

How to Study for Chapter 14 Costs of Production

(This Chapter will take two class periods to complete.)

Chapter 14 introduces 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. Go over the graphs very carefully. They will be important throughout the remainder of the course. Be sure you can explain in your own words why each graph has the shape it has. Also, 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 Chapter 14.

Objectives for Chapter 14 Costs of Production

At the end of Chapter 14, 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. Define and calculate **"average fixed cost"** **"average variable cost"** **"average total cost"**.
10. Given a set of numbers, calculate each of the following: the average variable cost, the average fixed cost, the average total cost, and the marginal cost. Then, draw each on a graph.
11. For each of the four graphs drawn in question 11, **explain why** it has the shape that it does
12. What is the relation between the marginal cost and the average total cost? What is the relation between the marginal cost and the average variable cost? In each case, **explain why**.

Chapter 14 Costs Of Production (latest revision June 2004)

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 economic costs*. We will begin our analysis by examining the total economic costs. We shall do this because the **principles affecting costs of production do not depend on the type of industry a business is in**. The principles we develop in this chapter and Chapter 15 are the same if we are analyzing a restaurant, an electricity company, a farm, a college, or any other type of business. 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, 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** therefore equals \$1,238,000 (\$960,000 + \$140,000 + \$138,000).

Besides the explicit cost, we must consider the *implicit costs* --- 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 that you had in your savings account. You still own the \$40,000. But now it is in the form of a business you own. But you have sacrificed the interest that could have been earned if you had kept the money in the 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 **total revenue** of \$1,400,000 (\$200,000 times 7). Remember from Chapter 4 that **total revenue is the money you bring in by selling your homes**. We would say that your **economic profit** is \$120,000 (\$1,400,000 minus \$1,280,000). **Economic profit is the difference between total revenues and total economic costs**. This economic profit of \$120,000 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 job and keeping your \$40,000 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

$$\text{Total Revenues} = \text{Price} \times \text{Quantity} = \$200,000 \times 7 \text{ Homes} = \$1,400,000$$

$$\begin{aligned} \text{Economics Profits} &= \text{Total Revenues} - \text{Total Economic Cost} \\ &= \$1,400,000 - \$1,280,000 = \$120,000 \end{aligned}$$

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?

Fixed and Variable Factors of Production

Many 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 the 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. *In the **long-run, there are no fixed factors of production. All factors of production are variable.*** This means that in the long-run, new companies can enter an industry, existing companies can go out of business permanently, companies can expand their capital, companies can contract their capital, and so forth. The words “short-run” and “long-run” do not refer to a specific period of time. Since the short-run is the situation that faces most businesses in most decisions, we will begin with it.

In the short-run, some factors of production are fixed. Being fixed means that the quantity of the factor of production does not change as direct a result of changing the quantity of the product produced (the number of homes produced per year). We shall assume that the capital goods are fixed. If we produces more homes, we will not have more capital goods to use. *The other factors of production are called the variable factors of production because their quantities do change if the quantity of the product (the number of homes produced per year) changes.* We shall 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. 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 \$1.80 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.)

- For each of the five years you will own the automobile, what is the **Total Fixed Cost**? Show calculations.
- For each of the five years you will own the automobile, what is the **Total Variable Cost**? Show calculations.
- What are some other costs of owning and operating an automobile other than those 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”.)
- 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?

The Production Function

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:

Number of Workers	Marginal Physical Product
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. Since it takes 7 workers to build one home, the additional production of each of those seven workers is $1/7$ of a home (.14). And since it takes 6 additional workers (from 7 to 13) to produce the second home, the additional production from each of those six workers is $1/6$ (.16) of a home. Stop here. See if you can explain what each of the other numbers means and how each was derived.

Increasing Marginal Returns

Now, focus on these marginal physical product numbers. Notice first, that through the first eighteen workers, they rise (.14, .16, .2). 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 on which one has a comparative advantage** (review the concept of comparative advantage). With more workers, the carpenters can specialize in carpentry, the plumbers can specialize in plumbing, and so forth. The company cannot have this specialization if it can only afford to hire a few workers. **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.

The Law of Diminishing Marginal Returns

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 marginal returns. Basically, the law 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 (18 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; nothing has been said yet about cost, revenues, or profits.**

Negative Marginal Returns

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.

Using the Production Function to Derive the Marginal Cost

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 (one at a time). *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?* This house requires the hiring of six additional workers (workers 8 to 13). Since each is paid \$20,000 (\$120,000 in total) and the natural resources of the second house still 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 (workers 14 to 18). 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. Notice that *when the marginal physical product (addition to production) is rising, the marginal cost (addition to cost) is falling.* This occurs because each new worker hired receives the same wage as the others. But each new worker adds more and more to production (not because the new worker is better, but because of specialization). So in effect, the company is paying the same wage to each worker but getting more additional production for its money.

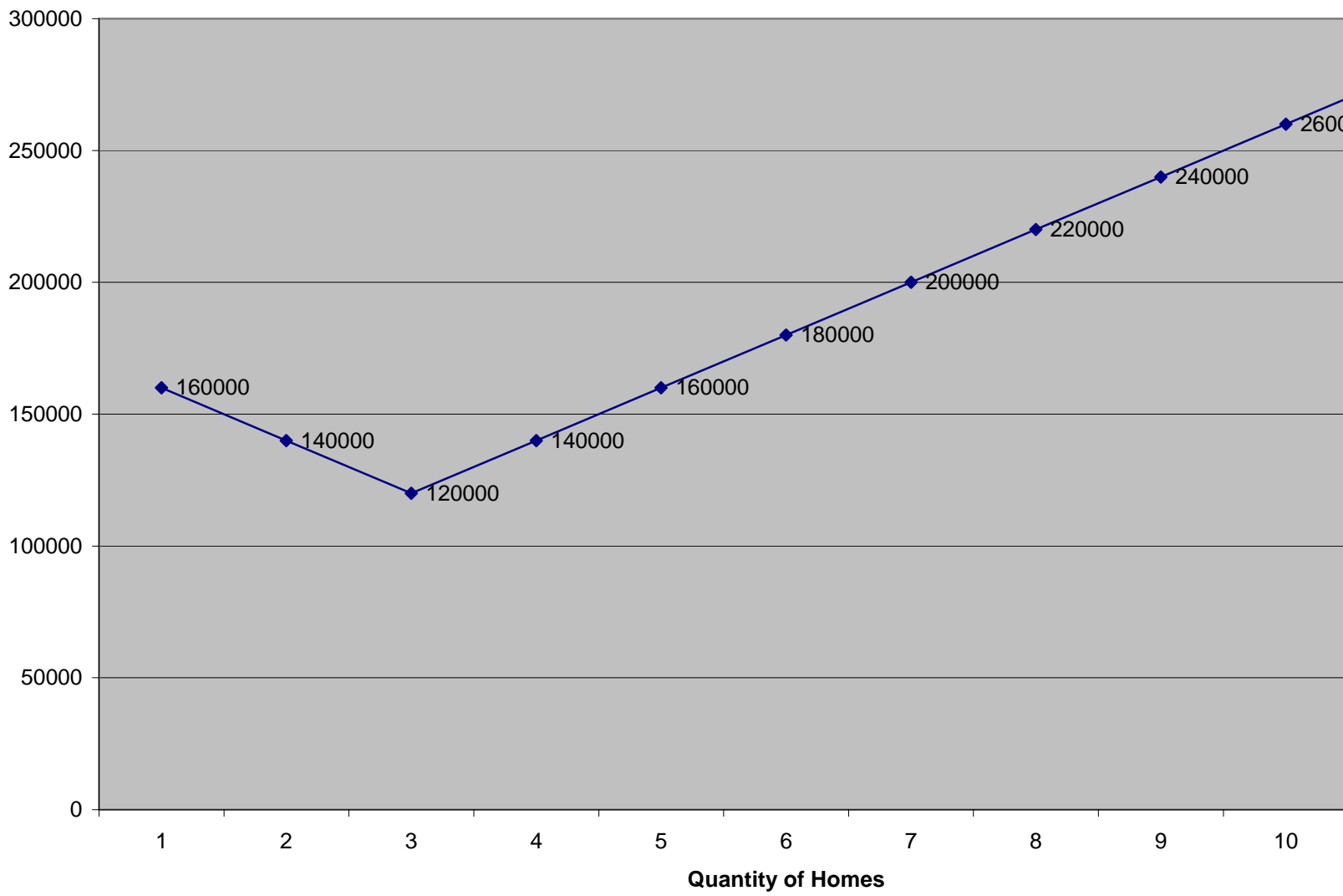
What is the marginal cost of the fourth house? This requires the hiring six additional workers (workers 19 to 24). With each worker paid \$20,000 (\$120,000 in total) and an additional \$20,000 in cost of natural resources, the marginal cost of the fourth house is \$140,000. Continue this calculation for the other houses. Notice that *as the marginal physical product*

(addition to production) is falling, the marginal cost (addition to 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). In effect, the company is paying the same wage to each worker but getting less additional production for its money. *Therefore, the law of diminishing marginal returns causes marginal cost to increase as more homes are produced.* The marginal cost is calculated in the following table.

<u>Quantity</u>	<u>Labor Cost</u>	<u>Natural Resource Cost</u>	<u>Total Variable Cost</u>	<u>Marginal Cost</u>
0	0	0	0	
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

Marginal cost is depicted in the graph on the next page. *Notice that as the marginal physical product is rising (falling), the marginal cost is falling (rising).* The principle of increasing marginal cost is essential to our analysis of company behavior in the short-run. It is based on the law of diminishing marginal returns.

Marginal Cost



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**. Notice that this production function is different from the one in the text. The one in the text tells us how many workers are needed to build one home. This production function tells us how much one worker can produce.

<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, show where there 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 _____ . Finally, graph the marginal cost on the graph paper on Page 23.

Other Cost Relations

Average Variable Cost

While the marginal cost is very important, we are also concerned with averages. First, we shall consider *the average variable cost*. **Remember that the variable cost is any cost that changes specifically because there is a change in the quantity of the product produced.** These are usually the costs of the labor and natural resources. *The average variable cost is the variable cost (i.e., cost of labor and natural resources) per house.*

$$\text{Average Variable Cost} = \frac{\text{Total Variable Cost}}{\text{Quantity of Houses}}$$

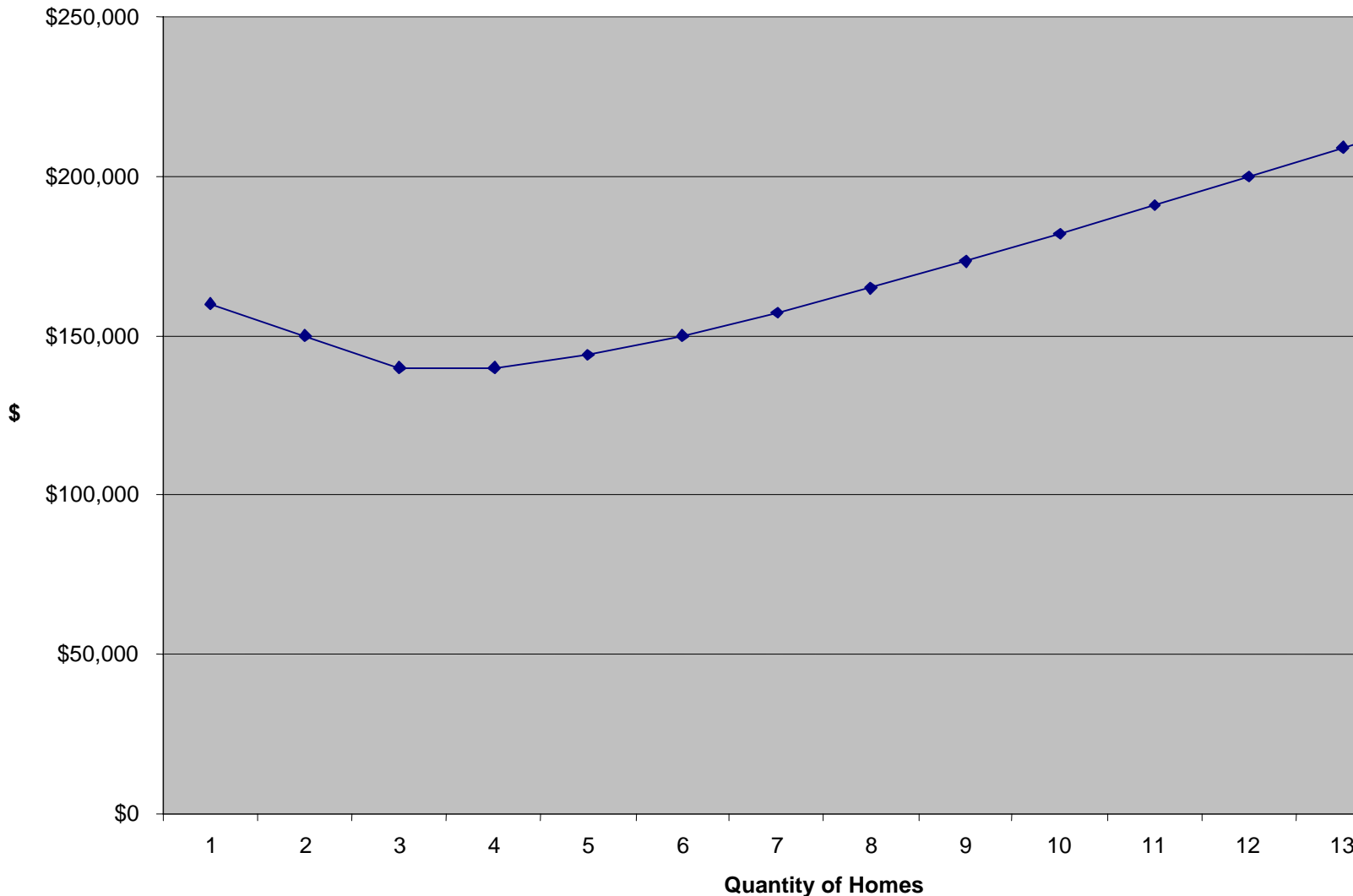
From the numbers on Page 8, we can calculate the average variable cost. For one home, the average variable cost is \$160,000 (\$160,000 divided by 1). For two homes, the average variable cost is \$150,000 (\$300,000 divided by 2). For 3 homes the average variable cost is \$140,000 (\$420,000 divided by 3). And so on.

Quantity	Total Variable Cost	Average Variable Cost
0	0	
1	\$160,000	\$160,000
2	300,000	150,000 (\$300,000 divided by 2)
3	420,000	140,000 (\$420,000 divided by 3)
4	560,000	140,000 (\$560,000 divided by 4)
5	720,000	144,000 (\$720,000 divided by 5)
6	900,000	150,000 (\$900,000 divided by 6)
7	1,100,000	157,143 (\$1,100,000 divided by 7)
8	1,320,000	165,000 (\$1,320,000 divided by 8)
9	1,560,000	173,333 (\$1,560,000 divided by 9)
10	1,820,000	182,000 (\$1,820,000 divided by 10)

To interpret these numbers, we can say that, **if 10 homes are produced, there will be \$182,000**

worth of labor and natural resources in the cost of each home. We can picture this in the graph on the next page. Notice that the average variable cost declines up to 3 houses. After that, it levels out and then begins to rise. **If we smooth it out, it generally has a U - shape.**

Average Variable Cost



First, why does average variable cost decline? The answer was explained earlier. As we produce more, we will hire more workers. With more workers, we can afford to reap the benefits of division of labor and specialization. Each additional worker adds more and more to production but receives the same wage. ***Second, why does the average variable cost stop falling and then begin to rise?*** The reason, also explained earlier, has to do with the **fixed amount of capital goods or land**. Given the amount of land and capital, the workers will become progressively less efficient as more are hired. However, there may be other reasons for the increasing average variable cost. **One additional reason may be that the most recently hired**

workers are simply not as good as the ones we chose first. Worker one may have already had years of experience whereas worker 100 may have never worked in this industry before. **A second additional reason concerns monitoring costs.** Workers have an incentive to shirk on the job. If there are few workers hired, peer pressure can be used to force each worker to do his or her job. But when the number of workers is large, it is easier for a worker to get away with shirking. The shirking itself will make the workers less efficient. And preventing the shirking will require **the hiring of supervisors**, who will add to costs. **A third additional reason involves the costs of coordination: as more and more workers are hired, it may become more costly to coordinate their activities.** More and more paperwork may be required. **A fourth additional reason involves teamwork.** How well the workers perform often depends on how well they blend as a "team". It is sometimes harder for a large group of workers to blend as a team than it is for a small group of workers.

Test Your Knowledge

1. If the company produced 10 homes, the average variable cost is \$182,000. Explain in your own words what this means.
2. Explain why the average variable cost falls as the company builds more homes.
3. Explain why the average variable cost rises as the company builds more than three homes.

Test Your Understanding

1. Go back to the case of the orange grove on Page 11. Use the total variable cost to **calculate the average variable cost**. Then, plot the numbers on a **graph**. Use the graph paper found on Page 23.

Quantity of Oranges	Total Variable Cost	Average Variable Cost
10,000	\$12,000	
40,000	24,000	
90,000	36,000	
130,000	48,000	
160,000	60,000	
180,000	72,000	
192,000	84,000	
198,000	96,000	
200,000	108,000	

Explain why the average variable cost **decreases** in the case of the orange grove. Then, **explain why** the average variable cost **increases** in the case of the orange grove.

Average Fixed Cost

Up to now, we have considered only the variable costs. But we must also consider the fixed costs. Remember that **the fixed cost is that part of the total cost that does not change because the quantity produced changes.** The fixed costs are generally the costs of the capital and the implicit costs. Earlier, the total fixed cost for this construction company was calculated to be \$180,000 per year --- the interest that must be paid to the bank (\$138,000) and the implicit costs (\$42,000). *We can calculate the average fixed cost as the total fixed cost per house:*

$$\text{Average Fixed Cost} = \frac{\text{Total Fixed Cost}}{\text{Quantity of Houses}}$$

This represents the cost of the capital plus the implicit costs that go into producing each house and is calculated as follows:

Quantity of Homes	Total Fixed Cost	Average Fixed Cost
0	\$180,000	
1	180,000	\$180,000
2	180,000	90,000 (\$180,000 divided by 2)
3	180,000	60,000 (\$180,000 divided by 3)
4	180,000	45,000 (\$180,000 divided by 4)
5	180,000	36,000 (\$180,000 divided by 5)
6	180,000	30,000 (\$180,000 divided by 6)
7	180,000	25,714 (\$180,000 divided by 7)
8	180,000	22,500 (\$180,000 divided by 8)
9	180,000	20,000 (\$180,000 divided by 9)
10	180,000	18,000 (\$180,000 divided by 10)

We would interpret these numbers by saying that, if 10 homes are produced, there would be \$18,000 worth of capital and implicit cost that went into the cost of producing each of those homes. We can graph this as shown on the next page.

Average Fixed Cost



There are two points to notice about average fixed costs. **First, as quantity produced increases, the average fixed cost is always falling.** This is commonly named "*spreading the fixed cost*". The average fixed cost can never become horizontal and it can never equal zero. **Second, as quantity produced increases, the average fixed costs drops rapidly at first. But as quantity produced continues to increase, the decline in average fixed cost becomes smaller and smaller (the graph becomes flatter and flatter)**

Think of the class you are in. Most of the costs of producing the class are fixed. The building will be there no matter how many students there are. The teacher will get the same salary no matter how many students there are. Considering all of the costs of providing this class, it will be much cheaper per student if there are 100 students in the room than if there are only 10. The fixed costs will be spread over 100 students instead of 10. This, of course, is the reason that small classes are commonly canceled.

Test Your Knowledge

If 10 homers are produced, the average fixed cost is \$18,000. Explain in your own words what this means.

Test Your Understanding

In the orange grove case above, the total fixed cost was \$36,000 per year. **Calculate the average fixed cost** in the following table and plot the numbers on a **graph**. Use the graph paper found on Page 23.

Quantity of Oranges	Total Fixed Cost	Average Fixed Cost
10,000	\$36,000	
40,000	36,000	
90,000	36,000	
130,000	36,000	
160,000	36,000	
180,000	36,000	
192,000	36,000	
198,000	36,000	
200,000	36,000	

Average Total Cost

Now we are ready to examine *the average total cost --- the cost of producing each house. The average cost is simply the sum of the average variable cost and the average fixed cost. Alternatively, it is the total cost per unit (cost per house).*

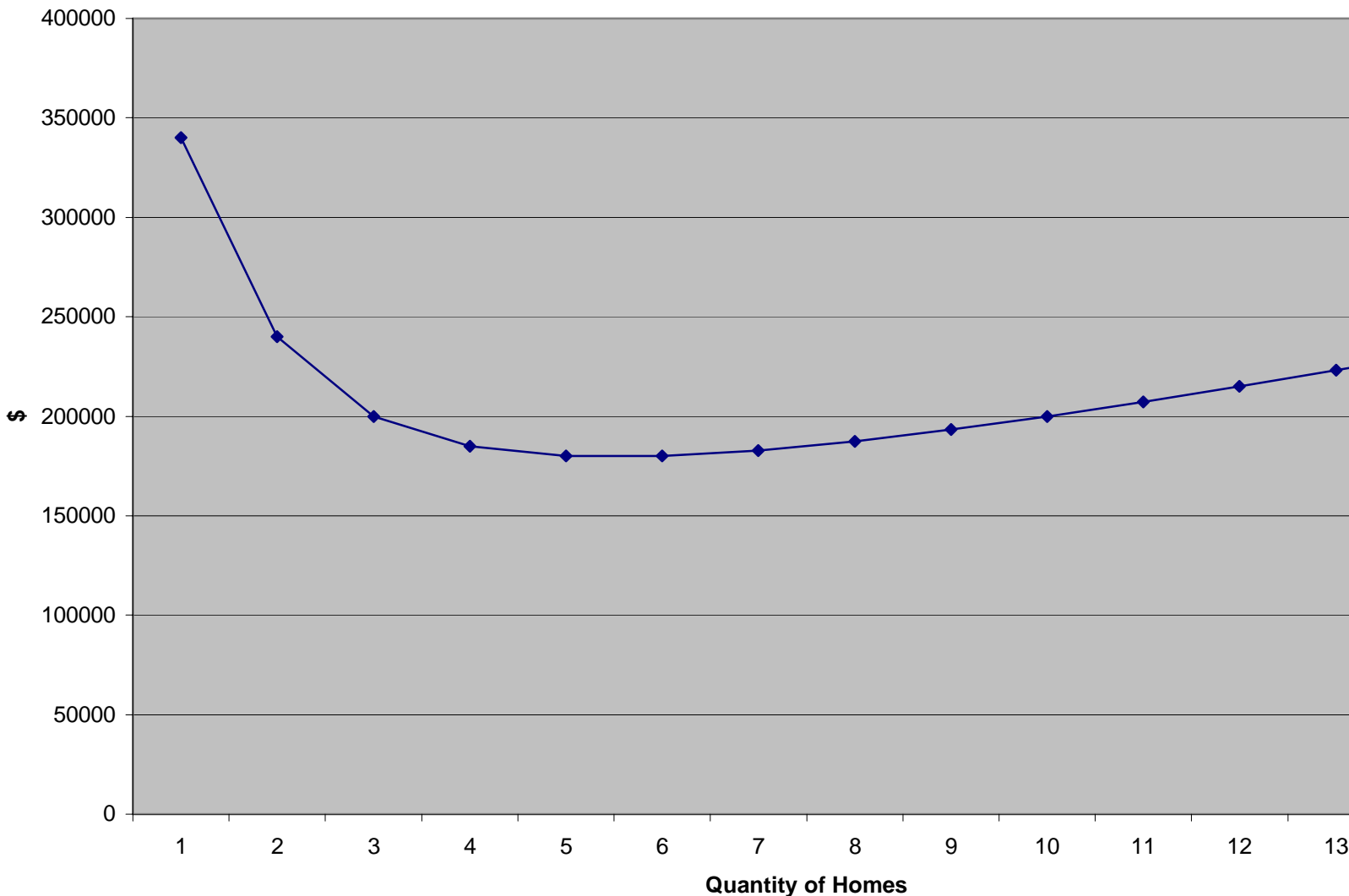
$$\text{Average Total Cost} = \frac{\text{Total Cost}}{\text{Quantity}}$$

We can calculate the average total cost as follows:

Quantity of Houses	Total Cost	Average Total Cost
0	180,000	
1	340,000	\$340,000
2	480,000	240,000 (\$480,000 divided by 2)
3	600,000	200,000 (\$600,000 divided by 3)
4	740,000	185,000 (\$740,000 divided by 4)
5	900,000	180,000 (\$900,000 divided by 5)
6	1,080,000	180,000 (\$1,080,000 divided by 6)
7	1,280,000	182,857 (\$1,280,000 divided by 7)
8	1,500,000	187,500 (\$1,500,000 divided by 8)
9	1,740,000	193,333 (\$1,740,000 divided by 9)
10	2,000,000	200,000 (\$2,000,000 divided by 10)

We interpret this as saying that, if 5 houses are produced, it will cost the company \$180,000 to produce each house (\$900,000 divided by 5). Of this, \$144,000 is the cost of the labor and natural resources and \$36,000 is the cost of the capital and the implicit costs. If 10 houses are produced, it will cost the company \$200,000 to produce each house (\$2,000,000 divided by 10). Of this, \$182,000 is the cost of the labor and the natural resources while \$18,000 is the cost of the capital (interest) and the implicit costs. We can graph this.

Average Total Cost



Notice that average total cost has a U - shape. It declines up to 6 houses. The decline in the average total cost is the result of the decline in the average variable cost up to 4 houses --- for the reasons given above --- and the decline in the average fixed cost. Beyond 4 houses, the average variable cost rises; however, the average fixed cost is still falling, and this is bringing the cost per house down. After 6 houses, the average total cost begins to rise. The average fixed cost is still falling; however, the decline in it is becoming smaller and smaller. This decline is more than offset by the rise in the average variable cost, which occurs for the reasons given.

Test Your Understanding.

When you buy cereal (or other boxed products), why is the 32 ounce box cheaper per ounce than the 16 oz box? This is falling average total cost. Use the principles above to explain the phenomenon.

Test Your Knowledge

1. If the company produces 10 houses, the average total cost is \$200,000. Explain in your own words what this means. Then, how much labor cost, how much natural resource cost, and how much capital cost is there in building each house?
2. As the company builds houses (up to 6), the average total cost falls. Explain why (two reasons).
3. As the company builds more than 6 houses, the average total cost rises. Explain why (two reasons)

Test Your Understanding

In the orange grove case, the total cost is calculated by adding the total variable cost (Page 13) and the total fixed cost (Page 16). Calculate the **average total cost** from the following table and then plot the points on a **graph**. Use the graph paper found on Page 23.

Quantity of Oranges Per Year	Total Cost	Average Total Cost
10,000	\$48,000	
40,000	60,000	
90,000	72,000	
130,000	84,000	
160,000	96,000	
180,000	108,000	
192,000	120,000	
198,000	132,000	
200,000	144,000	

Notice that average total cost has a U - shape. First, **explain why it declines** up to 180,000 pounds per year. Then, **explain why it rises** after 180,000 pounds per year.

The Cost Curves

We can now plot all four of our graphs together. This is shown on the graph on the next page. When you plot the three "averages", note that ***the average total cost is above the average variable cost and the average fixed cost.*** This occurs, of course, because it is the sum of the two.

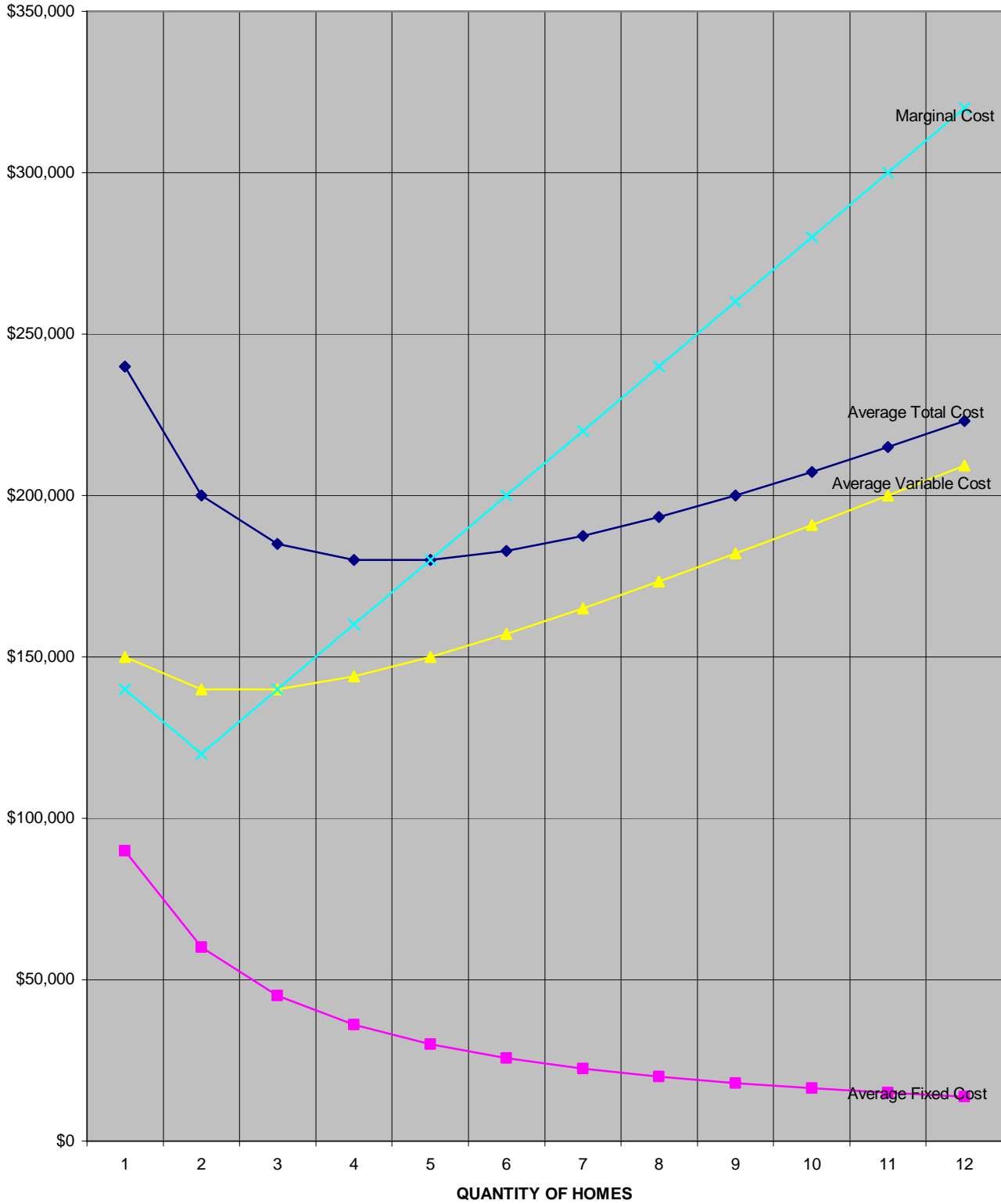
Of particular importance is the relation between the marginal cost and the average total cost (or average variable cost). This is part of a general relationship between marginal and average. To illustrate this relationship, think of the height of the people in the class. We measure everyone's height and calculate that the average height is 5'6". Then, a person comes late to class (the marginal person). We re-calculate and the average is now 5'5". Who came in late? Obviously, it would have to be someone very short. ***When the average is falling, the marginal***

must be below the average in order to pull the average down. Notice that we did not say whether the marginal is rising or falling --- simply that it is below the average. Now assume that a person comes late to class (the marginal person); when we re-calculate, the average height is now 5'7". Who came in late? Obviously, it would have to be someone very tall --- an NBA player. ***When the average is rising, the marginal must be above the average in order to pull the average up.*** Finally, assume that a person comes late to class (the marginal person); when we re-calculate, the average height is still 5'6". Who came in late? The answer, of course, is a person 5'6" tall. ***When the average is neither rising nor falling (at its minimum or maximum point), the marginal and the average are equal.*** Notice the graph: the marginal cost is below the average variable cost and the average total cost where they are falling. The marginal cost is above the average variable cost and the average total cost where they are rising. ***And the marginal cost crosses the average variable cost and the average cost at their minimum points.***

Test Your Understanding

In this chapter, you calculated the average variable cost, the average fixed cost, the average total cost, and the marginal cost for the orange grove. **Draw the four graphs** on one piece of graph paper (found at the end of this chapter). Use the graph paper found on Page 23.

COST CURVES



Test Your Understanding

1. In the number set above, when the fourth house was produced, the marginal cost rose but the average variable cost stayed the same. How do you explain this?
2. Explain why there is no relation between the marginal cost and the average fixed cost.
3. In this chapter, you calculated the average variable cost, the average fixed cost, the average total cost, and the marginal cost for the orange grove. You also drew all four graphs. Compare your calculations with those in the text. When the average variable cost is falling, the marginal cost is _____ the average variable cost. When the average variable cost is rising, the marginal cost is _____ the average variable cost. (Answer “below” or “above”) When the average total cost is falling, the marginal cost is _____ the average total cost. When the average total cost is rising, the marginal cost is _____ the average total cost. (Answer “below” or “above”)

Summary

In this chapter, we have defined economic costs and economic profits. We have distinguished between the short-run and the long-run. We have also distinguished between a fixed cost and a variable. We have developed the production function, allowing us to calculate the marginal physical product (addition to production). The main point in this chapter is the law of diminishing marginal returns --- as we hire more workers with a fixed amount of capital, the addition to production diminishes. Then, we defined, calculated, and graphed the marginal cost, the average variable cost, the average fixed cost, and the average total cost. All of these are based on the law of diminishing marginal returns. They will be very important concepts as we analyze business behavior. They all result in the short-run. However, they may not hold in the long-run. To that aspect, we will now turn in Chapter 15. Once we have completed this, we are set to begin our analysis of specific industries.

Practice Quiz on Chapter 14

1. 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:
 - a. \$103,000
 - b. \$130,000
 - c. \$233,000
 - d. \$260,000
2. Using the numbers in question 1, the part of the total cost that is **implicit cost** is:
 - a. \$103,000
 - b. \$110,000
 - c. \$130,000
 - d. 233,000
3. Using the numbers in question 1, the part of the total cost that is **fixed cost** is:
 - a. \$103,000
 - b. \$110,000
 - c. \$123,000
 - d. \$233,000
4. 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:
 - a. Total physical product begins to fall
 - b. The marginal physical product rises
 - c. The marginal physical product falls
 - d. The average physical product falls

5. Why is the law of diminishing marginal returns true?
 a. specialization and division of labor c. limited capital
 b. spreading the average fixed cost d. all factors being variable in the long-run
6. When the marginal physical product is rising, the marginal cost must be
 a. falling b. rising c. staying the same

Table for Questions 7 – 10

Quantity	Labor	Fixed Cost	Variable Cost	Total Cost
50	1	\$100	\$20	\$120
120	2	100	40	140
220	3	100	60	160
300	4	100	80	180
350	5	100	100	200

7. Using these numbers, the **average fixed cost** of producing 300 units is:
 a. \$100 b. \$3.00 c. \$0.33 d. \$180.00 e. \$0.60
8. Using the same numbers, the **average variable cost** of producing 50 units is:
 a. \$0.40 b. \$0.33 c. \$2.50 d. \$20 e. \$120
9. Using the same numbers, the **average total cost** of producing 300 units is:
 a. \$180 b. \$0.60 c. \$0.33 d. \$1.67
10. When the average total cost is rising, the marginal cost must be
 a. falling b. below the average total cost c. above the average total cost d. equal to the average total cost

Answers: 1. C 2. A 3. C 4. C 5. C 6. A 7. C 8. A 9. B 10. C

Cost Curves

