



## LESSON 1

# Production Possibilities and Opportunity Cost

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### LESSON DESCRIPTION

This lesson introduces students to production possibilities analysis, the production possibilities frontier (PPF) and to the concept of opportunity cost. Students participate in several short production simulations and create their own PPF curves.

### INTRODUCTION

Mick Jagger sang, “You can’t always get what you want. . . .” This is true for individuals *and* for nations—because the resources needed to produce the goods and services that we desire are scarce. Production possibilities represent an analysis of the alternative combinations of two goods that can be produced with a set of scarce resources using available technology in a given time period. This analysis produces a graphic representation, the production possibilities frontier (PPF), which illustrates the trade-offs involved in making decisions about producing goods.

The PPF shows society’s maximum production output of one good given the production output of another good. This trade-off can be seen in the classic “guns vs. butter” example: All societies must decide how many weapons to produce and how much food production to sacrifice in order to produce the guns and vice versa. The various combinations of goods (i.e., “guns” or “butter”) that can be produced can be plotted as points on a graph and, when these points are connected, the resultant curve is the PPF. Production possibilities analysis is fundamental to economics.

Economists describe the true cost of something as what you must give up in

order to get that thing. This can be seen in the concept of opportunity cost, which is the value of the next best alternative not chosen. Limited resources force us to choose between alternatives in order to satisfy our wants. This is the essence of opportunity cost—choosing to do one thing prevents us from having the opportunity to do another. The PPF can be used to calculate the opportunity cost of various production decisions. For example, given a set of scarce resources, in order to produce additional “butter,” a society has to give up the opportunity to produce some “guns.” Production possibilities analysis can also be used to determine how efficiently society has utilized its scarce resources. Every point along the PPF represents a production decision that uses all available resources. This is said to be efficient because society’s scarce resources are being fully employed in producing some combination of guns and butter. The PPF also represents a limit—combinations that fall beyond the frontier are not possible. On the other hand, any combination of guns and butter that society chooses to produce that fall inside the frontier are said to be inefficient because society is underutilizing its resources.

### COMPELLING QUESTION

Why can’t even developed countries produce everything their citizens want?

### CONCEPTS

Production possibilities frontier (PPF)

Opportunity cost

Resources

## OBJECTIVES

Students will be able to:

- Create production possibility frontiers (PPFs) using data from a simulation.
- Explain what economists mean by efficiency, using an example from a simulation.
- Calculate the opportunity cost of a production decision.
- Graph a production possibilities curve from a table.
- Use the PPF model to illustrate the concepts of trade-off and opportunity cost.

## CONTENT STANDARDS

### Voluntary National Content Standards in Economics

- Standard 1: Choices made by individuals, firms, or government officials are constrained by the resources to which they have access.
- Standard 3: Different methods can be used to allocate goods and services. People acting individually or collectively must choose which methods to use to allocate different kinds of goods and services.
- Standard 15: Investment in factories, machinery, new technology, and in the health, education, and training of people stimulates economic growth and can raise future standards of living.

### Common Core State Standards

- CCSS.Math.Content.HSF-IF.B.4: For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.

- CCSS.Math.Content.HSF-IF.C.7: Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.

## TIME REQUIRED

60–90 minutes. Procedures 1–27, 45 minutes on the first day; procedures 28–39, 45 minutes on the second day.

## MATERIALS

- Slides 1.1–1.10
- Activity 1.1, one copy per student
- Activity 1.2; photocopy sheet twice on card stock, back-to-back, and cut apart to make 30 two-sided smartphone and tablet computer cards
- Three labeled boxes, approximately shoe-box size or slightly larger
- Activity 1.3, one copy per student
- Activity 1.4, one set (16 rulers, 16 protractors) per student (for optional group version, one set per four students)
- Scissors, one per student (for optional group version, one per four students)
- “Protractors and Rulers” Excel workbook (available online with slides)
- Document camera
- Tape, two 4-inch strips per student or convenient access to a tape dispenser (for optional group version, two strips per four students)
- “x2” signs

## PROCEDURES

### Day One

1. Prepare in advance 30 cards, each with one smartphone on one side and one tablet computer on the other. Use Activity 1.3 provided with this lesson and run each sheet back-to-back.
2. Introduce the lesson by asking students whether they would like a smartphone or a tablet computer.

*Answers will vary.*

Ask them why they think that everyone can't have a smartphone or a tablet computer.

*They are likely to say they have limited income.*

Tell students that countries are like individuals—countries can't produce enough of either smartphones or tablet computers to satisfy everyone. Ask: Why can't countries just produce enough smartphones and tablets to satisfy everybody?

*They should say that a country will not have all the resources necessary to produce enough for everybody.*

Point out that countries face a scarcity of resources and must choose to use those resources to produce smartphones or tablet computers.

3. Tell students that they will now participate in a simulation that will demonstrate the trade-offs a country must make. They will be creating a diagram known as a **production possibility frontier** or **PPF**. A PPF shows all the combinations of goods that a country can produce using its available resources and technology.
4. Ask students to imagine that they are the citizens of a country called Technologia, which produces two goods: smartphones and tablet computers. Tell students they will be producing the PPF for these two goods.
5. Distribute Activity 1.1 and show Slide 1.1. After students have read the first paragraph of the introduction, ask them what these two goods have in common.

*Answers will vary but might include that both are examples of technology, both are wireless, both have touch screens.*

6. Show Slide 1.2. Explain to students that one resource needed to produce both smartphones and tablet computers is the rare earth mineral coltan. Coltan is a heat-resistant ore that can hold a strong electrical charge; it is used to make capacitors for touch screens in smartphones and tablets. Coltan is rare and almost all deposits of it are found in African countries such as the Democratic Republic of Congo.<sup>1</sup> Have students read the rest of the introduction.
7. Three boxes will be used in the simulation. Label one "coltan." Label the second "smartphones," and label the third "tablet computers." Place the coltan box front-and-center in the classroom, and place each of the other boxes at least 10 feet apart on either side of the coltan box.
8. Show Slides 1.3–1.6 as you describe the simulation (described in step 3 of Activity 1.1). Tell students that coltan is very scarce and only 20 pieces are available in the country to use in smartphones or tablet computers. Place 20 of the prepared smartphone/tablet cards in the coltan box.
9. Tell students you are now looking for another resource—labor. For Round 1, select 10 students to participate in the production of smartphones or tablet computers. Place five students on one side of the coltan box and five students on the other. Have students stand arm's-length apart.
10. Tell students they will be participating in a simulation on how coltan resources are used to produce tablets or smartphones. Note that there are 20 cards in the coltan box to be used in the production of smartphones or tablets. They will use the cards to produce one smartphone or one tablet, depending on which team they are on. Once the round begins, students will

<sup>1</sup> Source: University of Waterloo Earth Sciences Museum (<http://www.uwaterloo.ca/earth-sciences-museum>).

make as many of their goods as possible until the coltan is exhausted. Goods are produced by turning the card to the appropriate good (smartphone or tablet) and passing the card to the next person in line. Students can handle only one card at a time. The team with the most goods in their box at the end of the round will be declared the winners. Encourage students to cheer for the teams.

11. Build excitement by making this about competition: Who can produce the most? At the end of the first round, have students enter the results in Activity 1.1, Table 1.1. Use an interactive whiteboard or document camera to project a copy of Table 1.1 (Slide 1.7); work with students to enter results.
12. For Round 2, tell students you want to produce more smartphones. Take two students from the tablet computer production line and move them to the smartphone line. Replace the coltan cards in the coltan box. Remind students that they can hold only one coltan card at a time. Conduct Round 2. As before, project a copy of Table 1.1 and enter the results. (Note: Ideally, more smartphones and fewer tablet computers will have been produced, because the three students will have to run back and forth a bit. Even if this does not happen, another point will have been generated for the PPF—and, preferably, it will be different than that of the first round.)
13. For Round 3, tell students you want to produce even more smartphones. Take two more students from the production line for tablet computers and move them to the smartphone line. Return coltan slips to the coltan box. Remind students that they can hold only one coltan card at a time. Conduct Round 3. Again project a copy of Table 1.1 and enter results. (Note: Ideally, with just one student producing tablet computers, even more smartphones should be produced. Even if this does not happen, another point will have been generated for the PPF.)

14. Have students enter and plot results, using the blank axes in Activity 1.1.
15. Ask students: What is the maximum number of tablets Technologia could produce?

*20*

Ask students to plot the results if Technologia had produced only tablets.

*(20, 0)*

Ask students: What is the maximum number of smartphones Technologia could produce?

*20*

Ask students to plot the results if Technologia had decided to produce only smartphones.

*(0, 20)*

16. Tell students to connect the points they have graphed, and show them Slide 1.8.

*It should be a straight line from (0,20) to (20,0).*

Tell students the PPF they have graphed illustrates the trade-offs that countries must make when producing goods.

17. Tell students that, to an economist, the true cost of anything is more than the monetary price (or “price tag”) of the good or service. Economists focus on **opportunity costs** when assigning true costs. The opportunity cost is the cost of the next best choice, or what we give up to get something. Show students this in the graph by moving along the PPF. For example, to increase from 0 tablets to 1 tablet, smartphones must be given up. Ask: What is the opportunity cost to Technologia of producing one more tablet—that is, what had to be given up?

*One smart phone*

Ask: If a second tablet was wanted, what would be given up?

*One smart phone*

Emphasize that, because the opportunity cost is constant in this example, the PPF is a straight line. Ask: What is the opportunity cost to Technologia of production of a smartphone?

*One smartphone = one tablet; one tablet = one smartphone*

18. Demonstrate this using the smartphone/tablet cards. Hold up the smartphone side and tell students that instead of producing a smartphone with the coltan, Technologia chose to produce a tablet: therefore, Technologia lost the opportunity to produce that smartphone.
19. Tell students that the first PPF for smartphones/tablets represents Technologia's potential output at this time. Eventually, changes may cause this PPF to shift. Ask students to think of some changes that might cause the PPF to shift outward (away from the origin) representing growth in economy.

*Increase in resources, increase in productivity, increase in technology*

20. Gather all 20 cards and add the remaining 10 cards to the box (total of 30 cards). Ask students: What is represented by putting 30 coltan cards in the box?

*An increase in resources*

Choose 10 students not involved thus far and explain that you are going to play another three rounds.

21. Conduct three rounds, as was done in procedures 10–14.
22. Ask students: What is the maximum number of tablets Technologia could produce?

*30*

Ask: What would the result be if Technologia decided to produce *only* tablets?

*(30, 0)*

Have them plot these points. Ask: What is the maximum number of smartphones Technologia could produce?

*30*

Ask students to plot the results if Technologia decided to produce *only* smartphones.

*(0, 30)*

23. Show results on Slide 1.9. Point out that because resources have increased, more phones and tablets can be produced.
24. Finally, tell students that production technology has improved to the point where touch screens in smartphones require only half the coltan they did before. Place a large “x2” sign on the smartphone box.
25. Tell students that they probably don't need to do another simulation to predict what will happen to the PPF if the country has 30 units of coltan and each unit will produce two smartphones. Note that the production of a tablet computer still requires a full unit of coltan. Have students add this new PPF on their graph.

*The PPF should go from (0,60) to (30,0).*

Show Slide 1.10 to verify that students have plotted the points correctly.

26. Ask: What has happened to the opportunity cost of a tablet?

*The opportunity cost has increased to two smartphones for each tablet computer produced.*

27. Ask students these questions to review the first part of the lesson:

- a. Why do countries face a trade-off between goods such as tablet computers and smartphones?

*The resources needed to produce the goods, like coltan, are scarce.*

- b. In the first PPF graph, what was the opportunity cost of a smartphone?

*One tablet computer*

- c. In the first PPF graph, did the opportunity cost of a smartphone change?

*No, it was always the same, one tablet computer.*

- d. What can cause the PPF to shift outward?

*More resources or better technology*

## Day Two

28. Remind students of the results of the first day’s activities. Ask students to review the definitions of production possibilities and opportunity cost.

29. Tell students that the example they explored in the last lesson used a common resource: the mineral coltan. Often, however, when countries or individuals choose between combinations of two goods, the resources needed to produce one good are different from those needed to produce the other. Ask: Consider the production of two goods—pizzas and flat-screen TVs—What are some of the resources used in making pizzas?

*Labor, wheat, cheese, tomatoes, pizza ovens*

What about flat-screen TVs?

*Labor, digital components, electric circuits, factories*

What resources are used in the production of both goods?

*Labor*

30. Distribute copies of Activity 1.3. Tell students they will participate in a simulation of increasing opportunity cost—a more real-world example. Describe the simulation as the production of two goods: rulers and protractors.<sup>2</sup>

31. Optional Group Method: For maximum participation, each student should have paper strips, rectangles, pen, tape, and scissors. If materials are scarce, form groups of four students, with students taking turns to “produce” over the four rounds. The procedures below assume each student has materials.

32. Distribute one set of Activity 1.4 to each student (one copy of ruler sheet, two copies of protractor sheet). Before the simulation begins, have them use scissors to cut along the lines; students should have 16 strips and 16 rectangles to use in the four rounds of the simulation.

33. Explain that rulers are produced using 3.5-inch × 1-inch strips of paper that students will cut from Activity 1.4. A ruler is produced by making five vertical marks (see example in Activity 1.3).

34. Explain that protractors are produced by using scissors to cut semicircles from the 3.5-inch × 2-inch rectangles in Activity 1.4 and drawing five marks around the edge of the semicircle (see example in Activity 1.3).

35. For each round, students begin with four strips, four rectangles, a pen, a roll of tape, and a pair of scissors. Explain that resources may not be carried over from

<sup>2</sup> This activity is from Anderson, D. & Chasey, J. (1999). A production possibilities frontier experiment: Links and smiles, <http://www.marietta.edu/~delemeeg/exernom/f99.htm>, June 15, 2013.

one period to the next, and that only one layer of paper may be cut at a time.

36. Explain that in each round, students will have 80 seconds of production time. At the end of each round, they should record and plot their results as points in the axes in Activity 1.3.

- a. Round 1: Tell students to make four protractors and as many rulers as they can. Students should use the large rectangles to make the protractors. They may or may not have time to make all four rulers. Tell them not to worry if they do not use all the materials.
- b. Round 2: Tell students to make only rulers. Students should use the four narrow rectangles to make the rulers. To make more rulers, they should cut the large rectangles in half. Again, they may not use all the materials.
- c. Round 3: Tell students to make only protractors. Students should use the large rectangles to make protractors. They must tape together the smaller rectangles to make additional protractors. This takes considerable time; it is unlikely that they will finish all the materials.
- d. Round 4: Tell students to make one protractor and as many rulers as they can. They will have to use one large sheet for the protractor, move on to the narrow rectangles for the rulers, and use any remaining time to cut the large rectangles into rulers.

37. Have students draw the PPF based on the points they have plotted. Ask: Is the PPF a straight line, as in the coltan example?

*It is generally not a straight line.*

Does the opportunity cost remain constant?

*No, depending on how many rulers the students could produce, the opportunity cost of protractors will vary.*

38. Project the Excel workbook entitled “Protractors and Rulers” on an interactive whiteboard or using an LCD projector. Enter data from one student (see note below) as an example. Ask students to complete the questions in Activity 1.3:

(1) What was the opportunity cost of the first protractor (from point A to B)?

*Will vary with results, but should be low, perhaps only one ruler, maybe none, if student gave up.*

(2) What was the opportunity cost of the last protractors (from point C to D)?

*Will vary, but should be higher: maybe four or three rulers per protractor, or four rulers for two protractors—two rulers per protractor.*

(3) Why did the opportunity cost increase?

*To make the first few protractors, resources were better suited for making protractors than making rulers, so students give up a small number of rulers for a relatively large number of protractors. As students make more protractors, they must use resources more specialized for making rulers, so they lose a lot of rulers for relatively few protractors.*

(Note: The intent of the activity is to form a curved PPF. This is accomplished by providing resources [narrow paper and larger paper] that are not perfect substitutes. The production of four protractors and many rulers is the easiest combination to produce because the resources are most suitable for that combination. Other combinations—all rulers or

all protractors, for example—require more labor to turn less suitable resources into more than four of a good. This should increase the opportunity cost of production, making the PPF curved. Of course, you should be prepared to get other results because students may distract one another during production or increase productivity as they learn by doing. In choosing a student to report results, try to pick one whose graph produces a curved PPF. Hint: You can change the production time based on your experience in a class. If too many people finish all materials every round [a straight line PPF], reduce the production time.)

- (4) Ask: How does this relate to real-world production possibilities?

*Resources are often specialized. For example, the resources needed to make butter are less useful for making guns. Producing only guns, for example, would require that, when all the resources best suited to making guns were used up, the steel vats used in butter production would have to be melted down to make guns. This is analogous to altering protractor-specialized strips for use in ruler production. Similar specialization of resources, and the increasing opportunity costs of production that result, exists for many of the goods we consider producing.*

**CLOSURE**

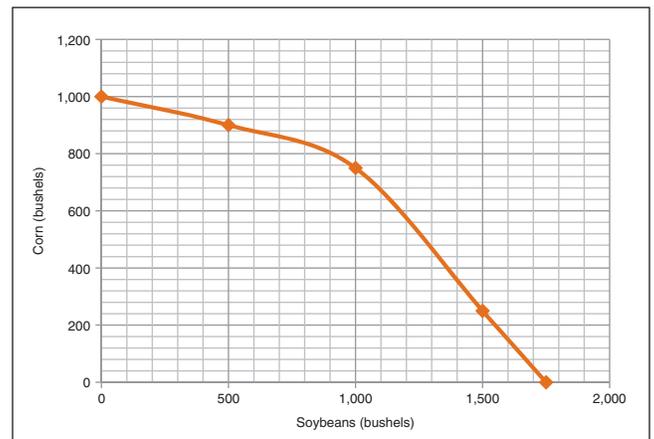
- 39. Tell students that economists are famous for the statement “There is no such thing as a free lunch.” Ask

students to apply what they have learned in this lesson by writing a short letter to the editor illustrating this concept. Tell them to pick two goods to write about to help them do so, and to include opportunity cost, trade-offs, production possibilities frontier and increasing opportunity cost.

**ASSESSMENT**

**Multiple Choice**

Imagine a farmer who owns a large, productive parcel of land on which she can produce either soybeans or corn. The questions that flow refer to this production possibilities schedule which shows the points along the production possibilities frontier (PPF) for this farmer.



Soybeans (bushels)	Corn (bushels)
1,750	0
1,500	250
1,000	750
500	900
0	1,000

1. The production possibilities frontier shown above
  - a. **depicts the boundary between those combinations of corn and soybeans that can be produced by one farmer given available resources and the current state of technology.**
  - b. shows how many goods and services are consumed by one farmer.
  - c. is a model that assumes there is no scarcity and no opportunity cost.
  - d. shows that both soybean and corn production can be increased at the same time.
  
2. Which of these is not a possible combination of soybean/corn output?
  - a. 1,000 bushels of soybeans, 750 bushels of corn
  - b. 500 bushels of soybeans, 500 bushels of corn
  - c. **500 bushels of soybeans, 1,000 bushels of corn**
  - d. 1,500 bushels of soybeans, 250 bushels of corn
  
3. Last year, this farmer produced 1,000 bushels of soybeans. This year, she wants to produce 1,500 bushels of soybeans. Assuming no change in resources or technology, what will her opportunity cost be?
  - a. 1,500 bushels of soybeans
  - b. 1,000 bushels of corn
  - c. 400 bushels of soybeans
  - d. **500 bushels of corn**

### Constructed Response

Choose two goods and draw a PPF in which the opportunity cost for a good increases as more of the good is produced. Explain why the opportunity cost increases as more of one good is produced. Finally, identify two things that will cause your PPF to shift outward.

*Answers will vary, according to goods chosen. The opportunity cost will increase because resources not suited to the production of a good are eventually used for its production. Technological improvements or increased resources will shift the PPF.*

## ACTIVITY 1.1

### Smartphones and Tablet Computers

#### Introduction

1. Imagine you are a citizen of a country called Technologia, which produces only two goods: smartphones and tablet computers. You will be participating in a simulation that will produce the production possibilities frontier (PPF) for these two goods. What do these two goods have in common?
2. One resource needed to produce both smartphones and tablet computers is the rare earth mineral coltan, a heat-resistant ore that can hold a strong electrical charge. It is used in making the capacitors needed to produce the touch screens in both smartphones and tablet computers. Coltan is rare and almost all the deposits are in African countries such as the Democratic Republic of Congo.

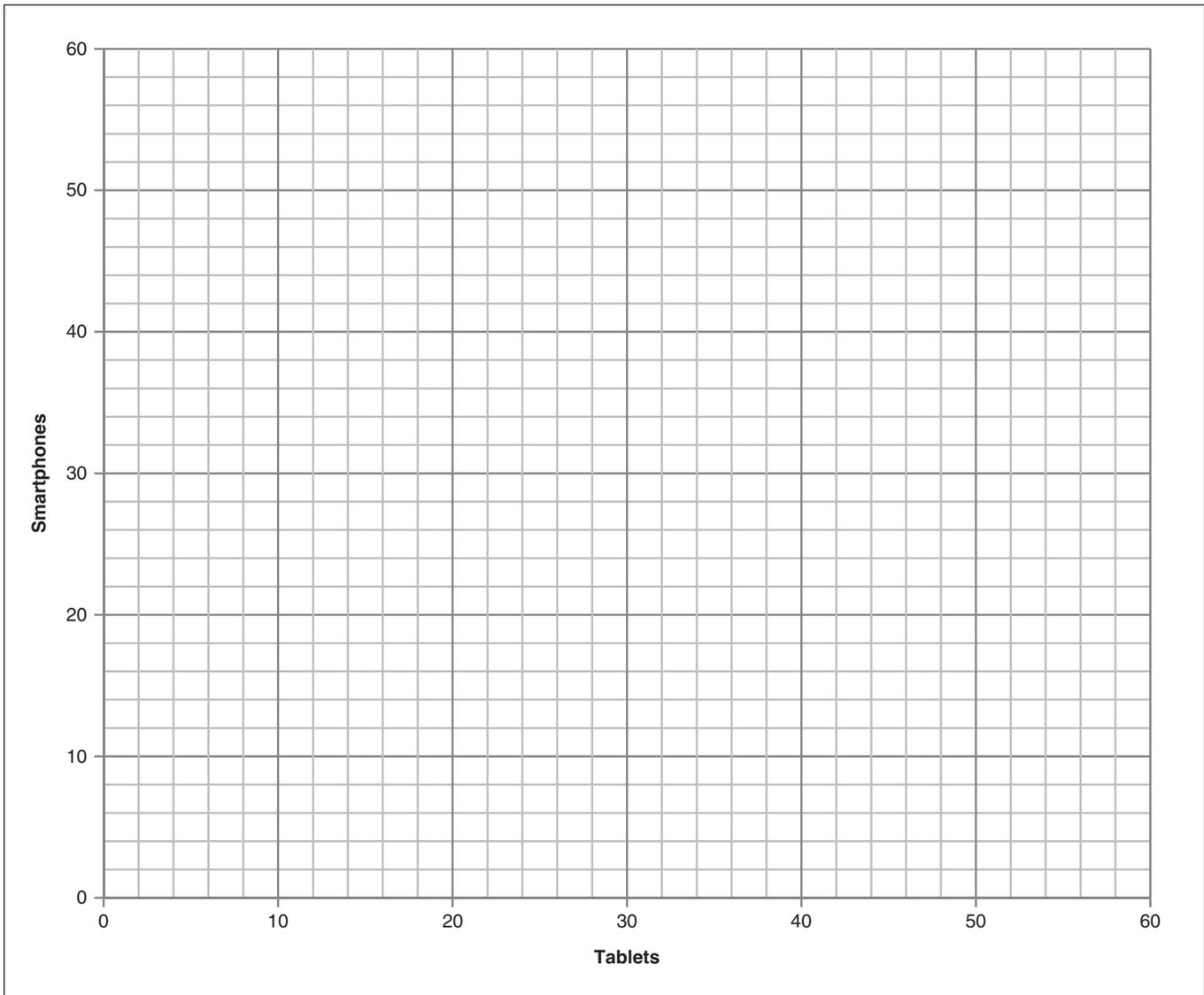
#### PPF for Technologia

3. Three boxes will be used in this simulation: “coltan,” “smartphones,” and “tablet computers.” The coltan box will contain a number of cards, each with a smartphone on one side and a tablet computer on the other. Ten students will be selected to simulate production of either smartphones or tablet computers. Those students will be making decisions about how to use coltan resources. Once the round begins, students will produce as many of each good as possible. Goods are produced by turning each coltan card to the appropriate good and passing the card to the next person in line until it is placed in the appropriate box. Students can only handle one card at a time. The team with the most goods in their box at the end of the round will be declared the winners.
4. After each round, enter your results into Table 1.1 and plot on the blank axes provided.

**Table 1.1: Smartphone and Tablet Computer Production Possibilities**

Round (point)	Number of Smartphones	Number of Tablet Computers
1 (A)		
2 (B)		
3 (C)		
4 (D)		
5 (E)		
6 (F)		

## Smartphones and Tablet Computers



## ACTIVITY 1.2

### Smartphone and Tablet Computer Cards

Smartphones



## ACTIVITY 1.2 (Continued)

### Smartphone and Tablet Computer Cards

Tablet Computers

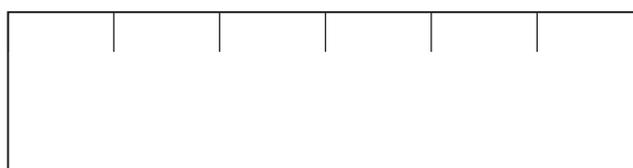


## ACTIVITY 1.3

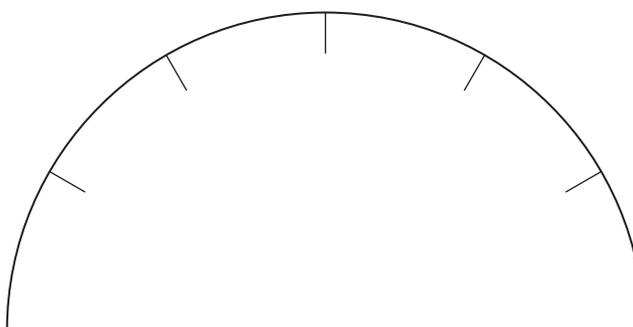
### Rulers and Protractors

Often when countries or individuals choose between combinations of two goods, the resources needed to produce one good are different from those needed to produce the other good. You will be participating in the simulation of the production of two goods: rulers and protractors. Rulers are produced using 3.5-inch  $\times$  1-inch strips of paper that you will cut from the Rulers and Protractors Sheet. A ruler is produced by making five vertical marks (see example below, not actual size). Protractors are produced by using scissors to cut a semicircle from a 3.5-inch  $\times$  2-inch rectangle and drawing five marks around the edge of the semicircle (see example below, not actual size).

#### Ruler Example



#### Protractor Example



Before the simulation begins, use scissors to cut along the lines of Activity 1.4. Once completed, you should have 16 strips and 16 rectangles.

For each round, begin with four strips, four rectangles, a pen, a roll of tape, and a pair of scissors. Resources may not be carried over from one period to the next, and only one sheet of paper may be cut at a time. You may tape together ruler strips to make protractors.

In each round, you will have 90 seconds of production time. At the end of each round, you will plot results in Table 1.2 below.

Round 1: Make four protractors and as many rulers as you can.

Round 2: Make only rulers.

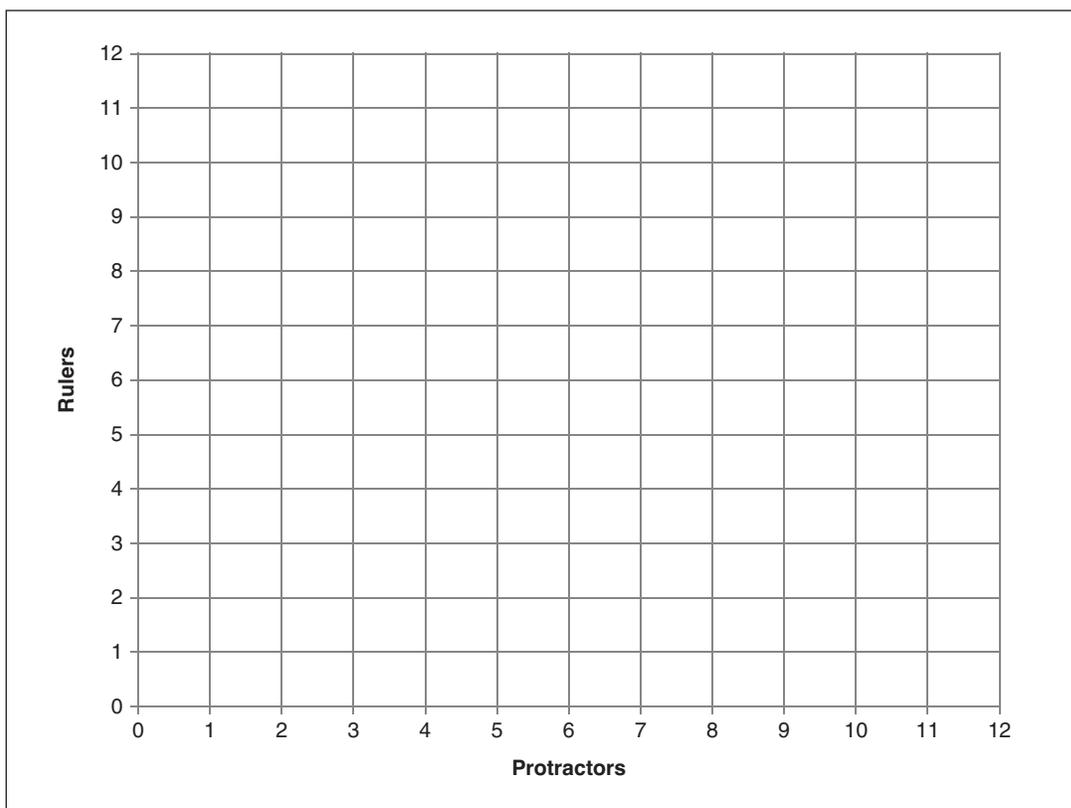
Round 3: Make only protractors.

Round 4: Make one protractor and as many rulers as you can.

Record the number of rulers and protractors produced in each round in Table 1.2. Careful! The rounds are not in sequential order. Once Table 1.2 is complete, plot these points on the blank axes that follows.

**Table 1.2**

<b>Point</b>	<b>Round</b>	<b>Rulers</b>	<b>Protractors</b>
<b>A</b>	<b>Round 2</b>		<b>0</b>
<b>B</b>	<b>Round 4</b>		<b>1</b>
<b>C</b>	<b>Round 1</b>		
<b>D</b>	<b>Round 3</b>	<b>0</b>	



## Opportunity Cost

To an economist, the true cost of anything is more than the monetary price (the “price tag”) of the good or service. Economists focus on the true cost as the opportunity cost. The opportunity cost is the cost of the next best choice, or what we give up to get what we want. In the case of protractors and rulers, when we choose to produce some protractors, we must give up the opportunity to produce some rulers.

1. What was the opportunity cost of the first protractor (from point A to B)?

2. What was the opportunity cost of the last protractor (from point C to D)?

\_\_\_\_\_ rulers were given up for \_\_\_\_\_ protractors OR

\_\_\_\_\_ rulers per protractor

3. Why did the opportunity cost increase?

4. How does this relate to real-world production possibilities?

## ACTIVITY 1.4

### Rulers and Protractors

#### Rulers


## ACTIVITY 1.4 (Continued)

### Rulers and Protractors

#### Protractors
