

How to Study for Classes 7 and 8 Costs of Production

Classes 7 and 8 introduce the main principles concerning costs of production. It is perhaps the most technical chapter in the course and needs to be studied slowly and carefully.

1. Begin by looking over the Objectives listed below. This will tell you the main points you should be looking for as you read the chapter.
2. New words or definitions and certain key points are highlighted in italics and in red color. Other key points are highlighted in bold type and in blue color. You will be given an In Class Assignment and a Homework assignment to illustrate the main concepts of this chapter.
3. There are several new words in this chapter. Be sure to spend time on the various definitions. There are also many calculations. Go over each carefully. Be sure you understand how each number was derived (do the calculations for yourself). Then, plot the calculations on graph paper to see how the graphs are derived.
4. Pay attention to the relation between marginal and average.
5. When you have finished the text, the Test Your Understanding questions, and the assignments, go back to the Objectives. See if you can answer the questions without looking back at the text. If not, go back and re-read that part of the text. Then, try the Practice Quiz for Classes 7 and 8.

Objectives for Classes 7 and 8 Costs of Production

At the end of Classes 7 and 8, you will be able to answer the following:

1. What is meant by **“explicit cost”**? by **“implicit cost”** by **“total economic cost”**? by **“economic profits or losses”**? Give examples.
What is a **“fixed factor of production”**? What is a **“variable factor of production”**?
2. What is a **“fixed cost”**? What is a **“variable cost”**? Which costs are likely to be fixed and which costs are likely to be variable?
3. What is the **“short-run”**? What is the **“long-run”**?
4. What is meant by the **“production function”**?
5. What is **“total (physical) product”**? What is **“marginal (physical) product”**?
6. What are **“increasing marginal returns”**? Why do they occur?
7. What is the **“law of diminishing (marginal) returns”**? Why does it occur?
8. What are **“negative marginal returns”**? Why do they occur?
9. What is **“marginal cost”**? **What is the relation between the marginal physical product and the marginal cost?** Why?
10. Why does marginal cost rise as more of a good or service is produced?

Classes 7 and 8 Costs Of Production (latest revision August 2004)

1. The Definition of Costs of Production and Economic Profits

In analyzing businesses, we assume that they have a simple goal: **to maximize their profits**. Businesses will do more of anything that will increase their profits and do less of anything that will decrease their profits. ***Profits are the difference between total revenues and total costs.*** We will begin our analysis by examining the total costs. We shall do this because the **principles affecting costs of production do not depend on the type of industry a business is in**. That is,

the principles affecting the costs of production are the same for a restaurant, an electricity company, a baseball team, a college, a farm, and so forth. This will not be true when we examine total revenues, which do depend on the type of industry.

In analyzing costs of production, we must first remember that cost always means *opportunity cost*. Opportunity cost is the value of everything that is sacrificed when we choose to do something. Because of this, "cost" means something different to the economist than it does to the accountant. Economists differentiate between explicit costs and implicit costs. ***Explicit costs are those paid to factors of production owned by people outside of the business.*** These will include wages paid to workers, payments for natural resources (such as oil or iron), payments for machinery, rent on the building, and so forth. ***Implicit costs (also called "normal profits") represent the opportunity costs of the owner.*** The accountant considers them part of profits while the economist considers them part of cost.

As an example, let us consider a construction company. You have always been good at construction activities and have worked in other companies. Now you desire to start your own company that you will run yourself. You quit your job that had been paying \$40,000 per year. You have \$40,000 in your savings account that you withdraw to start this company. This is certainly not enough. So you borrow the rest from the bank (\$2,300,000) and use the money to buy the machinery with which you will build homes. You hire 48 workers to do the construction work. And you must buy natural resources --- land, wood, nails, plasterboard, and so forth.

This is a reasonable description of a construction company. Let us examine the costs. The **explicit costs** are those paid to factors owned by people outside of the company. **One large explicit cost is the cost of hiring the workers.** Let us assume that each of the 48 workers is paid \$20,000 per year by your company, making the labor cost of your company equal to \$960,000 (48 times \$20,000). (Construction workers may work for several different companies in a year.) **A second explicit cost is the cost of the natural resources.** Assume that your company will build seven homes and that each requires \$20,000 worth of land, wood, nails, plasterboard, and so forth. The natural resource cost is therefore \$140,000 (7 times \$20,000). **The third explicit cost is the interest that must be paid to the bank.** Assume that the bank charges 6% interest. The interest cost is \$138,000 (6% of \$2,300,000). The **total explicit cost** equals \$1,238,000 (\$960,000 + \$140,000 + \$138,000).

Besides the explicit cost, we must consider the **implicit cost** --- the opportunity costs of the owner. There are two implicit costs. **One involves the wages lost by leaving your former job --- \$40,000.** **The other involves the interest lost on the savings account.** Notice that you have not sacrificed the \$40,000; you have sacrificed the interest that could have been earned if you had kept the money in the savings account. (The \$40,000 is still there; it is in the form of ownership of the business instead of in the form of a savings account.) Let us assume that this money could have been earning 5% interest. The lost interest is therefore \$2,000 (5% of \$40,000) and the **total implicit cost** equals \$42,000 (\$40,000 + \$2,000).

Based on these numbers, we say that the **total economic cost** of your construction company for a year is \$1,280,000 (\$1,238,000 explicit cost plus \$42,000 implicit cost). If we assume that you sell 7 homes during the year at a price of \$200,000 per home, your company would receive a **total revenue** of \$1,400,000 (\$200,000 times 7). We would say that your **economic profit** is \$120,000 (\$1,400,000 minus \$1,280,000). ***This means that you, as the owner, earned an income equal to the amount that could have been earned in the next best alternative (\$42,000***

from keeping your old job and keeping your money in the savings account) plus an additional \$120,000. Starting your construction company turned out to be a good move for you.

If the price had been \$160,000 per home, the total revenue received would have been \$1,120,000 (\$160,000 times 7). The economic profit would have been - \$160,000 (\$1,120,000 - \$1,280,000). We would say that there was an **economic loss** of \$160,000. *This means that you, as the owner, earned \$160,000 less than could have been earned by keeping your old job and keeping the \$40,000 in the savings account.*

Summary:

Explicit Costs:

Workers	\$960,000	
Natural Resources	140,000	
Interest on the Bank Loan	138,000	\$1,238,000

Implicit Costs:

Foregone Wages	40,000	
Foregone Interest	2,000	42,000

Total Economic Cost \$1,280,000

Total Revenues = Price x Quantity = \$200,000 x 7 = \$1,400,000

Economics Profits = Total Revenues - Total Economic Cost
 = \$1,400,000 - \$1,280,000
 = \$120,000

Test Your Understanding

Let us consider an orange grove. When the grove began in the 1950s, the orange trees were planted. Today, you have purchased the grove. The trees must be watered and fertilized. You have drip irrigation on timers to take care of the watering. You hire workers to do the fertilizing. Workers also keep the area clear of competing vegetation, using a small tractor. Herbicides may be applied by the workers. Workers also remove trees that have died and plant new ones from seedlings. The main chore for the workers is the picking of the oranges and the hauling of them to the processor. There are some buildings needed to keep the tractor and other equipment.

Let us examine the costs. Let us assume that we hire six full-time workers (or the equivalent). Each is paid \$12,000 per year (\$1,000 per month), making the labor cost equal \$72,000. The company has buildings. It has machinery, such as the tractor, the trucks, saws, shovels, and so forth, as well as buildings. Our measure of cost here is the part of the building and machines used up during the year (called depreciation). Let us assume that the cost of all of this capital for the year is \$16,000. Let us assume that the owner paid \$400,000 for the grove and the capital; this money could have been earning 5% interest. We shall assume here that owner does not work in this business.

The **explicit costs** of owning the orange grove are \$_____.

The **implicit costs** of owning the orange grove are \$_____.

The **total economic cost** of owning the orange grove is \$_____.

If we assume that we sell 180,000 pounds of oranges during the year at a price of \$0.60 per pound, the grove would receive a total revenue of \$108,000. We would say that the **economic profit** is equal to \$_____. What does this mean?

If the price had been \$0.70 per pound, the revenue received would have been \$126,000. The economic profit would have been \$_____. What does this mean?

2. The Production Function

Most of the basic principles in Microeconomics are based on the work of **Alfred Marshall** (1842-1924), whose main text was published in 1890. Marshall differentiated between the short-run and the long-run. *The short-run is defined as a period of time in which at least one factor of production (usually capital or land) is fixed. This means that a business exists in its present form and plans to continue in this manner.* It is not planning to expand or contract. There are no new companies in the industry. And it is not planning to go out of business. Since this is indeed the situation that faces most businesses in most decisions, we will begin with it.

In the short-run, some factors of production are fixed. They are fixed because the quantity of them does not change as a result of changing the quantity of the product produced (the number of homes produced per year). We will assume that the capital goods are fixed. *The other factors of production are called the variable factors of production because their quantities will change if the quantity of the product (the number of homes produced per year) changes.* We will assume that the natural resources and the labor are variable. If the company produces more homes, it will hire more workers and buy more wood, but will not change the size of the office building, the warehouse, or the amount of machinery.

Test Your Understanding

1. Go back to the case of the orange grove above.

The **variable costs** of owning the orange grove are \$_____.

The **fixed costs** of owning the orange grove are \$_____.

To answer this question, determine which factors of production are fixed (their quantity will not change if more oranges are produced) and which factors of production are variable (their quantity will change if the quantity of oranges produced changes). How much did each cost?

2. Consider the following expenses of owning and operating an automobile:

Purchase Price of the Automobile \$20,000 (The automobile is expected to last for five years.

After five years, the automobile will be traded in on a new one. The trade-in value is expected to be \$5,000.)

Car Insurance \$ 1,400

Car Registration \$ 200

Gasoline (You expect to drive 20,000 miles per year. Your automobile gets 25 miles per gallon on average. Gasoline costs \$1.60 per gallon.)

Oil Changes and Routine Maintenance (These cost you \$30 per oil change. You have your oil changed every 3,000 miles.)

Tires (You will need new tires every 40,000 miles. A set of four tires will cost you \$300.)

Other Maintenance (You will have a major service every 10,000 miles. At 10,000, 20,000, 40,000, 50,000, 70,000, 80,000, and 100,000 miles, the service would cost you \$250. At 30,000, 60,000, and 90,000 miles, the service would cost you \$500.)

A. For each of the five years you will own the automobile, what is the **Total Fixed Cost**? Show calculations.

B. For each of the five years you will own the automobile, what is the **Total Variable Cost**? Show calculations.

C. What are other costs of owning and operating an automobile that have not been listed above? Especially consider the **non-monetary costs** of driving. Are these costs **fixed or variable**? Explain why. (Hint: remember the definition of “opportunity cost”.)

D. If you do own the automobile for five years, you will drive 100,000 miles (20,000 miles times five years). On average, what would it cost you to drive each mile?

To simplify our analysis, let us focus only on the labor. The table below describes the relation between the number of homes produced per year and the number of workers hired. (Assume at this point that all homes are the same.) This relation is known as *a production function*.

<u>Number of Workers</u>	<u>Number of Homes</u>
0	0
7	1
13	2
18	3
24	4
31	5
39	6
48	7
58	8
69	9
81	10
94	11
108	12
123	13
139	14

Using this production function, we focus on what is called the marginal physical product. *The marginal physical product is the change in quantity produced when the number of workers is increased by one.* The calculations are:

<u>Number of Workers</u>	<u>Marginal Physical Product</u>
7	.14
13	.16
18	.20
24	.16
31	.14
39	.12
48	.11
58	.10
69	.09
81	.08
94	.077
108	.071
123	.067
139	.063

The marginal physical product is the change in the number of homes due to a given change in the number of workers. So the first number is 1 divided by 7, the second number is 1 divided by 6 (the change in the number of workers from 7 to 13), the third number is 1 divided by 5 (the change in the number of workers from 13 to 18), and so on.

Focus on these marginal physical product numbers. Notice first, that through the first

eighteen workers, they rise. We call this *increasing marginal returns*. It takes seven workers to build the first home but only an additional six (from 7 to 13) to build the second home. Why would this be so? When more workers are added, the tasks will be divided (we call this *division of labor*). Each person will *specialize*. Specialization confers several advantages. First, one performs better if one does only the tasks that one can do well. Second, doing a task repeatedly gives one the necessary skills and experience to be able to conceive of ways of improving performance. And third, less time is wasted moving between tasks. A worker will do a job on one of the houses and then be able to do the same job on the other house. Less time will be spent merely waiting for the other workers to complete their tasks. In addition, workers will be able to form into **teams** that may increase their productivity.

Notice secondly that, **after worker 18, the marginal physical product falls**. This is known as *diminishing marginal returns*. Why does this occur? **The problem here is the fixed factor of production (the capital or the land)**. There is only so much land and only so many machines. With a limited amount of land, additional workers must work on poorer quality land (perhaps on hillsides), making it harder to increase production. The limited amount of machinery means that workers may have to wait for others to finish using a machine before using it. This would lead to time not spent producing. And there are only so many ways to divide up the tasks. *The phenomenon described here is called the law of diminishing returns. Basically, it says that, if one factor of production is fixed (the capital or the land), then as more of the variable factor of production (labor) is added, beyond some point (four workers), the marginal physical product (addition to production) falls.* Notice that it is the **addition to production** that diminishes; the total production of homes is still increasing. The word “return” can be misleading; **notice that we are referring to production, not costs, revenues, or profits.**

Eventually the total production itself will fall (or we can say that the marginal physical product is negative). This is known as *negative marginal returns*. There are now so many workers that they are getting in each other’s way. Obviously, it would never be rational to hire this many workers. Negative marginal returns are not shown in the above calculation.

3. Using the Production Function to Derive the Marginal Cost of Production

What does this tell us about costs of production? To answer this, let us temporarily ignore the cost of the capital and the opportunity costs of the owner and focus only on the costs of the natural resources and the hired labor. As noted above, assume that each worker is paid \$20,000 per year by the company and that each house requires \$20,000 worth of land, wood, plasterboard, and other natural resources. Remember that we must consider our decisions marginally. **What is the marginal cost for the first house?** Ignoring the other costs for now, the first home requires the hiring of seven workers. These workers are paid \$20,000 each (\$140,000). This cost, plus the \$20,000 in natural resources, makes the marginal cost of the first house \$160,000. **What is the marginal cost of the second house?** These require the hiring of six additional workers. Since each is paid \$20,000 (\$120,000 in total) and the natural resources of the second house cost an additional \$20,000, the marginal cost of the second house is \$140,000. **What is the marginal cost of the third house?** This requires the hiring of five additional workers. With each worker paid \$20,000 (\$100,000 in total) and the additional \$20,000 in costs of natural resources, the marginal cost of the third house is \$120,000. *The basic principle here is: when the marginal physical product is rising, the marginal cost is falling.*

This occurs because each new worker hired receives the same wage but adds more and more to production (not because the new worker is better, but because of specialization). **What is the marginal cost of the fourth house?** This requires the hiring six additional workers. With each worker paid \$20,000 (\$120,000 in total) and an additional \$20,000 in cost of natural resources, the marginal cost of the fourth house is \$140,000. Continue this calculation for the fifth house. And so on. *The principle here is: as the marginal physical product is falling, the marginal cost is rising.* This occurs because each worker is paid the same \$20,000 per year but adds less and less to production (not because they are inferior workers, but because of the problems caused by the limited amount of capital). *Thus, the law of diminishing marginal returns causes marginal cost to increase as more homes are produced. The marginal cost is calculated as follows.*

<u>Quantity</u>	<u>Labor Cost</u>	<u>Natural Resource Cost</u>	<u>Total Variable Cost</u>	<u>Marginal Cost</u>
1	\$140,000	\$20,000	\$160,000	\$160,000
2	260,000	40,000	300,000	140,000
3	360,000	60,000	420,000	120,000
4	480,000	80,000	560,000	140,000
5	620,000	100,000	720,000	160,000
6	780,000	120,000	900,000	180,000
7	960,000	140,000	1,100,000	200,000
8	1,160,000	160,000	1,320,000	220,000
9	1,380,000	180,000	1,560,000	240,000
10	1,620,000	200,000	1,820,000	260,000
11	1,880,000	220,000	2,100,000	280,000
12	2,160,000	240,000	2,400,000	300,000
13	2,460,000	260,000	2,720,000	320,000
14	2,780,000	280,000	3,060,000	340,000

Notice that as the marginal physical product is rising (falling), the marginal cost is falling (rising). The marginal physical product is at its highest at the same point (18 workers) that the marginal cost curve is at its lowest (3 homes). *The principle of rising marginal costs is essential to our analysis of company behavior in the short-run. It is based on the law of diminishing marginal returns.*

Test Your Understanding

Assume again that you are the owner of an orange grove. The orange grove has its land, buildings, and machinery. These are the fixed factors of production. Let us focus on only one of the variable factors of production: labor. The following table describes the relation between the number of pounds of oranges sold per year and the number of workers hired. Assume that all oranges are the same. This relation is the **production function**.

<u>Number of Workers</u>	<u>Number of Pounds Per Year</u>
0	0
1	10,000
2	40,000
3	90,000
4	130,000
5	160,000
6	180,000
7	192,000
8	198,000
9	200,000
10	200,000
11	190,000

In the table below, calculate the marginal physical product

Number of Workers	Marginal Physical Product
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	

- B. Using the table, up to how many pounds of oranges are there **increasing marginal returns**? Think of the example of an orange grove. Give some **reasons** why there might be increasing marginal returns.
- C. Using the table, show where there are **diminishing marginal returns**. Think of the example of an orange grove. Give some **reasons** why there might be diminishing marginal returns.
- D. Ignore the cost of the capital, the cost of the natural resources, and the opportunity costs of the owner and focus only on the cost of the hired labor. Assume that each worker is paid \$12,000 per year (\$1,000 per month). What is the marginal cost for the first 10,000 pounds of oranges per year? Ignoring the other costs for now, the first 10,000 pounds require the hiring of one worker. That worker is paid \$12,000. Thus, each pound costs \$1.20 worth of labor to produce (\$12,000 divided by 10,000). The total variable cost is calculated as \$12,000 times the number of workers. The marginal cost was the change in the total cost from producing one additional pound of oranges. What is the marginal cost of the next 30,000 pounds of oranges? And so on. Use this to fill in the following table:

Workers	Quantity of Oranges	Total Variable Cost	Marginal Cost
1	10,000	\$12,000	\$1.20
2	40,000	24,000	
3	90,000	36,000	
4	130,000	48,000	
5	160,000	60,000	
6	180,000	72,000	
7	192,000	84,000	
8	198,000	96,000	
9	200,000	108,000	
10	200,000	120,000	

- E. Examine your two tables. When the marginal physical product is rising, the marginal cost is _____ . And when the marginal physical product is falling, the marginal cost is _____ .

Practice Quiz for Classes 7 and 8

- You are considering opening a restaurant. You estimate that the annual cost of labor will be \$50,000, interest on borrowed funds will be \$20,000, and food other supplies will cost \$60,000. Owner-supplied resources include a building that is currently renting for \$100,000 per year and \$30,000 in cash that is currently earning a 10% rate of interest. Your **economic cost** equals:
 - \$103,000
 - \$130,000
 - \$233,000
 - \$260,000
- Using the numbers in question 1, the part of the total cost that is **implicit cost** is:
 - \$103,000
 - \$110,000
 - \$130,000
 - 233,000
- Using the numbers in question 1, the part of the total cost that is **fixed cost** is:
 - \$103,000
 - \$110,000
 - \$123,000
 - \$233,000
- The period of time during which one factor of production is fixed (usually the capital goods) is called the
 - short-run
 - long-run
 - medium run
 - fixed run
- The **law of diminishing (marginal) returns** states that as more of a variable factor (such as labor) is added to a certain amount of a fixed factor (such as capital), beyond some point:
 - Total physical product begins to fall
 - The marginal physical product falls
 - The marginal physical product rises
 - The average physical product falls
- Why is the law of diminishing marginal returns true?
 - specialization and division of labor
 - limited capital
 - spreading the average fixed cost
 - all factors being variable in the long-run
- When the marginal physical product is falling, the marginal cost must be
 - falling
 - rising
 - staying the same

Answers: 1. C 2. A 3. C 4. A 5. C 6. C 7. B