Chapter 1
Introduction and Definitions of Basic Economic Concepts

Chapter Introduction

We start this chapter by defining economics. We discuss why the study of economics is important. Then we look at some of the basic concepts that will prove helpful throughout the rest of the course. These include marginal, scarcity, opportunity cost, positive versus normative economics, and investment, as it is defined in economics, versus saving. We look at some fallacies that we should avoid. We also briefly review some mathematical concepts and learn how to draw and interpret graphs.

A Definition of Economics

We start with defining economics.

Economics is the study of how individuals and societies allocate their scarce resources among various uses.

A few points need elaboration in this definition.

Resources

Economics deals with making decisions about the allocation of scarce resources. Resources are those goods that nature, previous generations, and current generations have provided to use in the production of goods and services.

Resources may be divided into three major categories. These are land, labor, and capital.

Land

In "land" we include whatever comes with a physical piece of real estate. It includes forests, rivers, minerals, climate, and so on.

Labor

By "labor" we not only mean number of people, or the number of hours worked, but also their skills. Perhaps a better term may be "effective" labor. For instance, if John can produce one widget in an hour and Jane can produce two widgets in an hour then we may say that John has one "effective" unit of labor and Jane has two "effective" units of labor.

Capital

"Capital" is the goods that have been produced and are used in the production of other goods and services. Examples of capital include roads, bridges, buildings, machines, software, and so on. Note that in economics "money" is not capital. We will define money in a later chapter, Chapter 9.

Scarce

What do we mean by "scarce" and how do we decide whether a resource is scarce?

By "scarce" we mean being in a limited quantity. When some resource is scarce, it means that it is in a limited quantity.

How do we decide whether something is scarce?

A simple yet important rule to follow when deciding whether a resource is scarce is to see whether it carries a price. If a good or service carries a price, it is scarce. Otherwise, it's not scarce. It is a zero-one proposition.

"What about the water that we drink on campus from a water fountain," you may ask? In fact, to keep the water drinkable and at a certain temperature, resources have been spent; a price has been incurred. Part of the price is paid by you, the student, through your fees and tuition. The rest may be covered by the state, or some other entity, such as a donor.

What about the fresh air that we breathe when we are outside? It doesn't carry a price. Is it free? No. It is not free. You, personally, may not pay a price, or may think that you are not paying a price, to breathe fresh air. But to keep the air breathable, someone, somewhere is paying a price. To keep the air breathable, pollutants must be kept below a certain level. Keeping pollutants below a certain level has a price; it takes resources. Indeed, it is hard to think of an example of a free good or service. Just because you, personally, do not pay a price every time to drink water from a water fountain, or breath clean air, does not mean it is free.

Note that in our everyday conversations we use scarce as a synonym for expensive. When the price of a good or service increases, we say that it has become scarce. Indeed, even in economics textbooks, when authors are not being careful, they use scarce and expensive interchangeably. This is not technically correct. Take the example of a gallon of gas. When the price of regular gas was, say, $1.00 per gallon, it was scarce. Now when the price of gas is $3.00, it is scarce. Suppose that at a future date the price of gas decreases to $0.50 per gallon, it will still be scarce. So long as gas carries a price, it will be scarce.

How do we represent the quality of being expensive? We will learn it shortly.

Why Study Economics

We can look at the reason for studying economics from the individual, social, and global perspectives.

Studying economics helps us, as individuals, understand how the economy works. A better understanding of the economy will help us make informed decisions. As consumers, the study of economics, will help us make informed decision about our purchases. The study of economics, as producers of goods and services, will help us better understand whether we should produce a product and sell it at a certain price.

The actions of individuals affect the whole society. A better understanding of the economy will help us be better citizens. The study of economics will help us better understand the effects of our decisions on the society. We will be better prepared to answer questions about the impact of raising or lowering taxes, the impact of voting for building public transportation. The study of economics makes us better informed voters.

Take the example of homelessness. Numerous cities across the US, indeed across the globe, are facing an increase in homelessness. The study of economics will help us better understand the causes and consequences of homelessness and take actions that may reduce homelessness.

No country is an island. The actions of one country affect the rest of the world. Our actions as consumers and producers affect us all. Pollution created by one country affects the climate of the rest of the world. The study of economic helps become better informed global citizen.

Economic Vocabulary

Every subject uses certain words and phrases in specialized ways. Economics is no different. Below we will learn words and phrases how they are used in economics. Once you understand the concept and reason behind each use, memorize it. This will help us avoid confusions.

Marginal

In economics, one of the most important concepts is “marginal.” By marginal we mean incremental (or decremental). While totals and averages are important, what matters for decision making is marginal. Whenever we want to decide whether a given action is worth it, we compare the marginal benefit from that action with the marginal cost of that action.

In Table 1.1 we calculate total benefit and marginal benefit from the consumption of each additional unit of a product.

Table 1.1: Total Benefit and Marginal Benefit

[1]	[2]	[3]
Unit	Total Benefit	Marginal Benefit
0	0	
1	20	20
2	39	19
3	57	18
4	74	17
5	90	16
6	105	15
7	105	0
8	100	-5

Source: M. Ashraf.

In Table 1.1 we list the number of units that we are consuming in Column 1, the total benefit that we get from this consumption in Column 2, and the marginal benefit that we get from the consumption of each additional unit in Column 3.

When we are consuming zero unit, we do not get any benefit; total benefit is zero. When we consume the first unit, both the total benefit and marginal benefit are 20. When we consume the second unit, total benefit increases to 39 whereas marginal benefit is 19. When we consume the third unit, total benefit increases to 57, whereas the marginal benefit now is 18, and so on.

How did we calculate marginal benefit? Recall that by marginal we mean incremental or decremental. When it comes to marginal benefit, it is the incremental or decremental benefit that we get by consuming one extra unit. It is the change in total benefit due to the change in units. Equation 1.1 presents the formula for calculating marginal.

$$Marginal = \frac{Change\ in\ Total}{Change\ in\ Units} = \frac{\Delta T}{\Delta U} \tag{1.1}$$

In Equation 1.1, I am using the Greek letter Δ to represent change, the letter *T* represents "Total," and the letter *U* represents the number of units.

Take another look at Table 1.1. Note that when we consumed the seventh unit, total benefit did not change. It stayed at 105. This means that the marginal benefit of the seventh unit is zero. Furthermore, when we consumed the eighth unit, total benefit decreased to 100. As a result, the marginal benefit of the eighths unit is -5.

You may be questioning the quantification of benefit from the consumption of our hypothetical good. Your questioning is correct. We cannot quantify the benefit that we get from consuming a good or service. While we can judge whether the additional unit was more, or less, enjoyable, we cannot attach a measurement unit. We did this just for the ease of exposition.

We can use the same formula to calculate marginal cost of, and marginal revenue from, the production of an additional unit.

Opportunity Cost

Opportunity cost is defined as the next-best alternative forgone. It is the amount of one thing that we give up, to get more of another thing.

The reason opportunity cost exists is because resources are scarce. We cannot have more of everything. We must give up part or all of one to get more of another thing. An example may help.

Suppose that on Tuesdays and Thursdays, from 11:00 a.m. to 12:15 p.m., you are taking Principles of Macroeconomics. Suppose also that the following list of activities represents your order of preference.

1. Principles of Macroeconomics
2. Principles of Marketing
3. College Algebra
4. Lunch
5. Working out
6. Hanging out with friends

One may ask the question: What is the opportunity cost of taking Principles of Macroeconomics? The answer: Principles of Marketing.

Why? Why not Principles of Marketing and College Algebra and lunch and working out and hanging out with friends? The reason is that you cannot partake in all these activities on Tuesdays and Thursdays, from 11:00 a.m. to 12:15 p.m. You must choose one.

You have decided to take Principles of Macroeconomics during this time slot. Using the definition of opportunity cost, the next-best alternative in our list is Principles of Marketing. So, this is the opportunity cost of taking Principles of Macroeconomics.

Using the same logic, the opportunity cost of taking Principles of Marketing is taking College Algebra. The opportunity cost of taking College Algebra is having lunch. And so on.

Scarce versus Expensive

Earlie in this chapter, we learned that “scarce” was a zero-one proposition; either a good or service is scarce, or it isn’t. And to decide whether a good or service is scarce, see if it carries a price. If it carries a price, it is scarce. If it doesn’t carry a price, it’s not scarce. The answer to the question of being “expensive” was left for later.

Now that we understand the concept of opportunity cost, we are ready to answer what it means to be expensive. When we say that some good or service has become expensive, we mean that the opportunity cost of this good or service has increased. Since usually we pay for a good or service in terms of some currency, say dollars, the opportunity cost a good or service is the number of dollars that we give up. That is, the price of a good or service is the opportunity cost of this good or service. In the next chapter we will revisit opportunity cost and learn how to calculate it.

Goods versus Services

I have used the term "goods and services." What is a good and what is a service? A good is something tangible. You can touch and feel it. Examples include a pen, a computer, a chair, and so on.

Service on the other hand is intangible. Examples include the services provided by a plumber, a doctor, an attorney, a professor, a gardener, and so on.

Investment versus Saving

In economics by "investment" we mean an addition to the existing stock of capital. That is, building new machines, new houses, new buildings, new software. Suppose that you buy an existing house to resell it later. This is not considered investment in economics. It is just a change in ownership. No new houses have been added to the existing number of houses. Analogously, buying bonds and stocks is not an act of investment. We will go into more detail what are bonds and stocks. For now, suffice it to say that a bond is a debt instrument, and a share of stock represents partial ownership of the firm.

Saving is defined as income minus consumption. When a household is buying a bond or a stock, it is saving. When you buy an old house to resell it later, you are saving. The only investment that a household makes is by buying a new house or adding room(s) to an existing house. Note that in the latter case, there is an addition to the existing stock of capital. In this case, the number of rooms has increased. So, it is called investment. Whenever you need to decide whether a given act is investment, ask yourself the following question: Is this act adding to the existing stock of capital? If the answer is yes, then it is an investment. If no, then it is not an investment.

Take another example. When *Facebook* bought *WhatsApp*, *Facebook* did not engage in an act of investment. Earlier on the owners of *WhatsApp* owned the company, now the owners of *Facebook* own the company. It is just a change in ownership. If *Facebook* were to develop a brand-new software or build a new office building for its employees, it will be called investment.

Tools to Refine Our Thinking

As students of economics, we must avoid erroneous and superficial thinking. Below I list a few tools to do this.

Post-hoc Fallacy (*Post hoc, ergo propter hoc*)

Suppose that Event A happens before Event B. It is not necessarily true that Event A caused Event B. Concluding from the sequence of events that the former event caused the latter event is called post-hoc fallacy.

This is a common error that lies behind every superstition. Wearing a "lucky" shirt to a ballgame, knocking on wood, saying particular words, and performing certain rituals before starting a task, and so on, are some of the examples of the post-hoc fallacy.

Fallacy of Composition

The fallacy of composition refers to the erroneous thinking that whatever is true for a part is also true for the whole. For instance, thinking that if a given strategy is beneficial for a firm, it is also beneficial for the economy.

Here is an example. Suppose that a firm is suffering loss; its total revenue is smaller than its total cost of production. The firms to wants to decrease total costs of production. One way to reduce costs of production is decrease labor input. That is, either fire some workers or ask existing workers to work fewer hours, or a combination of the two. This may be a prudent way to decrease costs of production. Suppose now that an economy's revenue is smaller than its expenditure—a situation referred to as budget deficit. When this same policy is adopted by the economy, it leads to mass unemployment. Not only that, as we will see in coming chapters, it may further increase the budget deficit.

False Choice Fallacy

This fallacy takes place when a statement implies that there are only two choices. Often, however, there are many more in-between.

Suppose that you are planning for an upcoming long weekend. One friend suggests going to camping and the other suggests staying in town and going to a dinner. The friend who is in favor of staying in town may make the case against going camping and for staying in town as follows.

Stay in Town

We will have a relaxing afternoon. We will go out to eat at a fancy restaurant. We will sip wine and enjoy a delicious meal while beautiful music is being played, and you may meet your soul mate and live happily ever after.

Go Camping

We will have to climb in hot weather with a backpack, gather wood, build a fire, and eat half-cooked food. We will have to try to go to sleep while dealing with bugs. In the middle of the night, we may get attacked by bears and eaten one bite at a time.

So, would you rather, (a) spend the rest of your life in a blissful union, or (b) be eaten by bears?

Note that the choice is not between one extreme outcome versus the other extreme outcome. Most likely the choice is between somewhere in the middle. The choice between (a) and (b) is a false choice. This is a fallacy to suggest that these are our only two choices—(a) versus (b).

Ceteris Paribus

While analyzing the effects of one variable on another variable, economists use the "ceteris paribus" assumption. It means holding the values of other factors constant.

Take the example of calculating the benefit of consuming a good or service. The benefit from consuming a good or service can depend upon not only the number of units consumed but also other factors. These may include income, weather, preferences, tastes, and so on. When we analyze the relationship between two variables, we hold other factors constant. This is important. It helps us focus on the problem at hand gets rid of the impact of the confounding factors.

What Is an Assumption?

In the above discussion we have used terms such as "suppose" and "assume." What does it mean to suppose? What does it mean to assume? In other words, what is an assumption?

When we are using such phraseology, we are creating a set of circumstances under which the statements that follow are true. If the circumstances that precede the statement are met, then the proceeding statement is true. If those conditions are not met, then the proceeding statement may or may not be true. Simply put, that an assumption is a set of circumstances under which a statement is true.

Positive versus Normative Economics

In logic, statements may be divided into two categories—positive statements and normative statements. A positive statement explains the state of the world. "When you drop an egg on the floor it will break" is an example of a positive statement. A positive statement does not assign a value judgement. It does not state whether dropping an egg on the floor is a "good" thing or a "bad" thing.

A normative statement on the other hand, evaluates a given situation and assigns a value judgement. "You should not drop the egg on the floor. It will break." is an example of a normative statement. It categorizes into "good" or "bad."

When trying to decide whether a given statement is positive or normative, look for words like "should" or "should not," "ought" or "ought not," "good" or "bad," and so on.

Analogously, along one dimension, economics may be divided into positive versus normative economics. "Holding other factors that may affect the purchasing decisions of people, increasing

the price of a product will decrease its quantity demanded" is an example of positive economics. "You should not increase the price of the product that you are selling because it will decrease the quantity that people will buy" is an example of normative economics. Normative economics is sometimes referred to as "policy economics." This is because normative economics helps us evaluate the impacts of various policies.

Fields of Economics

Economics can be divided into two main fields. These are microeconomics and macroeconomics.

In microeconomics we study individual households, firms, industries, and so on. In macroeconomics we study the overall economy.

Table 1.2: Microeconomics vs. Macroeconomics

[1]	[2]	[3]
Variable	Microeconomics	Macroeconomics
Output	Output of a particular firm or an industry.	Output of the overall economy.
Price	Price of a particular good or service such as a pen, a computer, services of a doctor, a plumber, and so on.	The overall price level. It is an "average" of all the prices of goods and services that are produced in the economy.
Employment	Employment in a particular firm or an industry, and employment status of a particular household, and so on.	Employment in the overall economy in all the industries. Employment status of all the households in the economy.
Unemployment	Unemployment of a household, in an industry, and so on.	Unemployment in the overall economy.

Source: M. Ashraf

Both microeconomics and macroeconomics have numerous subfields. I will suggest going to the American Economics Association's website (www.aeaweb.org) for details. The American Economic Association is the premier association of economists. There you will also find numerous useful resources.

Variable

A measure that changes from observation to observation. Examples of variables include your GPA, the number of students in ECN 2030, number of individuals employed by the university.

Time-Series versus Cross-Sectional Variables

Along one dimension, variables may be divided into time-series variables and cross-sectional variables.

When observations are made over time, the variable is called a time-series variable. An example of a time-series variable is the number of students enrolled in Principles of Macroeconomics during fall 2018, spring 2019, fall 2019, spring 2020, fall 2020. In this case we are measuring the number of students enrolled in Principles of Macroeconomics during each semester starting with fall 2018; we are taking observations over time.

When we make observations at a point in time, the variable is called a cross-sectional variable. Suppose instead of looking at the number of students enrolled in Principles of Macroeconomics from fall 2018 to fall 2020, we count the number of students enrolled in Principles of Macroeconomics, Principles of Microeconomics, Intermediate Macroeconomics, and Intermediate Microeconomics during fall 2020. In this case we are counting the number of students enrolled in these courses at a point in time, i.e., fall 2020.

Flow Variables versus Stock Variables

Along another dimension variables may be divided into flow variables and stock variables.

Flow Variable

A flow variable is a variable that requires a timespan attached to it for it to make sense. Suppose that someone tells you that their income is $1,000.00. For this statement to make sense, the person must mention the timespan: A $1,000.00 per hour is different than a $1,000.00 per month.

Other examples of flow variables may include the growth rate of income, the growth rate of a child, and so on.

Stock Variable

A stock variable on the other hand, does not need any qualifier. When someone tells you that their net worth, a measure of what one owns minus what one owes, is $1,000,000.00, you do not need any further explanation. This is their net worth right now.

Other examples of stock variables may include your GPA, your height, your weight, and so on.

Compare the definitions of time-series and cross-sectional variables with flow variables and stock variables. Do not confuse one with the other.

Use of Models

In economics we use models. A model is a formal statement of theory. Note that while in everyday language theory and opinion are often used as synonyms, a theory is not the same as an opinion. For a statement to rise to the level of a theory, it must generate testable hypothesis. That is, it must have the possibility of being refutable. An opinion does not require this restriction. Take two statements.

Statement 1: I like the yellow color.

Statement 2: Blue color helps reduce stress.

There is no way to refute the first statement. Whereas one can conduct an experiment to test the validity of the second statement.

Models may be expressed using written statements, diagrams, and mathematical equations. In economics we use all three types of models.

A Review of Basic Mathematical Concepts

In this section we review some basic mathematical concepts. This review is not meant to be exhaustive. I encourage you to review your college algebra textbook for more details.

Simple Average

In calculating a simple average, we sum up all the elements of a series and divide by the number of the elements. Suppose that we want to calculate the average of the following series.

12, 14, 9, 5, 10, and 54.

The sum of this series is 90 (=12 + 14 + 9 + 5 + 10 + 54). There are six elements in this series. We divide the sum, 90, by six. Our average is 15 (=90/6).

Equation 1.2 gives the formula for simple average.

$$\overline{X} = \left(\frac{1}{n}\right)\sum_{i=1}^{n} x_i \tag{1.2}$$

In Equation 1.2, $\overline{X}$, (read as x-bar) represents the average. The Greek letter **Σ** is the summation sign. The subscript, $i = 1$, and the superscript, n, represent the number of elements in the series. In our example $n = 6$. It is read as "the sum goes from $i = 1$ to n." The letter x represents each of the elements of the series.

Geometric Average

Another way to calculate average is given by Equation 1.3.

$$\overline{X} = \sqrt[n]{\prod_{i=1}^{n} x_n} \tag{1.3}$$

In calculating a geometric average, we multiply all the elements of a series and take the n^{th} root of the product. In Equation 1.3, the Greek letter Π represents the product. The rest of the variables are as defined above.

Let us take the geometric average of the series, 12, 14, 9, 5, 10, and 54. This is the same series for which we calculated simple average.

First, calculate the product of all the elements. This equals 4,082,400 (=12 × 14 × 9 × 5 × 10 × 54). Using Equation 1.3, we get the following answer.

$\overline{X} = \sqrt[n]{\prod_{i=1}^{n} x_n} = \sqrt[6]{4{,}082{,}400} \approx 12.64$. The sign "≈" means that the answer is approximately this. In this case I have cutoff the answer after two decimal places.

Geometric average has certain mathematical characteristics that are better suited to explain certain situations. A detailed discussion of this topic is beyond the scope of this textbook, As we will see in Chapter 6, however, that we use geometric average to calculate a measure of aggregate output.

Slope

Slope measures the change in one variable due to the change in another variable. Suppose there are two variables, *X* and *Y*. We want to see how does variable *Y* changes due to a change in variable *X*? We can use Equation 1.4 to figure this out.

$$Slope = \frac{Change\ in\ Y}{Change\ in\ X} = \frac{\Delta Y}{\Delta X} \tag{1.4}$$

As in Equation 1.1, the Greek letter Δ represents change. We calculate change by figuring out the difference between the two values of a variable. Suppose that y_1 represents the value of the variable *Y* at point 1, and y_2 represents the value of the variable *Y* at point 2. The change in *Y*, then, is $y_2 - y_1$. That is, $\Delta Y = y_2 - y_1$.

Note that I am representing the variable by an upper-case letter and in bold, and I am representing a given value of the variable by a lower-case letter. We will follow this convention throughout the book.

Notice, also, the similarities between Equations 1.1 and 1.4. Except for the difference in variables, *T* and *U* versus *Y* and *X*, the two equations are the same. In fact, the terms "marginal" and "slope" represent the same concept. In Equation 1.1 we are looking at the change in total benefit, *T*, due to change in units, *U*. In Equation 1.4 we are looking at the change in *Y* due to change in *X*.

Percentage Change

We calculate percentage change between two values of a variable, say *X*, using the following formula.

$$Percentage\ Change\ in\ X = \left(\frac{x_2 - x_1}{x_1}\right) \times 100 \quad (1.5)$$

Where the lower case, *x* represents a particular value of the variable *X*. In Equation 1.5, x_1 represents the first value of *X*, and x_2 represents the second value of *X*. We take the difference between the two values and compare the difference with the first value.

As an example, look at the data in Table 1.1. Suppose that we want to calculate percentage change between total utility of the first unit, 20, and the total utility of the second unit, 39. Using Equation 1.5, we get:

$$Percentage\ Change\ in\ Total\ Utility = \left(\frac{u_2 - u_1}{u_1}\right) \times 100 = \left(\frac{39 - 20}{20}\right) \times 100 = 95\%$$

Where the lowercase u_1 and u_2 represent the total utilities of the first and the second units, respectively. The result says that when we moved from the first unit to the second unit, the total utility increased by 95 percent. Keep in mind that this the percentage change in *total utility* by consuming the second unit, and not marginal utility or percentage change in marginal utility.

Graphs

In economics we use a lot of graphs to help us illustrate and understand various concepts. We will draw two-dimensional diagrams. That is, when we want to show a relationship between two variables, we will list values of one variable on the horizontal axis and one variable on the vertical axis.

Figure 1.1 plots data from Table 1.1, Columns 1 and 2—Units and Total Benefit. For the sake of simplicity, in plotting the data, I omit Units value zero.

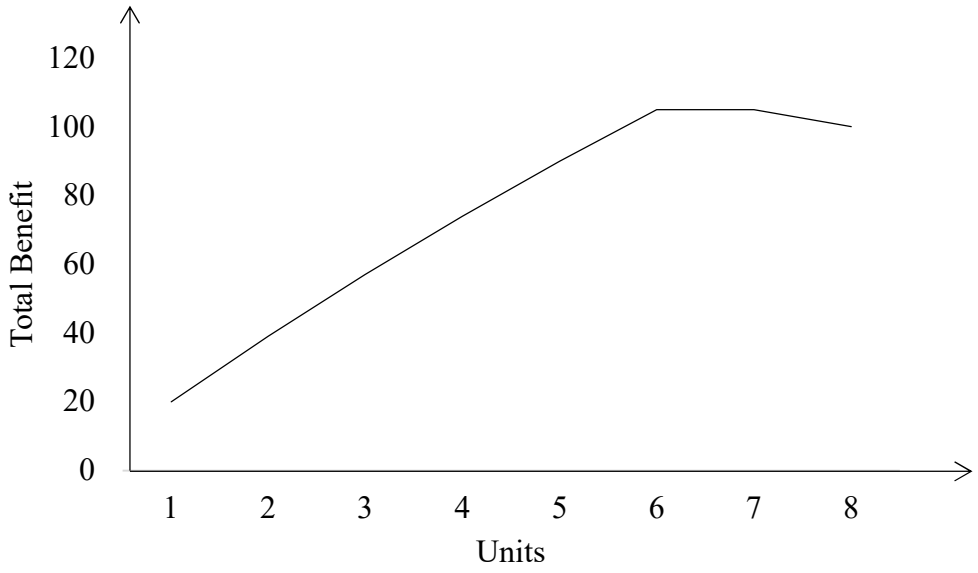

Figure 1.1: Total Benefit

Source: M. Ashraf.

Figure 1.1 Units are on the horizontal axis, and Total Benefit is on the vertical axis.

Note that I have listed the values of Units on the horizontal axis and Total Benefit on the vertical axis.

Figure 1.2 plots data from Table 1.1, Columns 1 and 3. Again, for the sake of simplicity, in plotting the data, I omit Unit value zero.

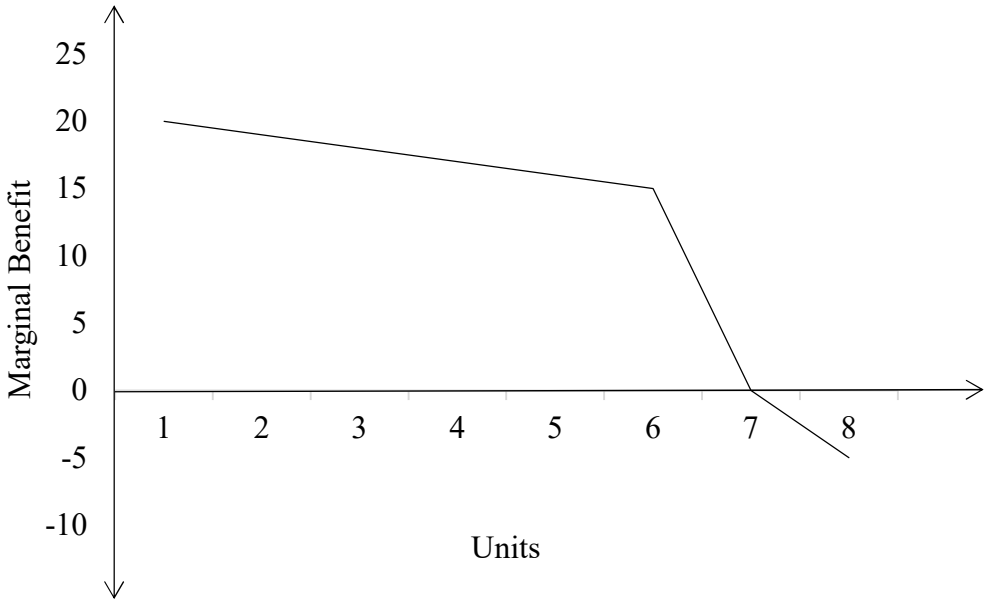

Figure 1.2: Marginal Benefit

Source: M. Ashraf

In Figure 1.2, Units are on the horizontal axis and Marginal Benefit is on the vertical axis.

In Figure 1.2, I have listed the values of Units on the horizontal axis, and the values of Marginal Benefit on the vertical axis.

Recall that marginal is the slope of total. Note, then, that Figure 1.2 plots the slope of the curve plotted in Figure 1.1. Furthermore, since the marginal benefit of the 7^{th} unit is zero and the marginal benefit of the 8^{th} unit is -5, the vertical axis in Figure 1.2 lists negative values as well.

Chapter Conclusion

In this introductory chapter we started with a definition of economics. We learned about various concepts that we will use in the remainder of this textbook. These include resources, marginal, opportunity cost, slope, and positive versus normative economics, among others. We learned the distinction between saving and investment. We learned how to draw and interpret graphs. It is important that you thoroughly understand the concepts discussed in this chapter. These concepts will be used throughout this textbook.

A Review of Terms

- Economics is the study of how individuals and societies allocate their scarce resources among various uses.
- Resources are those goods that nature, previous generations, and the current generation has provided that are used in the production of goods and services. Resources may be divided into three broad categories. These are land, labor, and capital.
- Capital refers to goods that have been produced to produce other goods and services. Examples of capital include roads, bridges, buildings, machines, software, and so on. In economics, money is not capital.
- Goods are tangible and services that intangible.
- Microeconomics deals with individual household, individual firm, individual industry, and so on.
- Macroeconomics deals with the overall economy.
- A good or service that carries a price is scarce, otherwise it is not.
- Opportunity cost is the next best alternative forgone. It is what we give up in order to get something.
- $Slope = \frac{Change\ in\ Y}{Chang\ \ in\ X} = \frac{\Delta Y}{\Delta X}$
- $Percentage\ Change\ in\ X = \left(\frac{x_2 - x_1}{x_1}\right) \times 100$
- $Average\ of\ X: \overline{X} = \left(\frac{1}{n}\right) \sum_{i=1}^{n} x_i$
- $Geometric\ Average\ of\ X: \overline{X} = \sqrt[n]{\prod_{i=1}^{n} x_n}$