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# Production Costs

## LEARNING OBJECTIVES

1. Explain the difference between accounting profit and economic profit
2. Interpret a production function
3. Identify the cost-minimizing combination of inputs
4. Define the various types of costs faced by firms
5. Discuss the sources of economies of scale

# PROFIT MAXIMIZATION

- Firms do not seek to maximize revenue, because that isn't what the owners get to keep. Part (or all) of revenue goes to paying costs.
- The owner keeps whatever revenue is left after costs are paid.
- A firm's **profit** is the difference between its total revenue and its total cost. A negative profit is a *loss*.

$$\text{profit} = \text{total revenue} - \text{total cost}$$

- The goal of most firms is to maximize profit.

# ACCOUNTING PROFIT

- Suppose you are considering opening a bakery. You estimate that you will receive \$260,000 in total revenue from sales.
- Your annual costs include costs for labor, ingredients, and equipment rental. These are examples of **explicit costs**, which are costs that involve actual payments of money.
- **Accounting profit** is total revenue minus total explicit cost.

accounting profit = total revenue – total explicit cost

# ECONOMIC PROFIT

- Other costs for opening a bakery include opportunity costs, such as not working another job and not renting out the building that you're using for the bakery.
- These are **implicit costs**, which are costs that do not involve a direct outlay of money.
- **Economic profit** is total revenue minus total cost.

economic profit = total revenue – (total explicit cost + total implicit cost)

- Since economic profit is accounting profit minus total implicit cost, it is always less than accounting profit.

# ACCOUNTING PROFIT VS ECONOMIC PROFIT PART I

- Decisions should be made based off of economic profit, not accounting profit.
- Consider the decision of opening a bakery:

accounting profit = \$260,000 in sales revenue

– \$100,000 for labor

– \$70,000 for ingredients

– \$25,000 for equipment rental

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= \$65,000

- Looking at accounting profit suggests that it would be good to open the bakery.



# ACCOUNTING PROFIT VS ECONOMIC PROFIT PART II

- Here is the analysis including implicit costs:

$$\begin{aligned}\text{economic profit} = & \quad \$260,000 \text{ in sales revenue} \\ & - \$100,000 \text{ for labor} \\ & - \$70,000 \text{ for ingredients} \\ & - \$25,000 \text{ for equipment rental} \\ & - \$60,000 \text{ for the opportunity} \\ & \quad \quad \quad \text{cost of using the building} \\ & - \$40,000 \text{ for the opportunity} \\ & \quad \quad \quad \text{cost of your time} \\ & \hline & = - \$35,000\end{aligned}$$

- Looking at economic profit shows that it would not be profit maximizing to open the bakery.

# THE PRODUCTION FUNCTION

- Part of profit maximization is minimizing costs.
- In order to determine the cost-minimizing quantity of each input, you need to know the *productivity* of each input.
- A **production function** shows the relationship between the quantity of an input that a firm uses and the quantity of output the firm can produce as a result.
- A common input to focus on is labor.



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# THE LONG RUN AND THE SHORT RUN

- Some inputs are easier to vary than others. It is easier to change your bakers' hours than it is to rent another oven or get rid of an oven you're currently renting.
- The **long run** describes the time period in which the quantities of all inputs can be changed. In the long run, the amounts of labor and capital can be adjusted to accommodate different output levels at the lowest cost.
- The **short run** describes the time period during which the quantity of at least one input cannot change. The length of the short run depends on the situation.

# FIXED INPUTS AND VARIABLE INPUTS

- Inputs whose quantity cannot be varied in the short run, such as buildings, are **fixed inputs**.
- Inputs whose quantity can be varied in the short run, such as labor, are **variable inputs**.
- We can use a production function to look at changes in a variable input, labor, assuming that all other inputs are fixed.



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# MARGINAL PRODUCT

- By specializing, two workers can often accomplish more than twice as much as one worker.
- Thus, it is important for firms to be able to measure the contribution of each unit of an input such as labor. This helps to inform hiring decisions.
- The **marginal product** of an input is the increase in output gained from an additional unit of that input, leaving the quantities of other inputs unchanged.



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# DIMINISHING MARGINAL PRODUCT

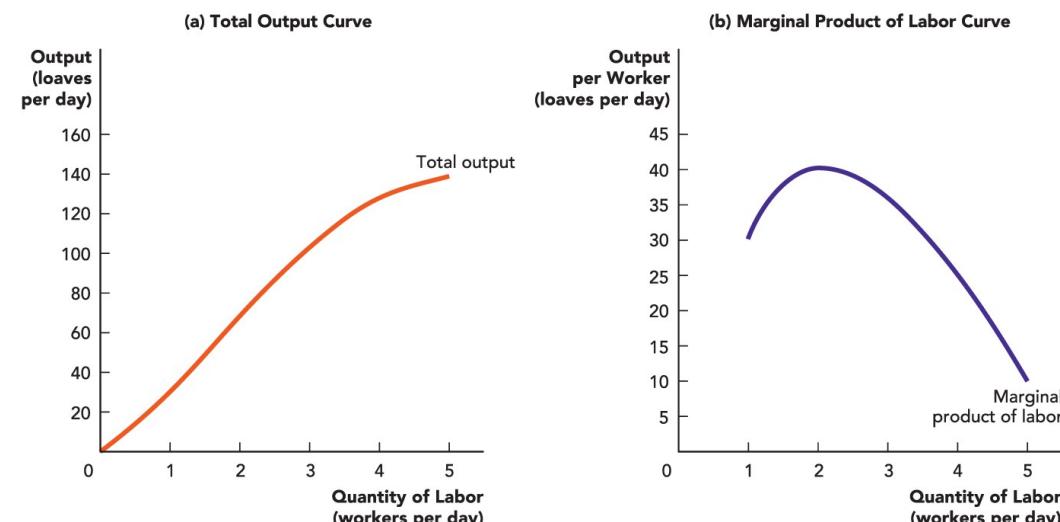
- As more labor (or any input) is added, keeping other inputs fixed, the marginal product tends to decrease, as there are fewer new opportunities for specialization and redundancy and congestion often occur.
- The **law of diminishing returns** states that as more of a variable input is added to a fixed input, the marginal product of the variable input eventually declines.

Workers	Total Output (loaves per day)	Marginal Product of Labor (loaves per day)
1	30	30
2	70	40
3	105	35
4	130	25
5	140	10

- In this case, the third worker has a lower marginal product than the second.

# TOTAL OUTPUT AND MARGINAL PRODUCT CURVES

- These curves show how the marginal product of labor and total output change as the quantity of labor changes.



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- Even though the marginal product of labor decreases after the second worker is added, total output continues to increase. As marginal product declines, total output grows more slowly.
- Total output would only decrease if a worker's marginal product were negative.



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## LEARN BY DOING: PRACTICE QUESTION 1

Which of these statements are true?

- I. Economic profit is usually greater than accounting profit.
  - II. Marginal product always decreases when more labor is added.
  - III. You should count the cost of rent even if you own the building that you're using.
- 
- a) I and II only
  - b) I and III only
  - c) II only
  - d) III only

# LEARN BY DOING: PRACTICE QUESTION 1

## (Answer)

Which of these statements are true?

- I. Economic profit is usually greater than accounting profit.
- II. Marginal product always decreases when more labor is added.
- III. You should count the cost of rent even if you own the building that you're using.
  - a) I and II only
  - b) I and III only
  - c) II only
  - d) **III only (correct answer)**

# COSTS OF INPUTS

- Most goods can be made using various combinations of capital and labor. Bread can be mixed and kneaded by bread machines or by bakers, for example.
- Minimizing costs depends on knowing the productivity of each input relative to its cost.
- The **wage** is the cost of a unit of labor.
- The cost of a unit of capital is the **rental rate** that must be paid each period to rent the capital used for production.
- Even if a firm owns the capital, the rental rate applies because the firm loses the opportunity to rent it out.

# MARGINAL PRODUCT PER DOLLAR



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- Just as consumers maximize utility by getting as much as possible from each dollar spent, firms minimize costs by getting as much as possible from each dollar paid.
- Suppose the wage rate is \$12.50 per hour and the rental rate is \$20 per hour. If hiring another worker would lead to 25 more loaves being produced, then the worker's *marginal product per dollar* is  $25 \div \$12.50 = 2$  loaves per dollar.
- If renting another oven would increase output by 50 loaves, then the marginal product per dollar of capital is  $50 \div \$20 = 2.5$  loaves per dollar.

# THE COST-MINIMIZING COMBINATION OF INPUTS

- Since the marginal product per dollar of capital (2.5) is greater than the marginal product per dollar of labor (2), the bakery should rent more ovens and hire less labor.
- This will result in more total output per dollar. In general, a firm can lower cost by hiring more of the input with the highest marginal product per dollar and less of the input with the lowest marginal product per dollar.
- The cost-minimizing combination of inputs is reached when

$$\frac{\text{marginal product of capital}}{\text{rental rate}} = \frac{\text{marginal product of labor}}{\text{wage}}$$

# FIXED COST AND VARIABLE COST

- Since fixed inputs cannot be adjusted in the short run, the cost of the fixed inputs, the **fixed cost**, remains constant, regardless of the quantity of output.
- Since variable inputs can be adjusted, the cost of variable inputs, the **variable cost**, is dependent on the quantity of output.
- If there is no output, the firm must still pay its fixed costs, but its variable cost becomes zero.

**total cost** = fixed cost + variable cost

# AVERAGE TOTAL COST

- Once you find the total cost, you can determine the cost, on average, of making one unit of output, in this case a loaf of bread.

$$\text{average total cost} = \frac{\text{total cost}}{\text{quantity of output}}$$

- The average total cost is important for a firm because if the average total cost of making a good is below the price paid for the good, the firm will earn a profit.



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# MARGINAL COST

- Marginal cost is the change in the firm's total cost when another unit is made:

$$\text{marginal cost} = \frac{\text{change in the total cost}}{\text{change in the quantity of output}}$$

- Inputs such as labor cost the same regardless of how much they produce, so diminishing marginal product means that as more is produced, it costs more to produce the same additional amount.
- Marginal cost decreases as marginal product increases and increases as marginal product decreases.

# SUMMARIZING COSTS WITH TABLES

(1)	(2)	(3)	(4)	(5)	(6)
Loaves	Fixed Cost	Variable Cost	Total Cost	Average Total Cost	Marginal Cost
0	\$10.00	\$0.00			
1	10.00	8.20			
2	10.00	12.20			
3	10.00	13.70			
4	10.00	14.80			
5	10.00	16.80			
6	10.00	20.00			
7	10.00	25.00			
8	10.00	32.80			
9	10.00	44.00			
10	10.00	59.00			

- This table shows how the different types of cost change as the number of loaves being produced change. We can also model how costs change with output using curves.

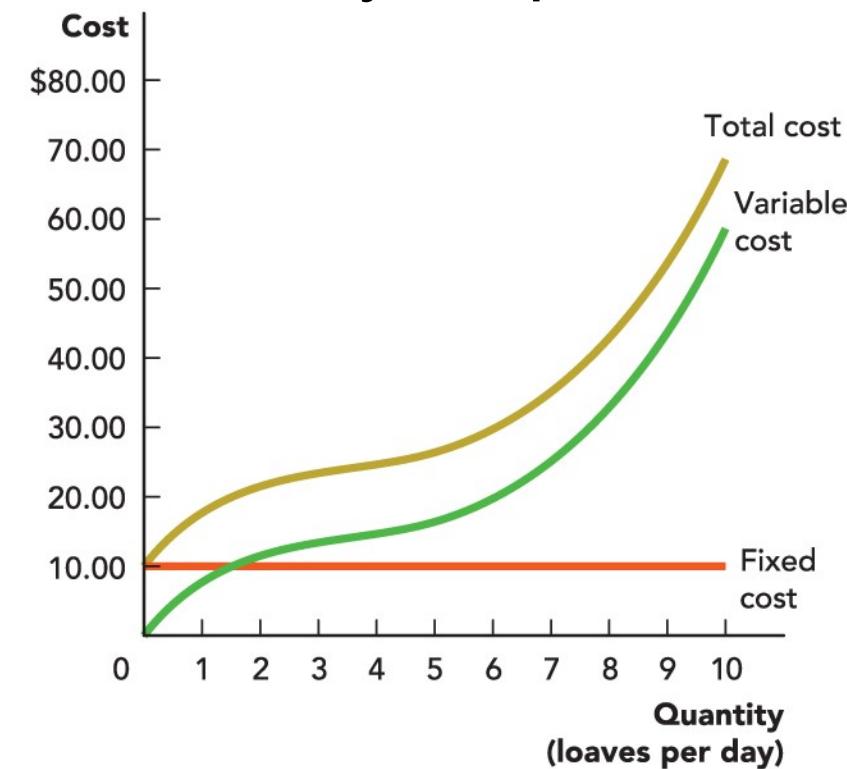
# SUMMARIZING COSTS WITH TABLES

(1)	(2)	(3)	(4)	(5)	(6)
Loaves	Fixed Cost	Variable Cost	Total Cost	Average Total Cost	Marginal Cost
0	\$10.00	\$0.00	\$10.00	—	—
1	10.00	8.20	18.20	\$18.20	\$8.20
2	10.00	12.20	22.20	11.10	4.00
3	10.00	13.70	23.70	7.90	1.50
4	10.00	14.80	24.80	6.20	1.10
5	10.00	16.80	26.80	5.36	2.00
6	10.00	20.00	30.00	5.00	3.20
7	10.00	25.00	35.00	5.00	5.00
8	10.00	32.80	42.80	5.35	7.80
9	10.00	44.00	54.00	6.00	11.20
10	10.00	59.00	69.00	6.90	15.00

- This table shows how the different types of cost change as the number of loaves being produced change. We can also model how costs change with output using curves.

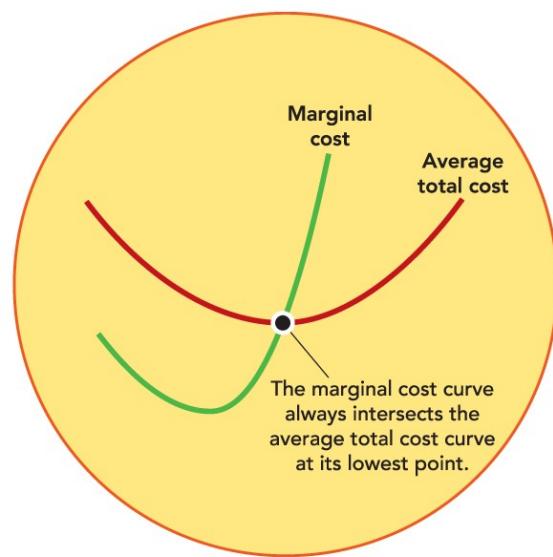
# SUMMARIZING COSTS WITH CURVES: TOTAL, VARIABLE, AND FIXED COST

- The fixed cost curve is horizontal because fixed costs do not vary with quantity.
- The variable cost curve rises as more money is spent on labor and ingredients.
- The total cost curve has the same shape as the variable cost curve but is shifted up by the amount of fixed cost, in this case \$10.

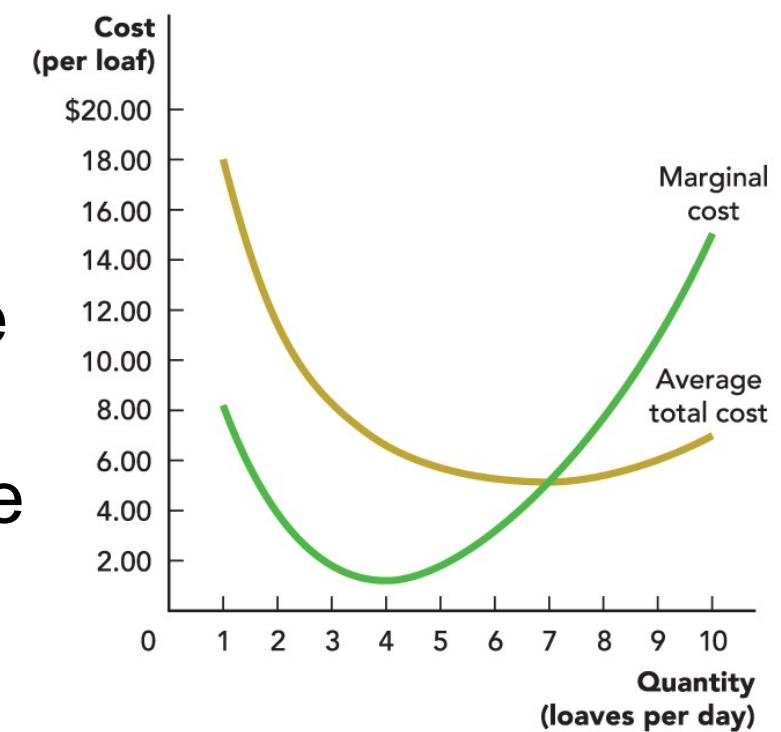


# SUMMARIZING COSTS WITH CURVES: MARGINAL AND AVERAGE TOTAL COST

- The marginal cost curve crosses the average total cost curve at the lowest point on the average total cost curve.
- If the cost of one more unit (marginal cost) is below the average, it will lower the average.



- If the marginal cost is above the average, it will raise the average total cost.



# THE IRRELEVANCE OF SUNK COSTS



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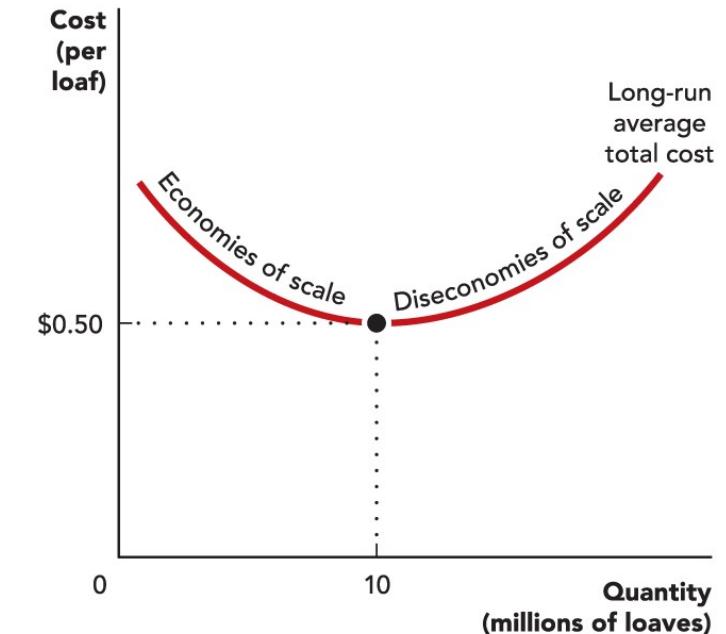
- A **sunk cost** is a cost that has already been paid and cannot be recovered.
- Sunk costs should not affect the decision-making process.
- For example, the time and money spent recruiting and training a new employee are sunk costs.
- If the new employee is unreliable, these sunk costs should not influence the decision of whether or not to retain him.

# ECONOMIES OF SCALE

- **Economies of scale** exist when an increase in output results in a decrease in the average total cost a firm faces in the long run.
- This happens because the cost of things such as rent, advertising, and expensive machinery can be spread across more units of output.
- In addition, large firms can negotiate lower input prices from suppliers because of the quantities they purchase.

# THE MINIMUM EFFICIENT SCALE AND DISECONOMIES OF SCALE

- At some point, economies of scale stop due to things such as needing new levels of management and difficulty in motivating workers.
- When this happens, the firm has reached its **minimum efficient scale**, which is the smallest quantity at which a firm's long-run average total cost is minimized.
- At some point after this, the firm begins to experience **diseconomies of scale**, in which the firm's long-run average total cost rises as output increases.



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## LEARN BY DOING: PRACTICE QUESTION 2

Suppose that you run a clothing company and you have two main inputs: workers and sewing machines. Each worker is paid \$10 an hour, and the rental rate for the machines is \$5 an hour. You find that by hiring another worker, you could produce another 2 suits per hour, while if you were to get another sewing machine, you could produce 1 more suit an hour. How could you minimize cost while maintaining output?

- a) employ more labor and less capital
- b) employ less labor and more capital
- c) employ less labor and less capital
- d) cost is already minimized.

## LEARN BY DOING: PRACTICE QUESTION 2

### (Answer)

Suppose that you run a clothing company and you have two main inputs: workers and sewing machines. Each worker is paid \$10 an hour, and the rental rate for the machines is \$5 an hour. You find that by hiring another worker you could produce another 2 suits per hour, while if you were to get another sewing machine, you could produce 1 more suit an hour. How could you minimize cost while maintaining output?

**(Answer)**

- a) employ more labor and less capital
- b) employ less labor and more capital
- c) employ less labor and less capital
- d) **cost is already minimized. (correct answer)**