APPENDIX TO CHAPTER 1

Acquiring an eye for economics: reading and understanding graphs

Economists rely on graphs to make visual pictures of a table of numbers or a formula. Developing an eye for economics as represented in graphs is easier than developing a nose for numbers in tables. Graphs help us see correlations, or patterns, in economic observations. Graphs and diagrams are also useful for understanding economic models. They help us see how variables in the model behave. They help us describe assumptions about what firms and consumers do.

This appendix reviews the rudiments of analytical geometry that are used to create graphs for representing observations and models.

TABLE 1A.1
Australian Federal Government debt

YEAR	DEBT (BILLIONS OF DOLLARS)
1974	13.3
1978	21.4
1982	26.7
1986	50.0
1990	43.2
1994	87.0
1998	94.7

Source: Australian Bureau of Statistics.

Representing observations with graphs

Most economic graphs are drawn in two dimensions, like the surface of this page, and the graphs are constructed using a **Cartesian coordinate system**. The idea of Cartesian coordinates is that pairs of observations on variables can be represented in a plane by designating one axis for one variable and the other axis for the other variable. Each point, or coordinate, on the plane corresponds to a pair of observations.

Time-series graphs

In many instances, we want to see how a variable changes over time. For example, many people are interested in changes in the federal (or Commonwealth) debt, that is, all the outstanding borrowing of the Federal Government that has not yet been paid back.[5] Table 1A.1 shows seven observations of the Australian federal debt in billions of dollars. The observations are for every four years. Because there are so few observations in table 1A.1, it is easy to graph them by hand, and we have done so in figure 1A.1. The graph in figure 1A.1 is called a **time-series graph** because it plots a series — that is, several values of the variable — over time. When there are many observations, as in table 1.1, economists use computers to plot the graphs automatically. Figure 1.1 was plotted by computer.

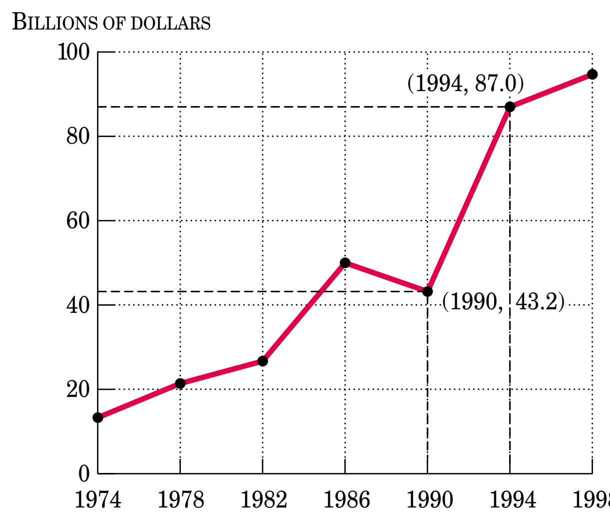

FIGURE 1A.1
Australian federal debt
Each point corresponds to a pair of observations — the year and the debt — from table 1A.1.

Observe the scales on the horizontal and vertical axes in figure 1A.1. The seven years are put on the horizontal axis, spread evenly from the year 1974 to the year 1998. For the vertical axis, one needs to decide on a scale. The range of variation for the debt in table 1A.1 is very wide — from a minimum of $13.3 billion to a maximum of $94.7 billion.

5. The federal debt here is measured by the total outstanding amount of federal government securities. These are financial assets (bonds and notes) whereby the government borrows funds by issuing and selling them.

Thus, the range of from $0 to $100 billion on the vertical axis in figure 1A.1 is wide enough to contain all these points.

Now observe how each pair of points from table 1A.1 is plotted in figure 1A.1. The point for the pair of observations for the year 1974 and the debt of $13.3 billion is found by going over to 1974 on the horizontal axis, then going up to $13.3 billion and putting a dot there. The point for 1978 and $21.4 billion and all the other points are found in the same way. In order to visualise the points better, they can be connected with lines. These lines are not part of the observations; they are only a convenience to help the eye follow the observations. The points for 1990 and 1994 are labelled with the pair of observations corresponding to table 1A.1, but in general there is no need to put in such labels.

Now look at the pattern of points in figure 1A.1. There was a rise in the federal debt between 1974 and 1986, followed by a decline between 1986 and 1990. A sharp rise followed between 1990 and 1994 and a slow rise between 1994 and 1998. A rise in the federal debt occurs as a result of running a persistent budget deficit, while a decline occurs when there is a surplus or when the government uses the proceeds from privatisation to pay off its debt.[6]

One could choose different scales than in figure 1A.1, and if you plotted your own graph from table 1A.1 without looking at figure 1A.1, your scales would probably be different. The scales determine how much movement there is in a time-series graph. For example, figure 1A.2 shows two ways to stretch the scales to make the increase in the debt look either more alarming or less alarming. The diagram on the bottom looks extremely alarming. But the diagram on the top looks less worrisome. So as not to be fooled by graphs, therefore, it is important to look at the scales and think about what they mean.

As an alternative to time-series graphs with dots connected by a line, the observations can be shown on a bar graph, as in figure 1A.3. Some people prefer the visual look of a bar graph, but as is clear from a comparison of figures 1A.1 and 1A.3, they provide the same information.

6. Figure 1A.1 conceals some facts because it is not plotted on a year-by-year basis. For example, between 1994 and 1998, the federal debt rose to over $100 billion before it declined to just over $94 billion.

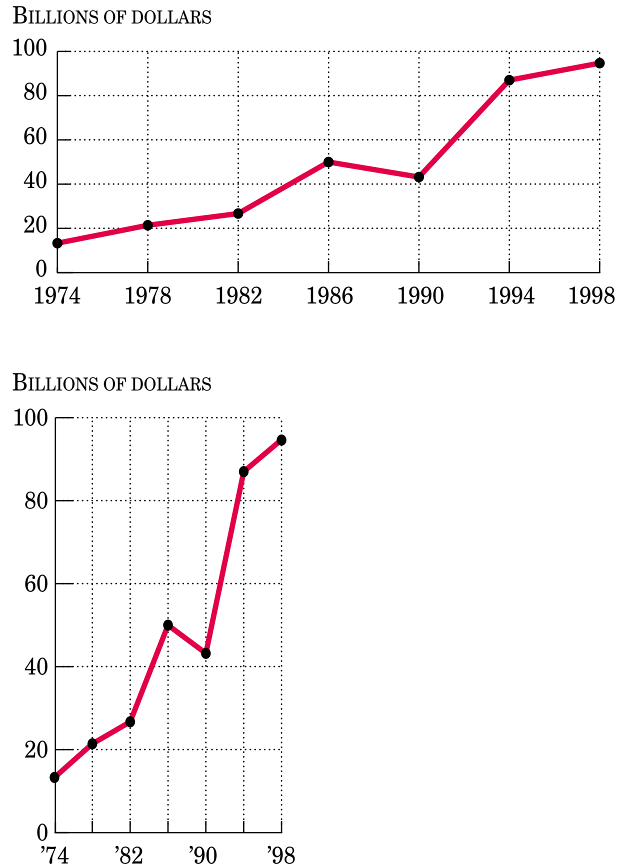

FIGURE 1A.2

Stretching the debt story in two ways

The points in both graphs are identical to figure 1A.1, but by stretching or shrinking the scales the problem can be made to look either less alarming or more alarming.

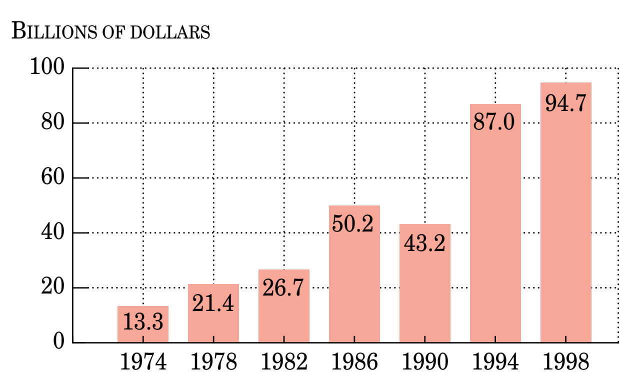

FIGURE 1A.3

Australian federal debt in bars

The observations are identical to those in figure 1A.1.

The debt as a per cent of GDP is given in table 1A.2 and graphed in figure 1A.4. Note that this figure makes the debt look a lot different from the first one.

The scale in figure 1A.4 for the debt as a percentage of GDP is from 0 to 30 per cent. This leaves some wasted space at the bottom and the top of the graph. To eliminate this space and have more room to see the graph itself, we can start the range near the minimum value and end it near the maximum value. This is done in figure 1A.5. Note, however, that cutting off the bottom of the scale could be misleading to people who do not look at the axis. In particular, 0 per cent is no longer at the point where the horizontal and vertical axis intersect.

TABLE 1A.2

Australian federal debt as a per cent of GDP

YEAR	DEBT (PER CENT OF GDP)
1974	25.3
1978	22.4
1982	16.6
1986	20.7
1990	11.7
1994	20.1
1998	18.0

Source: Australian Bureau of Statistics.

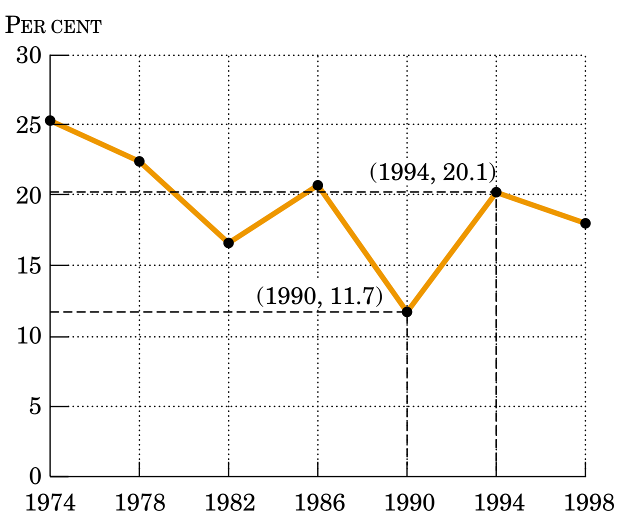

FIGURE 1A.4

Australian federal debt as a per cent of GDP

Each point corresponds to a pair of observations from table 1A.2.

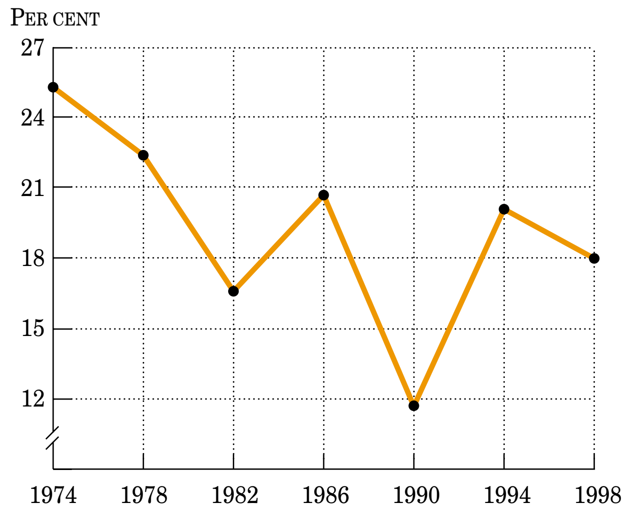

FIGURE 1A.5

A stretched-scale look at debt as a per cent of GDP

Zero per cent is no longer at the point where the horizontal and vertical axis intersect.

Time-series graphs showing two or more variables

So far we have demonstrated how a graph can be used to show observations on one variable over time. What if we want to see how two or more variables change over time together? Suppose, for example, we want to look at how observations on debt as a percentage of GDP compare with the interest rate the government must pay on its debt. The two variables are shown in table 1A.3.

TABLE 1A.3

Interest rate and federal debt as a per cent of GDP

YEAR	DEBT (PER CENT OF GDP)	INTEREST RATE (PER CENT)
1974	25.3	8.20
1978	22.4	9.62
1982	16.6	15.18
1986	20.7	13.69
1990	11.7	13.32
1994	20.1	7.30
1998	18.0	5.75

Source: Reserve Bank of Australia and table 1A.2.

The two sets of observations can be easily placed on the same time-series graph. In other words, we could plot the observations on the debt percentage and connect the dots and then plot the interest rate observations and connect the dots. If the scales of measurement of the two variables are much different, then it might be hard to see each, however. For example, the interest rate ranges between 5 and 16 per cent; it would not be very visible on a graph going all the way from 0 to 30 per cent, a range that is fine for the debt percentage. In this situation, a **dual scale** can be used, as shown in figure 1A.6. One scale is put on the left-hand vertical axis and the other scale is put on the right-hand vertical axis. With a dual-scale diagram, it is very important to be aware of the two scales. In this book we will emphasise the different axes in dual-scale diagrams by the colour line segment at the top of each vertical axis. The colour line segment corresponds to the colour of the curve plotted using that scale, as in figure 1A.6.

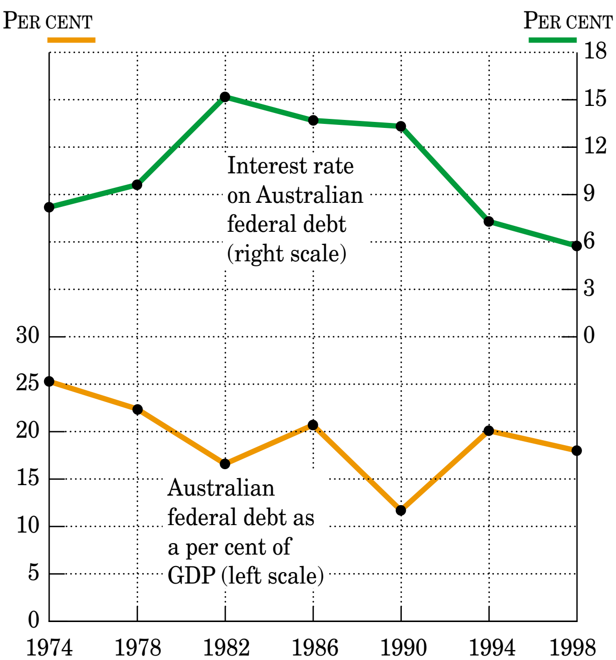

FIGURE 1A.6

Comparing two time-series with a dual scale

When two variables have different scales, a dual scale is useful. Here the interest rate and the debt as a per cent of GDP are plotted from table 1A.3.

Scatter plots

Finally, two variables can be usefully compared with a **scatter plot**. The Cartesian coordinate method is used, as in the time-series graph, except that we do not put the year on one of the axes; rather, the horizontal axis is used for one of the variables and the vertical axis for the other variable. We do this for the debt percentage and the interest rate in figure 1A.7. The interest rate is on the vertical axis and the debt percentage is on the horizontal axis. For example, the point corresponding to 1990 is 11.7 per cent for the debt as a per cent of GDP and 13.32 per cent for the interest rate.

Note that this scatter plot reveals a negative correlation between the debt percentage and the interest rate. Recall that a negative correlation is when the points in a scatter plot tend to decline as you move from left to right. Note that this negative correlation is also apparent in a different way in figure 1A.6 in which the debt percentage tended to fall as the interest rate rose over time and then tended to rise as the interest rate fell over time.

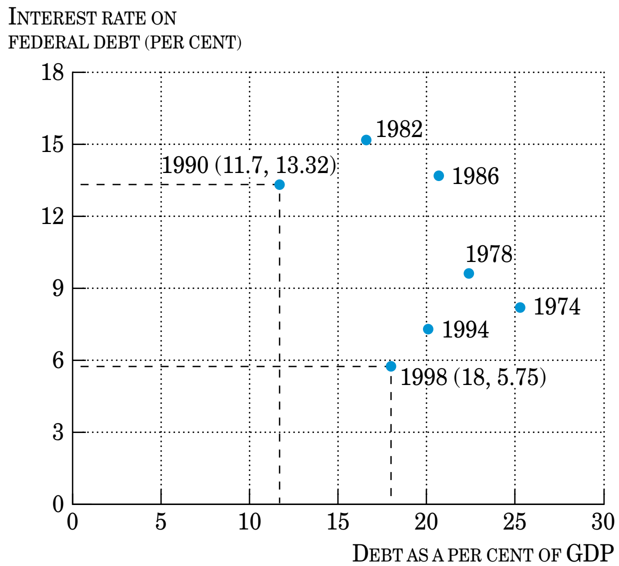

FIGURE 1A.7

Scatter plot

Interest rate and debt as a per cent of GDP are shown.

Remember that such a correlation does not imply causation or that there is an economic relation between the two variables. In particular it would be a serious mistake to conclude from figure 1A.7 that there is a negative causal relationship between the debt ratio and the interest rate. The observed correlation could be caused by a third variable, such as inflation, that is affecting both the debt percentage and the interest rate.

Pie charts

Time-series graphs, bar graphs and scatter plots are not the only visual ways to observe economic data. For example, the *pie chart* in figure 1A.8 is useful for comparing percentage shares for a small number of different groups or a small number of time periods. In this example, the pie chart is a visual representation of how the industrial countries produce more than half of the world's GDP while the developing countries produce 34 per cent and the former communist countries in Eastern Europe and the former Soviet Union, now in transition towards market economies, produce about 11 per cent.

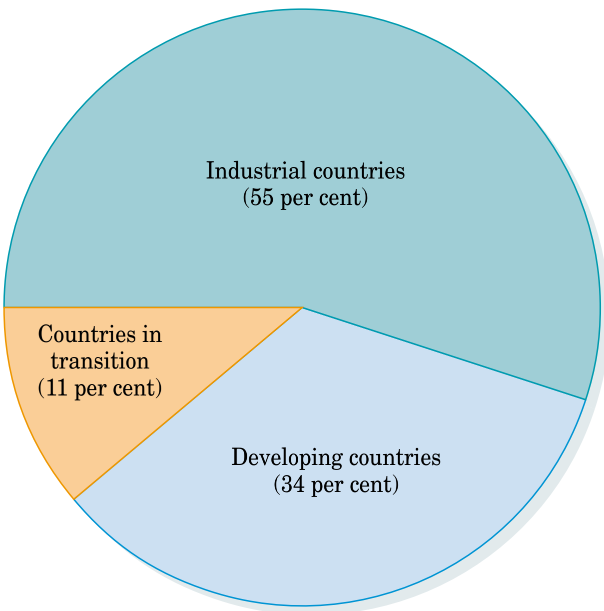

FIGURE 1A.8

Pie chart showing the shares of the world's GDP

The pie chart shows how the world's GDP is divided up into: (1) the industrial countries, such as the United States, Germany and Japan, (2) the developing countries, such as India, China and Nigeria and (3) countries in transition from communism to capitalism, such as Russia and Poland.

Source: International Monetary Fund.

Representing models with graphs

Graphs can also represent models. As with graphs showing observations, graphs showing models are usually restricted to curves in two dimensions.

Slopes of curves

Does a curve slope up or down? How steep is it? These questions are important in economics as in other sciences. The **slope** of a curve tells us how much the variable on the vertical axis changes when we change the variable on the horizontal axis by one unit.

The slope is computed as follows:

$$\text{slope} = \frac{\text{change in variable on vertical axis}}{\text{change in variable on horizontal axis}}$$

In most algebra courses, the vertical axis is usually called the y-axis and the horizontal axis is called the x-axis. Thus, the slope is sometime described as:

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

where the Greek letter Δ (delta) means 'change in'. In other words, the slope is the ratio of the 'rise' (vertical change) to the 'run' (horizontal change).

Figure 1A.9 shows how to compute the slope. In this case, the slope declines as the variable on the x-axis increases.

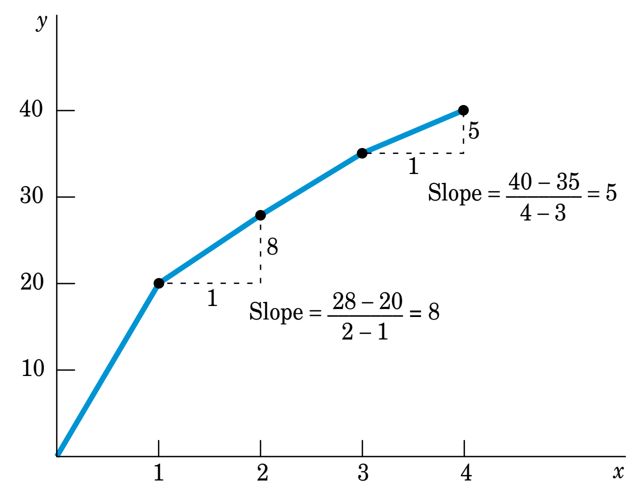

FIGURE 1A.9

Measuring the slope

The slope between two points is given by the change along the vertical axis divided by the change along the horizontal axis. In this example, the slope declines as x increases. Since the curve slopes up from left to right, it has a positive slope.

Observe that *the steeper the curve, the larger the slope.* When the curve gets very flat, the slope gets close to zero. Curves can either be upward-sloping or downward-sloping. If the curve slopes up from left to right, as in figure 1A.9, it has a **positive slope**, and we say the two variables are positively related. If the curve slopes down from left to right, it has a **negative slope**, and we say the two variables are negatively related. Figure 1A.10 shows a case where the slope is negative. When x increases by one unit

($\Delta x = 1$), y declines by two units ($\Delta y = -2$). Thus, the slope equals −2; it is negative. Observe how the curve slopes down from left to right.

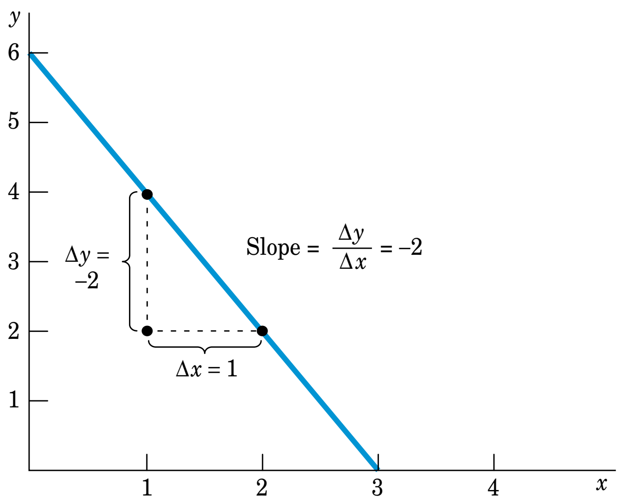

FIGURE 1A.10

A relationship with a negative slope

Here the slope is negative: $(\Delta y)/(\Delta x) = -2$. As x increases, y falls. The line slopes down from left to right. In this case, y and x are inversely, or negatively, related.

If the curve is a straight line, then the slope is a constant. Curves that are straight lines, as in figure 1A.10, are called **linear**. But economic relationships do not need to be linear, as the example in figure 1A.9 makes clear. Figure 1A.11 shows six different examples of curves and indicates how they are described.

Graphs of models with more than two variables

In most cases, economic models involve more than two variables. For example, the number of physical examinations could depend on the number of nurses as well as the number of doctors. Or the amount of lemonade demanded might depend on the weather as well as on the price.

Economists have devised several methods to represent models with more than two variables with two-dimensional graphs. Suppose, for example, that the relationship between y and x in figure 1A.10 depends on third variable z. For a given value for x, larger values of z lead to larger values of y. This example is graphed in figure 1A.12. As in figure 1A.10, when x increases, y falls. This is a **movement along the curve**. But what if z changes? We represent this as a **shift of the curve**. An increase in z shifts the curve up; a decrease in z shifts the curve down.

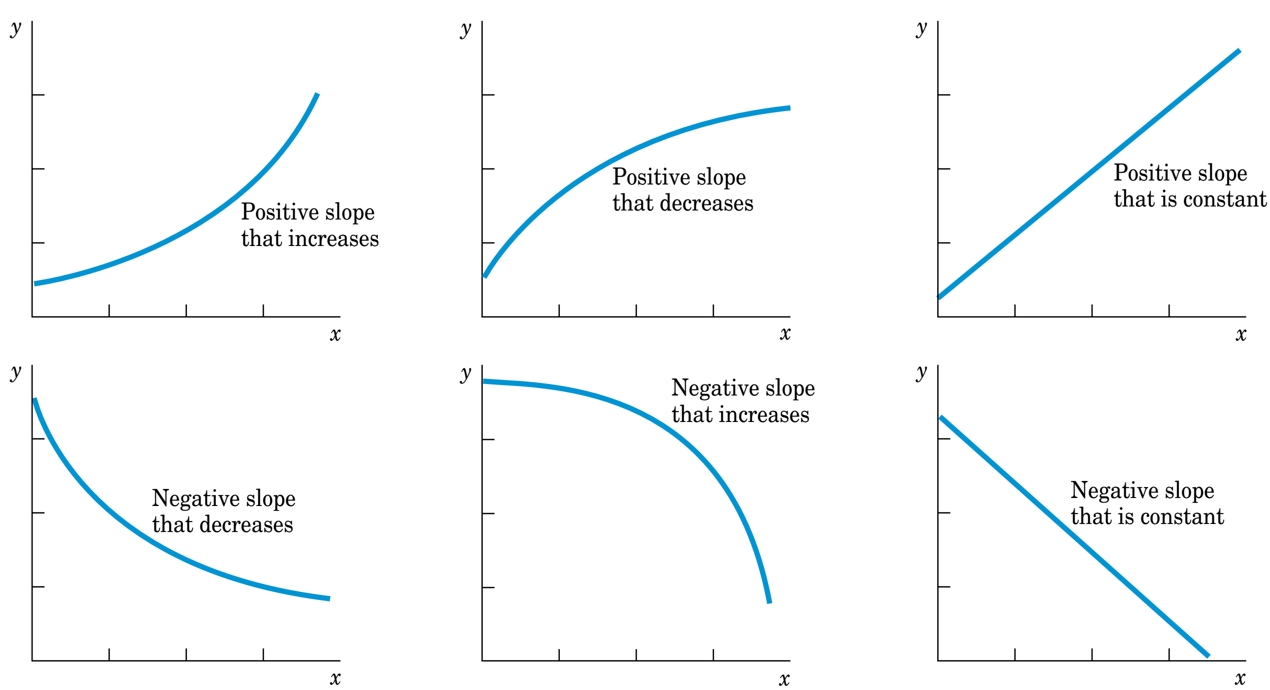

FIGURE 1A.11

Six types of relationships

In the top row, the variables are positively related. In the bottom row, they are negatively related.

Thus, by distinguishing between shifts and movements along a curve, economists represent models with more than two variables in only two dimensions. Only two variables (x and y) are shown explicitly on the graph, and when the third (z) is fixed, changes in x and y are movements along the curve. When z changes, the curve shifts. The distinction between 'movements along' and 'shifts of' curves will come up many times in this book.

FIGURE 1A.12

A third variable shifts the curve

In order to represent models with three variables (x, y and z) on a two-dimensional graph, economists distinguish between movements along the curve (when x and y change, holding z unchanged) and shifts of the curve (when z changes).