Chapter 1 Appendix – Working With Graphs

Understanding how to read and construct graphs will be crucial to learning economics. There are many reasons why economists use graphs to present ideas, the most important of which matches the old saying, "a picture is worth a thousand words." If you already have experience with graphs, you probably don't need to read this appendix. If you don't have experience with graphs, fear not! This appendix will introduce the fundamentals of constructing and interpreting graphs.

[H1] Constructing Graphs

Graphs are visual representations of relationships between two or more variables. Although graphs can take many forms, most are constructed in the same way. This section describes how graphs are constructed.

[H2] Obtain Data

The first step in constructing a graph is obtaining the data you want to show in the graph. Economic data can come from government agencies, from surveys, and from business records. Suppose that we are interested in graphing the number of students enrolled in college across time. We can obtain data on this relationship from the US Department of Education's National Center for Education Statistics. Table 1 shows enrollment in US colleges and universities for each year between 2000 and 2009.

Table 1: US College and University Enrollment over time

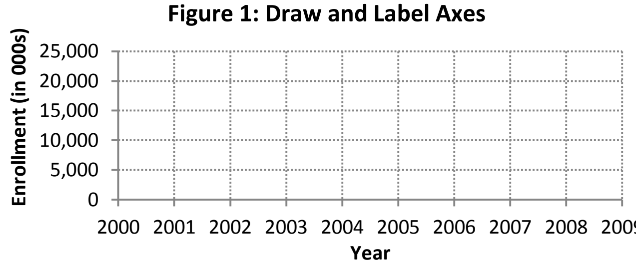
Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total (in 000s)	15,312	15,928	16,612	16,911	17,272	17,487	17,759	18,248	19,103	20,428

Source: US Department of Education National Center for Education Statistics. www.nces.ed.gov

[H2] Draw and Label Axes

The second step in constructing a graph is drawing and labeling the axes of the graph. For many graphs, data is shown on the Cartesian coordinate system, named after René Descartes, the French philosopher and mathematician who invented this graphing system. The Cartesian coordinate system graphs data using a set of two axes to represent values of two variables. The axes are drawn perpendicular to each other and the point where they intersect is called the origin of the graph. The horizontal axis is called the x-axis and the vertical axis is called the y-axis. The variable that is measured on the y-axis is the y-variable. The variable that is measured on the x-axis is the x-variable. Rightward movements along the x-axis correspond to increases in the value of the x-variable. Similarly, upward movements along the y-axis correspond to increases in the value of the y-variable. Figure 1 shows the axes for a graph that will show college enrollment over time. The years are labeled on the x-axis and the enrollment numbers are labeled on the y-axis.

Figure 1: Draw and Label Axes

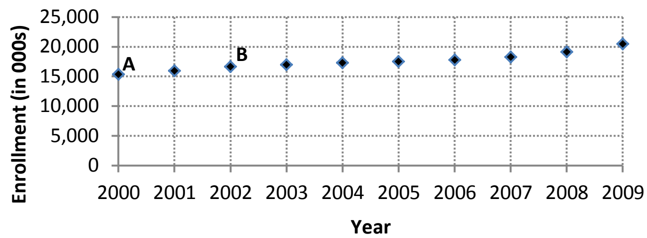


The first step in constructing a graph is to draw and label the graph's axes. The horizontal axis is called the x-axis. The vertical axis is called the y-axis. Rightward movements along the horizontal axis and upward movements along the vertical axis represent increases in the values of the x- and y-variables, respectively. Vertical and horizontal gridlines can be drawn at each of the values on the x- and y-axes.

[H2] Plot Points

The next step in constructing a graph is to plot the corresponding data points on the graph. Corresponding data points are the data values that go together. We can see from Table 1 that college enrollment in year 2000 was 15,312 thousand students. So the year value of 2000 and the enrollment value of 15,312 correspond to one another. Point A in Figure 2 shows this corresponding data point. Similarly, enrollment in year 2002 was 16,612 thousand students, which is shown by point B in Figure 2. Plotting all of the corresponding data points for each of the years in Table 1 generates points shown in Figure 2.

Figure 2: Plot the Corresponding Data Points

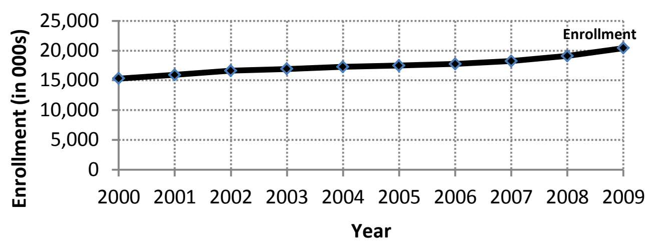


The second step in constructing a graph is to plot the corresponding data points onto the graph. In year 2000, college enrollment was 15,312 thousand students, so point A plots the value 15,312 to correspond to the year 2000. College enrollment was 16,612 thousand students in 2002, so we plot the value 16,612 to correspond with year 2002 (point B).

[H2] Draw the Curve

The third step in constructing a graph is to connect the data points and label the resulting curve or line. By convention, the term "curve" is used to describe the connected data points, regardless of whether the curve is a straight line or not. The curve showing enrollment over time is labeled "Enrollment" in Figure 3.

Figure 3: Draw the Curve



The third step in constructing a graph is to connect the data points and label the resulting curve.

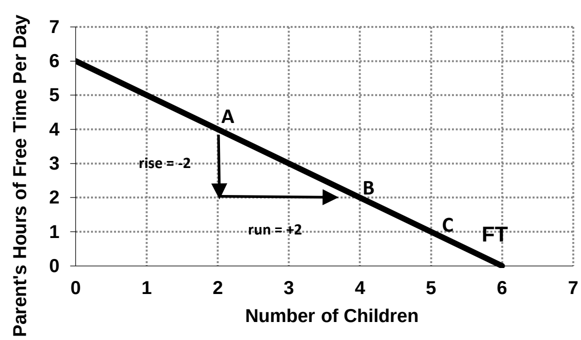
<u>[H1] Interpreting and Modifying Graphs</u>

Once you have constructed a graph, it is time to interpret what the graph tells you. Two key parts of a graph can give clues about the relationship the graph is describing. These include the intercept points of the graph and the slope of the curve.

[H2] Intercepts

The intercepts of a graph are the places where the curve intersects the y- and x-axes. The y-intercept shows the value of the y-variable when the x-variable is zero. The x-intercept shows the value of the x-variable when the y-variable is zero. Curve FT in Figure 4 graphs hypothetical data showing the relationship between the number of children and the amount of free time that a parent has. The y-axis of Figure 4 tells us that people with 0 children have 6 hours of free time each day. The x-axis tells us that people with 6 children have 0 hours of free time each day. In graphs like Figure 3, that depict changes in variables over time, the y-intercept usually corresponds to the first time period in our data.

Figure 4: Intercepts and Slope



Curve FT shows the relationship between a parent's free time and the number of children he or she has. The y-intercept tells us that having zero children would correspond to the parent having 6 hours of free time each day. The x-intercept shows that having 6 children would correspond to the parent having 0 hours of free time each day. The slope of FT between point A and B is equal to the rise over the run, or -2 / +2 = -1. For each additional child, the number of hours of free time falls by 1 per day.

[H2] Slope

Another important key to understanding the relationships described by graphs is the slope of the curve shown in a graph. The slope of a curve tells us how much one variable changes when another variable changes. Just like the slope of the roof of a house, the slope of a curve is equal to the "rise over the run," or the change in the value of the y-variable over the change in the value of the x-variable between two data points.

$$\text{Slope} = \frac{\text{rise}}{\text{run}} = \frac{\text{change in the y}-\text{variable}}{\text{change in the x}-\text{variable}}$$

The slope of a curve can be measured between any two points on the curve. In Figure 4, the slope between point A and point B is measured as the change in the hours of free time divided by the change in the number of children, or

$$\text{Slope between A and B} = \frac{-2}{+2} = -1.$$

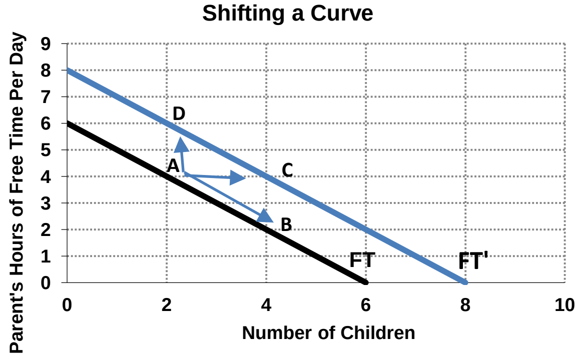
We can interpret this slope value of -1 as indicating that an increase in the number of children in a family by one is associated in a reduction in the parent's amount of free time by one hour per day. In Figure 4, the slope of the curve FT would be -1 regardless of whether we measured the slope between point A and B, between point A and C, between point B and C, or between any other two points on the graph. In other words, curve FT has a constant slope. All straight lines have a constant slope. In Figure 3, however, the slope of the Enrollment curve changes between different points on the graph.

The negative value of the slope of the FT curve in Figure 4 implies that the number of children and hours of free time have an inverse or negative relationship with one another. When variables are inversely or negatively related, an increase in the x-variable is associated with a decrease in the y-variable and vice versa. Alternatively, the slope of the Enrollment curve in Figure 3 is positive, indicating that there is a direct or positive relationship between college enrollment and time. In other words, as time passes college enrollment has risen.

[H2] Moving Along a Curve versus Shifting a Curve

As you progress through the text, it will be important to distinguish between *moving along* a curve and *shifting* a curve. In Figure 5, curve FT shows the tradeoff between a parent's free time and the number of children he or she has, just as in Figure 4. At point A, the parent has 2 children and 4 hours of free time per day. All else equal, when the number of children increases from 2 to 4, the number of hours of free time the parent has falls from 4 hours per day to 2 hours per day, as shown by the movement along the curve FT from Point A to Point B.

Figure 5: Moving Along a Curve versus Shifting a Curve



Curve FT shows the relationship between a parent's free time and the number of children he or she has, ceteris paribus. When the number of children changes, ceteris paribus, there is a movement along the curve FT from point A to point B. If the parent changes the amount of time he or she works outside the home, the relationship between free time and the number of children changes, as shown by the curve FT. Ceteris paribus, changes in variables measured on the axes cause movements along the FT curve. Changes in variables that are not measured on the axes cause a shift in the curve from FT to FT'.

Now suppose that the parent changes the amount of time he or she works outside the home, perhaps moving from a full-time job to a part-time job. Changing the hours that the parent works will change the amount of free time the parent has, even if the number if children the parent has stays the same. For example, a parent with 2 children may be able to have 6 hours of free time instead of only 4 hours of free time, as shown by the movement from point A on curve FT to point D on curve FT'. Alternatively, on curve FT, a parent who has 2 children was able to have 4 hours of free time, but a parent working fewer hours could have 4 hours of free time even if they have 4 children, as shown by the movement from point A on curve FT to point C on curve FT'. The change in the amount of time a parent works outside the home causes a shift from curve FT to curve FT'.

More generally, a movement along a curve happens when one of the variables measured on the axes changes, ceteris paribus. A shift in a curve occurs when a variable that is not measured on the axes changes. In Figure 5, the movement from A to B occurs because the number of children changes. The shift from curve FT to FT' occurs because of the change in the amount of time the parent works outside the home.

You will gain experience with graphs throughout your class in economics. As you are studying each of the chapters in the book, you can deepen your understanding if you take the time to draw each of the graphs in the book on your own and use your own words to describe what the graph is telling you.