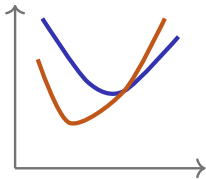


# Production, Cost & Perfect Competition

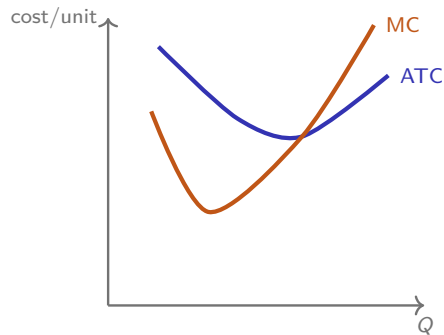
## AP Microeconomics ■ Unit 3

### AP Microeconomics



## What we will cover

- 1 Production & marginal product
- 2 Short-run costs
- 3 Long-run costs & scale
- 4 Types of profit
- 5 Profit maximization
- 6 Perfect competition



1

Production

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# The production function: one oven or two?

A bakery combines workers and ovens to make loaves. Its **production function** 生产函数 links inputs to output.

## Choose the time horizon

Today: hire workers, but no new oven.

Next year: change workers and ovens.

Which case is short run? Which input is fixed today?



A machine is capital; whether it is fixed depends on the decision period.

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Which case is short run? Which input is fixed today?

Today is **short run** 短期: fixed oven. Next year's plan is **long run** 长期: all inputs variable.



A machine is capital; whether it is fixed depends on the decision period.

## One oven: calculate the workers' contributions

### Try before the solution

The oven and technology stay unchanged. With no workers, output is zero. Each worker works the same daily hours.

| Workers $L$         | 0 | 1  | 2  | 3  | 4  |
|---------------------|---|----|----|----|----|
| Loaves per day $TP$ | 0 | 10 | 24 | 33 | 39 |

Calculate each worker's marginal product and average product at  $L = 3$ . When do diminishing marginal returns begin? Is total output then falling?

$MP = \Delta TP / \Delta L$  measures extra output;  $AP = TP / L$  measures output per worker.

## Diminishing marginal returns: less extra output

| Workers $L$           | 1  | 2  | 3  | 4  |
|-----------------------|----|----|----|----|
| Total product $TP$    | 10 | 24 | 33 | 39 |
| Marginal product $MP$ | 10 | 14 | 9  | 6  |

### The third worker

$$MP = \Delta TP / \Delta L$$

$$MP = (33 - 24) / (3 - 2) = 9 \text{ loaves per worker-day.}$$

$$AP = TP / L = 33 / 3 = 11 \text{ loaves per worker-day.}$$

MP falls from 14 to 9 with the third worker: diminishing marginal returns begin here, holding other inputs fixed.

TP still rises from 24 to 33 because MP is positive. Falling MP does not mean falling TP.

2

Costs

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## Short-run costs: build the measures from data

### Fixed plant

Fixed cost: \$100.

At 10 units, TC is \$300.

At 11 units, TC is \$325.

FC stays unchanged.

| Measure          | Equation                    |
|------------------|-----------------------------|
| Variable cost    | $VC = TC - FC$              |
| Average fixed    | $AFC = FC/Q$                |
| Average variable | $AVC = VC/Q$                |
| Average total    | $ATC = TC/Q$                |
| Marginal         | $MC = \Delta TC / \Delta Q$ |

Find VC, AFC, AVC and ATC at 10 units; then find the cost of the eleventh unit.  
Denominators measure output, not workers.

## Worked costs: average is not marginal

### At 10 units

$$VC = TC - FC = 300 - 100 = \$200$$

$$AFC = FC/Q = 100/10 = \$10$$

$$AVC = VC/Q = 200/10 = \$20$$

$$ATC = TC/Q = 300/10 = \$30$$

### One extra unit

$$MC = \Delta TC / \Delta Q$$

$$MC = (325 - 300) / (11 - 10)$$

$$MC = \$25 \text{ per extra unit.}$$

The new ATC is  $ATC = 325/11 \approx \$29.55$ .  
The extra unit costs less than the previous average, so it lowers that average.

Average costs are dollars per unit; total costs are dollars. At zero output FC remains \$100, but cost per unit is undefined.

## Why marginal product and marginal cost move oppositely

Labor is the only variable input. Each worker costs \$60 per day; other input prices and technology stay fixed. Use the bakery table.

|                             |       |      |       |
|-----------------------------|-------|------|-------|
| Worker added                | 2     | 3    | 4     |
| Extra loaves                | 14    | 9    | 6     |
| $MC = \Delta VC / \Delta Q$ | 60/14 | 60/9 | 60/6  |
| Dollars per extra loaf      | 4.29  | 6.67 | 10.00 |

With constant wage,  $MC = w/MP$ : lower MP raises MC. The graphs need not be literal reflections.

## A cost change: which curves move?

### Compare two separate changes

- A. The plant's fixed rent rises by \$50; output and variable-input prices are unchanged.
- B. The hourly wage rises; labor productivity is unchanged.

For each, decide what happens to FC, AVC, ATC and MC.

## A cost change: which curves move?

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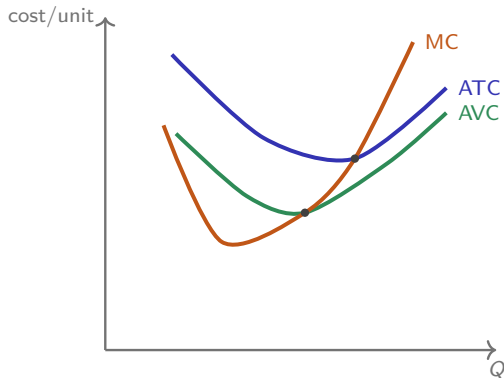
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For each, decide what happens to FC, AVC, ATC and MC.

### Trace the cost, not a memorized curve shift

- A. FC rises; ATC rises by  $50/Q$ . AVC and MC do not change because extra output does not add rent.
- B. Variable cost rises at positive output; AVC and ATC rise. Each extra unit costs more labor expenditure, so MC rises.

# A standard short-run cost diagram



*MC* cuts *AVC* and *ATC* at their **minimum** points.

When *MC* is below the average, it pulls the average **down**; above it, **up**. With constant wage and labor as the only variable input, falling MP raises MC; marginal-versus-average reasoning explains the minima.

# 3

## Long run & scale

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## Long-run costs: compare cost per unit

Long run: all inputs can vary. Compare these complete cost plans.

| Plan | Output | Total cost |
|------|--------|------------|
| A    | 40     | \$600      |
| B    | 60     | \$1080     |

### Choose the evidence

Calculate each plan's LRATC. Does total cost alone establish diseconomies?

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Calculate each plan's LRATC. Does total cost alone establish diseconomies?

$LRATC = TC/Q$ : plan A gives  $600/40 = \$15$  per unit; B gives  $1080/60 = \$18$  per unit.

LRATC rises: diseconomies over this range. Higher total cost alone is insufficient.

## Scale: changing every input is a different experiment

### Double every input

Hold technology fixed.

More than double output: increasing returns.

Double output: constant returns.

Less than double output: decreasing returns.

### Average-cost evidence

**Economies of scale** 规模经济:  
LRATC falls.

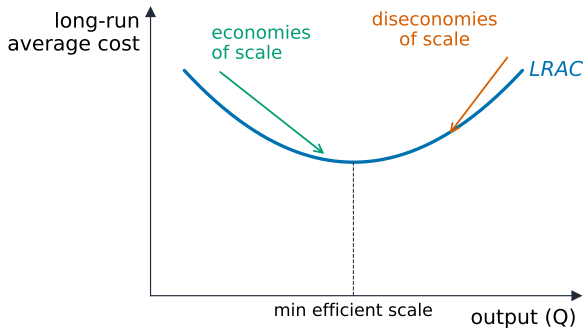
Constant LRATC: constant-cost range.

**Diseconomies of scale** 规模不经济:  
LRATC rises.

With fixed input prices, increasing returns can lower LRATC.

Diminishing marginal returns fixes another input; returns to scale varies all inputs.

## Minimum efficient scale and market size



### Minimum efficient

**scale** 最小有效规模 is the smallest output at minimum LRATC.

If MES is large relative to market demand, fewer firms can operate at that scale. This helps explain concentration; it does not alone prove monopoly.

LRATC traces the lowest attainable average cost across plant choices.

4

Profit

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## Types of profit: what did the shopkeeper give up?

### One year's business

All amounts refer to the same year. Treat these as all relevant costs.

| Item                                   | Dollars |
|----------------------------------------|---------|
| Revenue                                | 200,000 |
| Payments for rent, wages and materials | 120,000 |
| Salary forgone in the next-best job    | 70,000  |
| Interest forgone on invested savings   | 5,000   |

Classify explicit and implicit costs. Calculate accounting profit and economic profit. Does positive accounting profit alone justify staying?

## Economic profit: the same business, two measures

### Cash payments

**Explicit costs** 显性成本 ( $EC$ ) are \$120,000.

$$\text{Accounting profit} = TR - EC$$

$$\begin{aligned} \text{Accounting profit} \\ &= 200,000 - 120,000 \end{aligned}$$

$$\text{Accounting profit} = \$80,000.$$

### Include the next-best use

**Implicit costs** 隐性成本 ( $IC$ )

$$IC = 70,000 + 5,000 = \$75,000.$$

$$\text{Economic profit} = TR - EC - IC$$

$$\begin{aligned} \text{Economic profit} \\ &= 200,000 - 120,000 - 75,000 \end{aligned}$$

$$\text{Economic profit} = \$5,000.$$

**Normal profit** 正常利润 means zero economic profit: all opportunity costs are covered. Accounting profit alone omits owner-supplied resources.

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## Profit maximization

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## Profit maximization: choose an output, then check it

A price-taking firm can sell at \$8 per unit. Its short-run costs are:

$$TC = 32 + 2q + \frac{1}{2}q^2, \quad MC = 2 + q.$$

All costs are economic costs; the \$32 fixed cost is unavoidable this period. The output  $q$  can vary continuously.

### Try before the worked decision

Find the best positive output using  $MR = MC$ . Then calculate TR, VC and economic profit. Would shutting down give a smaller loss?

An operating optimum and a decision to operate are separate checks. A profit maximum can be a loss.

## The marginal rule can select a loss-minimizing output

### Best operating output

A price taker has  $MR = P = 8$ .

$$MR = MC$$

$$8 = 2 + q$$

$$q = 8 - 2 = 6 \text{ units.}$$

MC crosses MR from below: more units beyond 6 add more cost than revenue.

### Measure the result

$$TR = Pq = 8 \times 6 = \$48$$

$$VC = 2q + \frac{1}{2}q^2$$

$$VC = 2(6) + \frac{1}{2}(6)^2 = \$30$$

$$\pi = TR - FC - VC$$

$$\pi = 48 - 32 - 30 = -\$14.$$

## Discrete output: equality need not occur

A different firm sells indivisible units at \$8 each. Its complete feasible output choices are 0 through 4.

|            |    |    |    |    |    |
|------------|----|----|----|----|----|
| Output     | 0  | 1  | 2  | 3  | 4  |
| Total cost | 10 | 14 | 19 | 26 | 36 |

### Choose the largest total profit

Calculate  $TR = Pq$  and  $\pi = TR - TC$  for each output. Does the firm need a unit where MR equals MC exactly?

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### Choose the largest total profit

Calculate  $TR = Pq$  and  $\pi = TR - TC$  for each output. Does the firm need a unit where MR equals MC exactly?

Profits are  $-10, -6, -3, -2, -4$  dollars: choose 3 units. The third unit adds \$8 revenue and \$7 cost; the fourth adds \$8 revenue and \$10 cost.

Equality is the smooth interior rule. With discrete choices, compare feasible total

## Use the production table to choose workers

Return to the one-oven bakery, not the continuous-cost firm. Its choices are zero through four workers, each working the same daily hours.

|                |   |    |    |    |    |
|----------------|---|----|----|----|----|
| Workers        | 0 | 1  | 2  | 3  | 4  |
| Loaves per day | 0 | 10 | 24 | 33 | 39 |

### A staffing decision

Each loaf sells for \$8; each worker costs \$60 per day. Labor is the only variable input. The oven's fixed cost is unavoidable today. Choose the number of workers and justify it with marginal revenue and cost.

## The extra worker: value the extra output

Each extra worker costs \$60. Extra revenue is price times that worker's marginal product.

| Worker added                | 1  | 2   | 3  | 4   |
|-----------------------------|----|-----|----|-----|
| Extra loaves $MP$           | 10 | 14  | 9  | 6   |
| Extra revenue $P \times MP$ | 80 | 112 | 72 | 48  |
| Extra labor cost            | 60 | 60  | 60 | 60  |
| Extra profit                | 20 | 52  | 12 | -12 |

Choose three workers: the third adds \$72 revenue for \$60 cost; the fourth would lower profit by \$12. The first three contribute \$84 toward fixed cost and profit.

## Produce, or shut down? Compare the losses

Use the same continuous-output firm:  $P = 8$ , best positive output  $q = 6$ ,  $FC = 32$ ,  $VC = 30$  and  $TR = 48$ .

### Operate at six units

$$\pi = TR - FC - VC$$

$$\pi = 48 - 32 - 30 = -\$14.$$

Revenue covers variable cost and \$18 of fixed cost.

### Shut down this period

Output and variable cost become zero; FC remains \$32.

$$\pi = 0 - FC = -\$32.$$

Operating reduces the loss by \$18.

Here  $AVC = VC/q = \$5$  and  $ATC = TC/q \approx \$10.33$ . Price below ATC means loss; price above AVC makes operating preferable to shutdown.

## Shutdown is not the same as long-run exit

### The same firm at a price of \$1

For every positive  $q$ ,  $TR = q$  and  $VC = 2q + \frac{1}{2}q^2$ , so revenue cannot cover variable cost. It shuts down and loses the unavoidable \$32 fixed cost.

### What changes in the long run?

Fixed commitments can be changed. Expected continuing economic losses encourage exit; expected positive economic profit encourages entry when entry is free.

For a price taker, compare  $P$  with  $AVC$  at its best operating output. At  $P = AVC$ , operation and shutdown can tie. A temporary loss alone does not establish that exit is best.

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## Perfect competition

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## Perfect competition: can one seller raise the price?

A market has many small firms, identical products, **free entry/exit** 自由进出 and perfect information. Buyers can buy the same product elsewhere at \$12.

### One firm's decision

One firm posts \$13 while all others keep charging \$12 and can supply the buyers. What happens to its sales and revenue?

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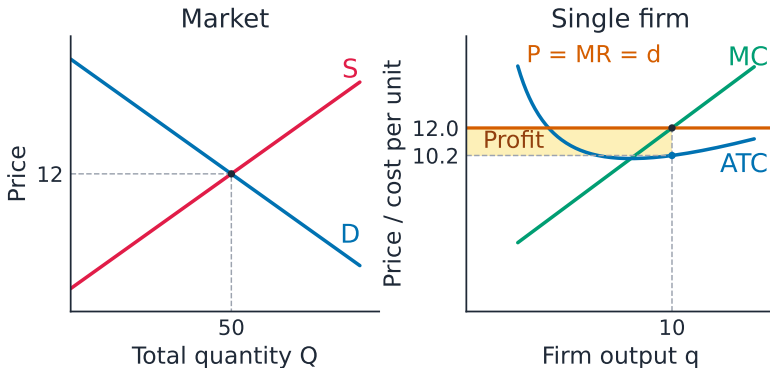
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One firm posts \$13 while all others keep charging \$12 and can supply the buyers. What happens to its sales and revenue?

Buyers choose the identical cheaper product: this firm sells nothing and earns zero revenue. It cannot raise the market price by changing its own price.

A **price taker** 价格接受者 faces horizontal firm demand at the market price:  $P = AR = MR$ . The whole market's demand curve still slopes down.

## The market price becomes the firm's marginal revenue



Market:  $P = 12$ . Firm:  $MC = 2 + q = 12$  gives  $q = 10$ . Read  $ATC$  at that output, not at its minimum; the shaded area is economic profit.

## One cost function, three market prices

Keep  $TC = 32 + 2q + \frac{1}{2}q^2$  and  $MC = 2 + q$ . For each price, choose  $q = P - 2$ , then compare revenue with total cost.

|                                 |     |    |     |
|---------------------------------|-----|----|-----|
| Market price                    | 12  | 10 | 8   |
| Best positive output $q$        | 10  | 8  | 6   |
| $TR = Pq$                       | 120 | 80 | 48  |
| $TC = 32 + 2q + \frac{1}{2}q^2$ | 102 | 80 | 62  |
| $\pi = TR - TC$                 | 18  | 0  | -14 |

Profit, normal profit and operating loss can all occur in the short run. At P12,  $(P - ATC)q = (12 - 10.2)10 = \$18$ . At P10, q8 is also minimum ATC.

## Demand rises: trace the market and the firm

Initially the market is in long-run equilibrium at \$10; the typical firm's output is 8. A permanent demand increase raises the short-run market price to \$12.

### **Draw both graphs before the explanation**

On market axes show the demand shift and new equilibrium. On separate firm axes show the new horizontal MR line, output and profit rectangle. Does the firm's MC curve shift just because product demand rises?

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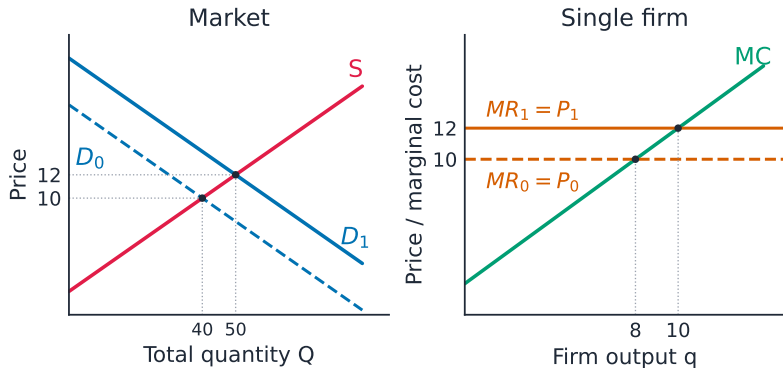
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On market axes show the demand shift and new equilibrium. On separate firm axes show the new horizontal MR line, output and profit rectangle. Does the firm's MC curve shift just because product demand rises?

Market demand shifts right. The firm's MR line rises from 10 to 12; it moves along unchanged MC from  $q = 8$  to  $q = 10$ . Economic profit becomes \$18.

A higher output price changes MR. It does not itself change the firm's production costs.

## Demand shock: the two graphs change differently



Market demand shifts right:  $P: 10 \rightarrow 12$ ,  $Q: 40 \rightarrow 50$ . The firm's horizontal MR line shifts up; output moves along unchanged MC from 8 to 10.

## Entry after profit: two quantities move differently

Assume a constant-cost industry: input prices and firms' cost curves stay unchanged as new firms enter.

### Follow the adjustment

Profit attracts entry. Market supply shifts right; price falls toward the unchanged minimum ATC of \$10.

Each typical firm returns from 10 to 8 units and earns zero economic profit.

More firms can raise total market output while each incumbent produces less than at the short-run peak.

After a demand fall, continuing losses encourage exit; market supply shifts left. Adjustment takes time.

## Must long-run price return to its original level?

All three industries start at P10. Demand permanently rises. The table gives the new lowest average cost after industry expansion; assume free entry and comparable firms.

| Industry                 | A  | B  | C |
|--------------------------|----|----|---|
| New minimum average cost | 10 | 11 | 9 |

### Classify and explain

Which industry is constant-cost, increasing-cost or decreasing-cost? What price is consistent with zero economic profit in each new long-run equilibrium?

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### Classify and explain

Which industry is constant-cost, increasing-cost or decreasing-cost? What price is consistent with zero economic profit in each new long-run equilibrium?

A: constant-cost, P10. B: increasing-cost, P11. C: decreasing-cost, P9. Industry expansion can change input prices and firms' cost curves.

The original price returns in the constant-cost case. An increasing-cost industry is

## Why perfect competition is efficient

**Productive efficiency** 生产效率:

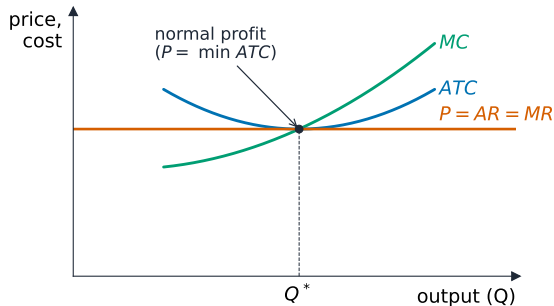
output at minimum ATC.

**Allocative efficiency** 配置效率:

$P = MC$ , when private marginal costs and benefits equal social ones.

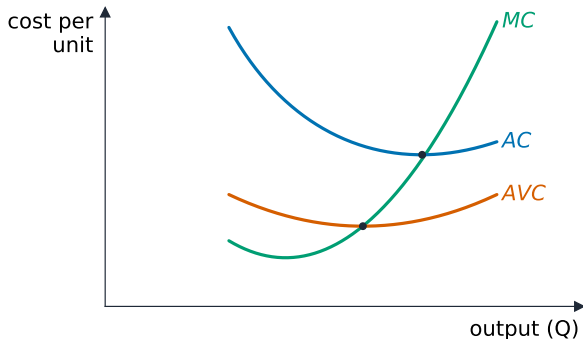
In long-run competitive equilibrium, operating firms satisfy

$P = MC = \min ATC$  and earn normal profit.



A short-run competitive firm can satisfy  $P = MC$  while producing away from minimum ATC. The two efficiency tests ask different questions.

## Read the short-run cost curves



Where marginal is below average, what happens to average as output rises?

Why do MC and ATC meet at minimum ATC in the smooth model?

If fixed rent alone rises, which curves here shift?

Use the graph to explain the relationships. A falling ATC does not mean TC is falling.

## Exam tips

- Show the formula, substitute the data, and give units. Separate total, average and marginal values.
- Label market and firm graphs separately; mark output, price and the profit or loss rectangle.
- State which inputs are fixed before explaining diminishing returns or returns to scale. Check shutdown separately from the best operating output.

7

Recap

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## Check yourself: defend the firm's decision

### New data; independent cases

- A. A shop earns accounting profit of \$80,000; its implicit costs are \$90,000. Find economic profit.
- B. At its best positive output, another firm has  $q = 5$ ,  $P = 4$ ,  $VC = 20$ , and unavoidable  $FC = 10$ . Compare operation and shutdown.
- C. A competitive firm earns zero economic profit in long-run equilibrium. Does the owner receive no reward for their resources?

Give a numerical comparison for A and B, and an opportunity-cost explanation for C. Do not answer a shutdown decision from ATC alone.

## Check yourself

### A: accounting profit is not the opportunity-cost result

Economic profit = accounting profit – implicit costs.

$$\text{Economic profit} = 80,000 - 90,000 = -\$10,000.$$

### B: the boundary case

$$TR = Pq = 4(5) = \$20 = VC.$$

Operating profit =  $TR - VC - FC = 20 - 20 - 10 = -\$10$ . Shutdown profit =  $-FC = -\$10$ . The firm is indifferent.

C: normal profit covers all opportunity costs, including the owner's resources. Zero economic profit does not mean zero accounting profit or no income.