The amount of red content in Walmart’s ads is positively correlated with the growth of Walmart’s revenue. In other words, when ads are red-themed, Walmart’s month-over-month sales revenue tends to grow the fastest. However, the redness does not cause Walmart’s revenue to rise. The Christmas season causes Walmart’s ads to be red and the Christmas season also causes Walmart’s sales revenue to rise. The Christmas season is the omitted variable that explains the positive correlation between red ads and revenue growth.

The amount of red content in Walmart’s ads is positively correlated with the growth of Walmart’s revenue. In other words, when ads are red-themed, Walmart’s month-over-month sales revenue tends to grow the fastest. However, the redness does not cause Walmart’s revenue to rise. The Christmas season causes Walmart’s ads to be red and the Christmas season also causes Walmart’s sales revenue to rise. The Christmas season is the omitted variable that explains the positive correlation between red ads and revenue growth.

direction of cause and effect. For example, consider the fact that relatively wealthy people tend to be relatively healthy too. This has led some social scientists to conclude that greater wealth causes better health—for instance, wealthy people can afford better healthcare. On the other hand, there may be reverse causality: better health may cause greater wealth. For example, healthy people can work harder and have fewer healthcare expenditures than less healthy people. It turns out that both causal channels seem to exist: greater wealth causes better health and better health causes greater wealth!

In our analysis of the returns to education, could it be that reverse causality is at play: higher wages at age 30 cause you to get more education at age 20? We can logically rule this out. Assuming that you don’t have a time machine, it is unlikely that your wage as a 30-year-old causes you to obtain more education in your 20s. So in the returns-to-education example, reverse causality is probably not a problem. But in many other analyses—for example, the wealth-health relationship—reverse causality is a key consideration.

Economists have developed a rich set of tools to determine what is causation and what is only correlation. We turn to some of these tools next.

Experimental Economics and Natural Experiments

One method of determining cause and effect is to run an experiment—a controlled method of investigating causal relationships among variables. Though you may not read much about economic experiments in the newspaper, headlines for experiments in the field of medicine are common. For example, the Food and Drug Administration (FDA) requires pharmaceutical companies to run carefully designed experiments to provide evidence that new drugs work before they are approved for general public use.

To run an experiment, researchers usually create a treatment (test) group and a control group. Participants are assigned randomly to participate either as a member of the treatment group or as a member of the control group—a process called randomization. Randomization is the assignment of subjects by chance, rather than by choice, to a treatment group or control group. The treatment group and the control group are treated identically, except along a single dimension that is intentionally varied across the two groups. The impact of this variation is the focus of the experiment.

If we want to know whether a promising new medicine helps patients with diabetes, we could take 1,000 patients with diabetes and randomly place 500 of them into a treatment group—those who receive the new medicine. The other 500 patients would be in the control group and receive the standard diabetes medications that are already widely used. Then, we would follow all of the patients and see how their health changes over the next few years. This experiment would test the causal hypothesis that the new drug is better than the old drug.

Now, consider an economics experiment. Suppose that we want to know what difference a college degree makes. We could take 1,000 high school students who cannot afford college, but who want to attend college, and randomly place 500 of them into a treatment group where
Section 2.2  |  Causation and Correlation

they had all of their college expenses paid. The other 500 students would be placed in the control group. Then, we would keep track of all of the original 1,000 students—including the 500 control group students who weren’t able to go to college because they couldn’t afford it. We would use periodic surveys during their adult lives to see how the wages in the group that got a college education compare with the wages of the group that did not attend college. This experiment would test the hypothesis that a college education causes wages to rise.

One problem with experimentation is that experiments can sometimes be very costly to conduct. For instance, the college-attendance experiment that we just described would cost tens of millions of dollars, because the researchers would need to pay the college fees for 500 students. Another problem is that experiments do not provide immediate answers to some important questions. For example, learning about how one more year of education affects wages over the entire working life would take many decades if we ran an experiment on high school students today.

Another problem is that experiments are sometimes run poorly. For example, if medical researchers do not truly randomize the assignment of patients to medical treatments, then the experiment may not teach us anything at all. For instance, if patients who go to cutting-edge research hospitals tend to be the ones who get prescribed the newest kind of diabetes medication, then we don’t know whether the new medication caused those patients to get better or whether it was some other thing that their fancy hospitals did that actually caused the patients’ health to improve. In a well-designed experiment, randomization alone would determine who got the new medicine and who got the old medicine.

When research is badly designed, economists tend to be very skeptical of its conclusions. We say “garbage in, garbage out” to capture the idea that bad research methods invalidate a study’s conclusions.

If we don’t have the budget or time to run an experiment, how else can we identify cause and effect? One approach is to study historical data that has been generated by a “natural” experiment. A natural experiment is an empirical study in which some process—out of the control of the experimenter—has assigned subjects to control and treatment groups in a random or nearly random way.

Economists have found and exploited natural experiments to answer numerous major questions. This methodology can be very useful in providing a more definitive answer to our question at hand: What are you getting from your education?

A natural experiment is an empirical study in which some process—out of the control of the experimenter—has assigned subjects to control and treatment groups in a random or nearly random way.

Evidence-Based Economics

Q: How much do wages increase when an individual is compelled by law to get an extra year of schooling?

Many decades ago, compulsory schooling laws were much more permissive, allowing teenagers to drop out well before they graduated from high school. Philip Oreopoulos studied a natural experiment that was created by a change in these compulsory schooling laws.¹ Oreopoulos looked at an educational reform in the United Kingdom in 1947, which increased the minimum school leaving age from 14 to 15. As a result of this change, the fraction of children dropping out of school by age 14 fell by 50 percentage points between 1946 and 1948.

In this way, those kids reaching age 14 before 1947 are a “control group” for those reaching age 14 after 1947. Oreopoulos found that the students who turned 14 in 1948 and were therefore compelled to stay in school one extra year earned 10 percent more on average than the students who turned 14 in 1946.

Natural experiments are a very useful source of data in empirical economics. In many problems, they help us separate correlation from causation. Applied to the returns to education, they suggest that the correlation between years of education and higher income is not due to some omitted variable, but reflects the causal influence of education.
Evidence-Based Economics (Continued)

The returns-to-education model thus obtains strong confirmation from the data. Does a 10 percent return to each additional year of education increase your appetite for more years of schooling?

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<th>Answer</th>
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<td>How much do wages increase when an individual is compelled by law to get an extra year of schooling?</td>
<td>On average, wages rise by 10 percent when kids are compelled to stay in school an extra year.</td>
<td>United Kingdom General Household Survey. Compare kids in the United Kingdom who were allowed to drop out of school at age 14 with others who were compelled to stay in school an extra year due to changes in compulsory schooling laws.</td>
<td>Factors other than the change in the compulsory schooling laws might explain why the kids who were compelled to stay in school eventually earned more in the workforce (this is an example of an omitted variable).</td>
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2.3 Economic Questions and Answers

Economists like to think about our research as a process in which we pose and answer questions. We’ve already seen a couple of these questions. For example, in the current chapter, we asked, “How much do wages increase when an individual is compelled by law to get an extra year of schooling?” and in Chapter 1, we asked, “What is the opportunity cost of your time?”

Good questions come in many different forms. But the most exciting economic questions share two properties.

1. **Good questions address topics that are important to individual economic agents and/or to our society.** Economists tend to think about economic research as something that contributes to society’s welfare. We try to pursue research that has general implications for human behavior or economic performance. For example, understanding the returns to education is important because individuals invest a lot of resources obtaining an education. The United States spends nearly a tenth of its economic output on education—$1.5 trillion per year. It is useful to quantify the payoffs from all this investment. If the returns to education are very high, society may want to encourage even more educational investment. If the returns to education are low, we should share this important fact with students who are deciding whether or not to stay in school. Knowing the returns to education will help individuals and governments decide how much of their scarce resources to allocate to educational investment.

2. **Good economic questions can be answered.** In some other disciplines, posing a good question is enough. For example, philosophers believe that some of the most important questions don’t have answers. In contrast, economists are primarily interested in questions that can be answered with enough hard work and careful reasoning.

Here are some of the economic questions that we discuss in this book. As you look over the set, you will see that these are big questions with significant implications for you and for society as a whole. The rest of this book sets out to discover answers to these questions. We believe the journey will be exhilarating—so let’s get started!
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**Summary**

The scientific method is the name for the ongoing process that economists and other scientists use to (a) develop mathematical models of the world and (b) test those models with data.

Empirical evidence is a set of facts established by observation and measurement, which are used to evaluate a model.

Economists try to uncover causal relationships among variables.

One method to determine causality is to run an experiment—a controlled method of investigating causal relationships among variables. Economists now actively pursue experiments both in the laboratory and in the field. Economists also study historical data that have been generated by a natural experiment to infer causality.

**Key Terms**

- scientific method p. 21
- model p. 21
- data p. 22
- empirical evidence p. 23
- hypotheses p. 23
- mean (average) p. 25
- causation p. 27
- correlation p. 27
- variable p. 27
- positive correlation p. 27
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- experiment p. 28
- randomization p. 28
- natural experiment p. 29

**Questions**

*All questions are available in MyEconLab for practice and instructor assignment.*

1. What does it mean to say that economists use the scientific method? How do economists distinguish between models that work and those that don’t?

2. What is meant by empiricism? How do empiricists use hypotheses?

3. What are two important properties of economic models? Models are often simplified descriptions of a real-world phenomenon. Does this mean that they are unrealistic?

4. How is the mean calculated from a series of observations? Suppose 5,000 people bought popsicles on a hot summer day. If the mean of the average number of popsicles bought is 2, how many popsicles were sold that day?

5. How does the sample size affect the validity of an empirical argument? When is it acceptable to use only one example to disprove a statement?


7. Give an example of a pair of variables that have a positive correlation, a pair of variables that have a negative correlation, and a pair of variables that have zero correlation.

8. What is meant by randomization? How does randomization affect the results of an experiment?

9. This chapter discussed natural and randomized experiments. How does a natural experiment differ from a randomized one? Which one is likely to yield more accurate results?

10. Suppose you had to find the effect of seatbelt rules on road accident fatalities. Would you choose to run a randomized experiment or would it make sense to use natural experiments here? Explain.
Problems

All problems are available in MyEconLab for practice and instructor assignment.

1. This chapter talks about means. The median is a closely related concept. The median is the numerical value separating the higher half of your data from the lower half. You can find the median by arranging all of the observations from lowest value to highest value and picking the middle value (assuming you have an odd number of observations). Although the mean and median are closely related, the difference between the mean and the median is sometimes of interest.
   a. Suppose country A has five families. Their incomes are $10,000, $20,000, $30,000, $40,000, and $50,000. What is the median family income in A? What is the mean income?
   b. Country B also has five families. Their incomes are $10,000, $20,000, $30,000, $40,000, and $150,000. What is the median family income in B? What is the mean income?
   c. In which country is income inequality greater, A or B?
   d. Suppose you thought income inequality in the US had increased over time. Based on your answers to this question, would you expect that the ratio of the mean income in the US to the median income has risen or fallen? Explain.

2. Consider the following situation: your math professor tells your class that the mean score on the final exam is 43. The exam was scored on a total of 100 points. Does this imply that you, too, scored poorly on the exam? Explain.

3. This chapter stressed the importance of using appropriate samples for empirical studies. Consider the following two problems in that light.
   a. You are given a class assignment to find out if people’s political leanings affect the newspaper or magazine that they choose to read. You survey two students taking a political science class and five people at a coffee shop. Almost all the people you have spoken to tell you that their political affiliations do not affect what they read. Based on the results of your study, you conclude that there is no relationship between political inclinations and the choice of a newspaper. Is this a valid conclusion? Why or why not?
   b. Your uncle tells you that the newspaper or magazine that people buy will depend on their age. He says that he believes this because, at home, his wife and his teenage children read different papers. Do you think his conclusion is justified?

4. Some studies have found that people who owned guns were more likely to be killed with a gun. Do you think this study is strong evidence in favor of stricter gun control laws? Explain.

5. As the text explains, it can sometimes be very difficult to sort out the direction of causality.
   a. Why might you think that more police officers would lead to lower crime rates? Why might you think that higher crime rates would lead to more police officers?
   b. In 2012, the New England Journal of Medicine published research that showed a strong correlation between the consumption of chocolate in a country and the number of Nobel Prize winners in that country. Do you think countries that want to encourage their citizens to win Nobel Prizes should increase their consumption of chocolate?

6. The chapter shows that in general people with more education earn higher salaries. Economists have offered two explanations of this relationship. The human capital argument says that high schools and colleges teach people valuable skills, and employers are willing to pay higher salaries to attract people with those skills. The signaling argument says that college graduates earn more because a college degree is a signal to employers that a job applicant is diligent, intelligent, and persevering. How might you use data on people with two, three, and four years of college education to shed light on this controversy?

7. Maimonides, a twelfth-century scholar, said, “Twenty-five children may be put in the charge of one teacher. If the number in the class exceeds twenty-five but is not more than forty, he should have an assistant to help with the instruction. If there are more than forty, two teachers must be appointed.” Israel follows Maimonides’s rule in determining the number of teachers for each class. How could you use Maimonides’s rule as a natural experiment to study the effect of teacher-student ratios on student achievement?

8. Oregon expanded its Medicaid coverage in 2008. Roughly 90,000 people applied but the state had funds to cover only an additional 30,000 people (who were randomly chosen from the total applicant pool of 90,000). How could you use the Oregon experience to estimate the impact of increased access to healthcare on health outcomes?

9. A simple economic model predicts that a fall in the price of bus tickets means that more people will take the bus. However, you observe that some people still do not take the bus even after the price of a ticket fell.
   a. Is the model incorrect?
   b. How would you test this model?
Appendix

Constructing and Interpreting Graphs

As you start to learn economics, it’s important that you have a good grasp of how to make sense of data and how to present data clearly in visible form. Graphs are everywhere—on TV, on the Web, in newspapers and magazines, in economics textbooks. Why are graphs so popular?

A well-designed graph summarizes information with a simple visual display—the old adage “a picture is worth a thousand words” might help you understand the popularity of visual images. In this textbook, you will find many graphs, and you will see that they provide a way to supplement the verbal description of economic concepts.

To illustrate how we construct and interpret graphs, we will walk you through a recent study that we have conducted, presenting some data summaries along the way.

A Study About Incentives

Would you study harder for this economics class if we paid you $50 for earning an A? What if we raised the stakes to $500? Your first impulse might be to think “Well, sure . . . why not? That money could buy a new Kindle and maybe a ticket to a Beyoncé concert.”

But as we have learned in Chapter 1, there are opportunity costs of studying more, such as attending fewer rock concerts or spending less time at your favorite coffee house chatting with friends. Such opportunity costs must be weighed against the benefits of earning an A in this course. You might conclude that because this question is hypothetical, anyway, there’s no need to think harder about how you would behave.

But it might not be as imaginary as you first thought.

Over the past few years, thousands of students around the United States have actually been confronted with such an offer. In fact, Sally Sadoff, Steven Levitt, and John List carried out an experiment at two high schools in the suburbs of Chicago over the past several years in which they used incentives to change students’ behavior. Such an experiment allows us to think about the relationship between two variables, such as how an increase in a financial reward affects student test scores. And it naturally leads to a discussion of cause and effect, which we have just studied in this chapter: we’ll compare causal relationships between variables and consider simple correlations between variables. Both causation and correlation are powerful concepts in gaining an understanding of the world around us.

Experimental Design

There are two high schools in Chicago Heights, and both have a problem with student dropouts. In terms of dropouts, it is not uncommon for more than 50 percent of incoming ninth-graders to drop out before receiving a high school diploma. There are clearly problems in this school district, but they are not unique to Chicago Heights; many urban school districts face a similar problem.

How can economists help? Some economists, including one of the coauthors of this book, have devised incentive schemes to lower the dropout rates and increase academic achievement in schools. In this instance, students were paid for improved academic performance.²
Let’s first consider the experiment to lower the dropout rate. Each student was randomly placed into one of the following three groups:

**Control Group:** No students received financial compensation for meeting special standards established by experimenters (which are explained below).

**Treatment Group with Student Incentives:** Students would receive $50 for each month the standards were met.

**Treatment Group with Parent Incentives:** Students’ parents would receive $50 for each month the standards were met.

A student was deemed to have met the monthly standards if he or she:

1. did not have a D or F in any classes during that month,
2. had no more than one unexcused absence during that month,
3. had no suspensions during that month.

### Describing Variables

Before we discover how much money these students actually made, let’s consider more carefully the variables that we might be interested in knowing. As its name suggests, a variable is a factor that is likely to vary or change; that is, it can take different values in different situations. In this section, we show you how to use three different techniques to help graphically describe variables:

1. Pie charts
2. Bar graphs
3. Time series graphs

### Pie Charts

Understanding pie charts is a piece of cake. A **pie chart** is a circular chart split into segments to show the percentages of parts relative to the whole. Put another way, pie charts are used to describe how a single variable is broken up into different categories, or “slices.” Economists often use pie charts to show important economic variables, such as sources of government tax revenue or the targets of government expenditure, which we discuss in Chapter 10.

For example, consider the race of the students in our experiment. In Exhibit 2A.1, we learn that 59 percent of ninth-graders in the experiment are African-American. We therefore differentiate 59 percent of our pie chart with the color blue to represent the proportion of African-Americans relative to all participants in the experiment. We see that 15 percent of the students are non-Hispanic whites, represented by the red piece of the pie. We continue...
breaking down participation by race until we have filled in 100 percent of the circle. The circle then describes the racial composition of the participants in the experiment.

**Bar Charts**

Another type of graph that can be used to summarize and display a variable is a bar chart. A bar chart uses bars (no surprise there) of different heights or lengths to indicate the properties of different groups. Bar charts make it easy to compare a single variable across many groups. To make a bar chart, simply draw rectangles side-by-side, making each rectangle as high (or as long, in the case of horizontal bars) as the value of the variable it is describing.

For example, Exhibit 2A.2 captures the overall success rates of students in the various experimental groups. In the exhibit we have the independent variable—the variable that the experimenter is choosing (which treatment a student is placed in)—on the horizontal or x-axis. On the vertical or y-axis is the dependent variable—the variable that is potentially affected by the experimental treatment. In the exhibit, the dependent variable is the proportion of students meeting the academic standards. Note that 100 percent is a proportion of 1, and 30 percent is a proportion of 0.30.

We find some interesting experimental results in Exhibit 2A.2. For instance, we can see from the bar graph that 28 percent of students in the Control group (students who received no incentives) met the standards. In comparison, 34.8 percent of students in the Parent Incentive group met the standards. This is a considerable increase in the number of students meeting the standards—important evidence that incentives can work.

**Time Series Graphs**

With pie charts and bar graphs, we can summarize how a variable is broken up into different groups, but what if we want to understand how a variable changes over time? For instance, how did the proportion of students meeting the standards change over the school year? A time series graph can do the trick. A time series graph displays data at different points in time.

As an example, consider Exhibit 2A.3, which displays the proportion of students meeting the standards in each month in the Control and Parent Incentive groups. Keep in mind that although there are multiple months and groups, we are still measuring only a single variable—in this case, the proportion meeting the standard. As Exhibit 2A.3 makes clear, the number of students meeting the standard is higher in the Parent Incentive treatment group than in the Control group. But notice that the difference within the Parent Incentive and Control groups changes from month to month. Without a time series, we would not be able to appreciate these month-to-month differences and would not be able to get a sense for how the
Effectiveness of the incentive varies over the school year. As you read this book, one important data property to recognize is how variables change over time; time series graphs are invaluable in helping us understand how a variable changes over time.

**Scatter Plots**

You might ask yourself, without such monetary incentives is education worth it? In this chapter we showed you how wages and years of education are related. Another way to show the relationship is with a scatter plot. A scatter plot displays the relationship between two variables as plotted points of data. Exhibit 2A.4 shows the relationship between years of education and average weekly income across U.S. states in September of 2013. For example, the point 10.4 years of education and $800 in weekly earnings is from New Jersey. This means that the average years of education for New Jersey adults is 10.4 and the average weekly earnings is $800.

**Cause and Effect**

We’ve written a fair amount about causation and correlation in this chapter. Economists are much more interested in the former. Causation relates two variables in an active way—a causes b if, because of a, b has occurred.
For example, we could conclude in our experimental study that paying money for the students’ performance causes them to improve their academic performance. This would not necessarily be the case if the experiment were not properly implemented—for example, if students were not randomly placed into control and treatment groups. For instance, imagine that the experimenters had placed all of the students who had achieved poorly in the past in the control group. Then the relatively poor performance of the control group might be due to the composition of students who were assigned to the control group, and not to the lack of payment. Any relationship between academic achievement and payment stemming from such an experiment could be interpreted as a correlation because all other things were not equal at the start of the experiment—the control group would have a higher proportion of low achievers than the other groups.

Fortunately, the Chicago Heights Experiment was implemented using the principle of randomization, discussed earlier in this chapter. The experimenters split students into groups randomly, so each experimental group had an equal representation of students and their attributes (variables such as average student intelligence were similar across groups). Because the only possible reason that a student would be assigned to one group instead of another was chance, we can argue that any difference between the groups’ academic performance at the end of the experiment was due to the difference the experimental treatment imposed, such as differences in financial incentives.

This means that we can claim that the cause of the difference between the performance of the Student Incentive group and the Control group, for example, is that students in the Student Incentive group were given an incentive of $50 whereas students in the Control group received no incentive for improvement.

**Correlation Does Not Imply Causality**

Often, correlation is misinterpreted as causation. You should think of correlation between two variables as providing a reason to look for a causal relationship, but correlation should only be considered a first step to establishing causality. As an example, not long ago, a high-ranking marketing executive showed us Exhibit 2A.5 (the numbers are changed for confidentiality reasons). He was trying to demonstrate that his company’s retail advertisements were effective in increasing sales: “It shows a clear positive relationship between ads and sales. When we placed 1,000 ads, sales were roughly $35 million. But see how sales dipped to roughly $20 million when we placed only 100 ads?! This proves that more advertisements lead to more sales.”

Before discussing whether this exhibit proves causality, let’s step back and think about the basic characteristics of Exhibit 2A.5. In such an exhibit we have:

1. The x-variable plotted on the horizontal axis, or x-axis; in our figure the x-variable is the number of advertisements.
2. The y-variable plotted on the vertical axis, or y-axis; in our figure the y-variable is the sales in millions of dollars.

3. The origin, which is the point where the x-axis intersects the y-axis; both sales and the number of advertisements are equal to zero at the origin.

In the exhibit, the number of advertisements is the independent variable, and the amount of sales is the dependent variable. When the values of both variables increase together in the same direction, they have a positive relationship; when one increases and the other decreases, and they move in opposite directions, they have a negative relationship.

So in Exhibit 2A.5, we find a positive relationship between the two variables. What is the strength of that positive relationship? This is called the slope. The slope is the change in the value of the variable plotted on the y-axis divided by the change in the value of the variable plotted on the x-axis:

$$\text{Slope} = \frac{\text{Change in } y}{\text{Change in } x} = \frac{\text{Rise}}{\text{Run}}$$

In this example, the increase in the number of advertisements from 100 to 1,000 was associated with an increase in sales from $20 million to $35 million. Thus, the rise, or the change in sales (y), is $15 million and the run, or change in x, is 900. Because both are rising (moving in the same direction), the slope is positive:

$$\text{Slope} = \frac{$35,000,000 - $20,000,000}{1000 \text{ ads} - 100 \text{ ads}} = \frac{$15,000,000}{900 \text{ ads}} = $16,667 \text{ per ad.}$$

Thus, our exhibit implies that one more advertisement is associated with $16,667 more in sales. But, does this necessarily mean that if the retailer increases the number of advertisements by one, this will cause sales to increase by $16,667?

Unfortunately, no. While it is tempting to interpret the sales increasing with ads as a causal relationship between the two variables, because the number of advertisements was not randomly determined with an experiment, we cannot be sure that this relationship is causal. In this case, the marketing executive forgot to think about why they so drastically increased their advertisement volume to begin with! They did so because of the holiday season, a time when sales would presumably have been high anyway.

So, after some further digging (we spare you the details), what the data actually say is that the retailer placed more ads during times of busy shopping (around Thanksgiving and in December), but that is exactly when sales were high—because of the holiday shopping season. Similar to what happened in the Walmart red/blue ad example in this chapter, once we recognize such seasonal effects and take them into account, the causal relationship between ads and sales disappeared!

This example shows that you should be careful when you connect a few points in a graph. Just because two variables move together (a correlation), they are not necessarily related in a causal way. They could merely be linked by another variable that is causing them both to increase—in this case, the shopping season.

To see the general idea of what is happening more clearly, let’s instead graph the quantity of ice cream cones consumed versus the number of drownings in the United States. Using data across months from 1999 to 2005, and combining those data with sales (in millions) from one of the biggest U.S. ice cream companies over the same months, we constructed Exhibit 2A.6. In Exhibit 2A.6, we see that in months when ice cream sales are really high, there are a lot of drownings. Likewise, when there are very few ice cream sales, there are many fewer drownings. Does this mean that you should not swim after you eat ice cream?

Indeed, parents persuaded by such a chart might believe that it’s causal, and never let their kids eat ice cream near swimming pools or lakes! But luckily for us ice cream lovers, there is an omitted variable lurking in the background. In the summertime, when it is hot people eat more ice cream and swim more. More swimming leads to more drowning. Even though people eat more ice cream cones in the summer, eating ice cream doesn’t cause people to drown.

The slope is the change in the value of the variable plotted on the y-axis divided by the change in the value of the variable plotted on the x-axis.
Just as a heightened shopping season was the omitted variable in the retailer advertisement example, here the omitted variable is heat—it causes us to swim more and to eat more ice cream cones. While the former causes more drownings (as we would all expect), the latter has nothing to do with drowning even though there is a positive correlation between the two as shown in Exhibit 2A.6.

Beyond an understanding of how to construct data figures, we hope that this appendix gave you an appreciation for how to interpret visual displays of data. An important lesson is that just because two variables are correlated—and move together in a figure—does not mean that they are causally related. Causality is the gold standard in the social sciences. Without understanding the causal relationship between two variables, we cannot reliably predict how the world will change when the government intervenes to change one of the variables. Experiments help to reveal causal relationships. We learned from the Chicago Heights experiment that incentives can affect student performance.

Appendix Problems

A1. How would you represent the following graphically?
   a. Income inequality in the United States has increased over the past 10 years.
   b. All the workers in the manufacturing sector in a particular country fit into one (and only one) of the following three categories: 31.5 percent are high school dropouts, 63.5 percent have a regular high school diploma, and the rest have a vocational training certificate.
   c. The median income of a household in Alabama was $43,464 in 2012 and the median income of a household in Connecticut was $64,247 in 2012.

A2. Consider the following data that show the quantity of coffee produced in Brazil from 2004 to 2012.

<table>
<thead>
<tr>
<th>Year</th>
<th>Production (in tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>2,465,710</td>
</tr>
<tr>
<td>2005</td>
<td>2,140,169</td>
</tr>
<tr>
<td>2006</td>
<td>2,573,368</td>
</tr>
<tr>
<td>2007</td>
<td>2,249,011</td>
</tr>
<tr>
<td>2008</td>
<td>2,796,927</td>
</tr>
<tr>
<td>2009</td>
<td>2,440,056</td>
</tr>
<tr>
<td>2010</td>
<td>2,907,265</td>
</tr>
<tr>
<td>2011</td>
<td>2,700,440</td>
</tr>
<tr>
<td>2012</td>
<td>3,037,534</td>
</tr>
</tbody>
</table>

   a. Plot the data in a time series graph.
   b. What is the mean quantity of coffee that Brazil produced from 2009 to 2011?
   c. In percentage terms, how much has the 2012 crop increased over the 2009–2011 mean?
A3. Suppose the following table shows the relationship between revenue that the Girl Scouts generate and the number of cookie boxes that they sell.

<table>
<thead>
<tr>
<th>Number of Cookie Boxes</th>
<th>Revenue ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>200</td>
</tr>
<tr>
<td>150</td>
<td>600</td>
</tr>
<tr>
<td>250</td>
<td>1000</td>
</tr>
<tr>
<td>350</td>
<td>1400</td>
</tr>
<tr>
<td>450</td>
<td>1800</td>
</tr>
<tr>
<td>550</td>
<td>2200</td>
</tr>
</tbody>
</table>

a. Present the data in a scatter plot.

b. Do the two variables have a positive relationship or do they have a negative relationship? Explain.

c. What is the slope of the line that you get in the scatter plot? What does the slope imply about the price of a box of Girl Scout cookies?

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Appendix Key Terms

- pie chart p. 35
- bar chart p. 36
- independent variable p. 36
- dependent variable p. 36
- time series graph p. 36
- scatter plot p. 37
- slope p. 39