

## 12. The Costs of Production

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# Overview

- ▶ Next few chapters talk about “Firm’s production decision”, “supply”, and “market organization”
- ▶ In this chapter, we look at firms’ behavior in a greater detail.
- ▶ Firms are optimizing their decisions on “optimal inputs”, “optimal level of outputs”
- ▶ to achieve “Profit maximization”

# Questions?

- ▶ What is a production function?  
What is marginal product?  
How are they related?
- ▶ What are the various costs, and  
how are they related to each other and to output?
- ▶ How are costs different in the short run vs. the long run?
- ▶ What are “economies of scale”?

# Total Revenue, Total Cost, Profit

- ▶ We assume that the firm's goal is to maximize profit.
  - ▶ Total revenue minus total cost

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$$Profit = Revenue - Cost$$

- ▶ Total revenue
  - ▶ Amount a firm receives for the sale of its output
- ▶ Total cost
  - ▶ Market value of the inputs a firm uses in production

# What are Costs?

- ▶ Explicit costs
  - ▶ Input costs that require an outlay of money by the firm
- ▶ Implicit costs 가
  - ▶ Input costs that do not require an outlay of money by the firm
  - ▶ Ignored by accountants
- \* Costs as opportunity costs (from the Ten Principles)
  - ▶ The cost of something is what you give up to get it
- ▶ Total costs
  - ▶ Explicit costs + Implicit costs
- ▶ Firm's cost of production
  - Include all the opportunity costs of making its output of goods and services

## Explicit vs. Implicit Costs: An Example

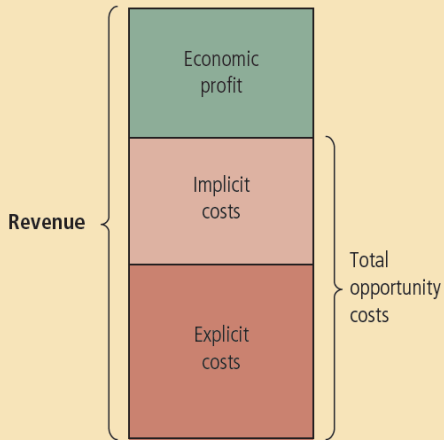
- ▶ You need \$100,000 to start your business. The interest rate is 5%.
  - ▶ Case 1: borrow \$100,000
    - ▶ explicit cost = \$5,000 interest on loan
  - ▶ Case 2: use \$40,000 of your savings, borrow the other \$60,000
    - ▶ explicit cost = \$3,000 (5%) interest on the loan
    - ▶ implicit cost = \$2,000 (5%) foregone interest you could have earned on your \$40,000. 40000
- ▶ In both cases, total costs are \$5,000.

# Profit

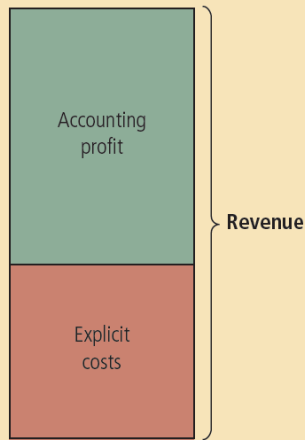
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How an Economist  
Views a Firm



How an Accountant  
Views a Firm



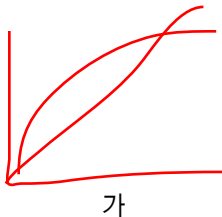
# Production and Costs

- ▶ Production function
  - ▶ Relationship between
    - ▶ Quantity of inputs used to make a good
    - ▶ And the quantity of output of that good
  - ▶ Gets flatter as production rises
  - ▶ For example,

$$Y = zN^a \quad a \in (0, 1)$$
$$= ( \quad ) ( \quad )^{(a)}$$



# Production and Costs



## ► Marginal product

- Increase in output that arises from an *additional* unit of input
- Marginal Product of Labor =  $\Delta Y / \Delta N$
- Slope of the production function
- For example,

$$MP_N = z \cdot a \cdot N^{(a-1)} \quad a \in (0, 1)$$

## ► “Rational people think at the margin”

- When  $MP_N > w$ , it pays off to hire one extra worker
- When  $MP_N < w$ , it pays off to fire one extra worker

$$= z \cdot N^a - wN$$

$$' = zaN^{(a-1)} - w$$

# Production and Costs

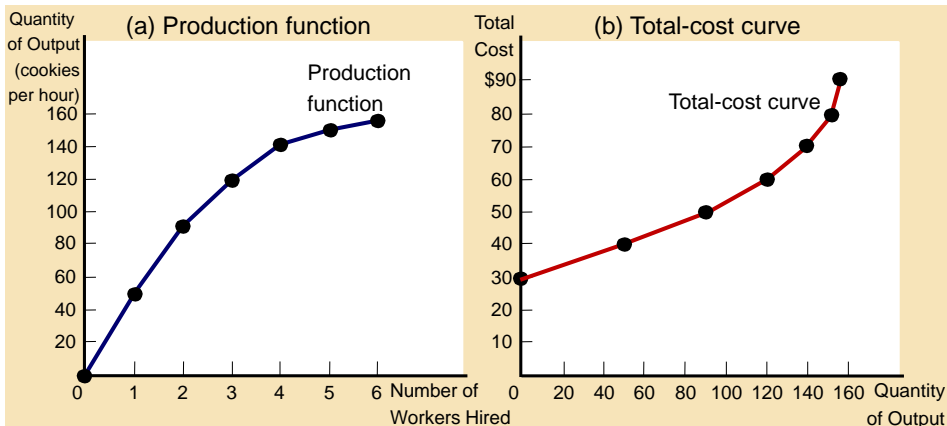
- ▶ Diminishing marginal product
  - ▶ Marginal product of an input declines as the quantity of the input increases
  - ▶ As you hire more workers, the average worker has less land to work with and is less productive.
- ▶ Total-cost curve
  - ▶ Relationship between quantity produced and total costs
  - ▶ Gets steeper as the amount produced rises (because  $MP$  is diminishing!)

## Numerical Example

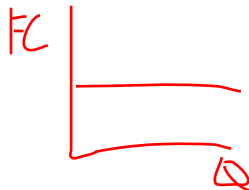
Number of Workers	Output (quantity of cookies produced per hour)	Marginal Product of Labor	Cost of Factory	Cost of Workers	Total Cost of Inputs (cost of factory + cost of workers)
0	0		\$30	\$0	\$30
		50			
1	50	40	30	10	40
2	90	30	30	20	50
3	120	20	30	30	60
4	140	10	30	40	70
5	150	5	30	50	80
6	155		30	60	90

## And Graphical Presentation

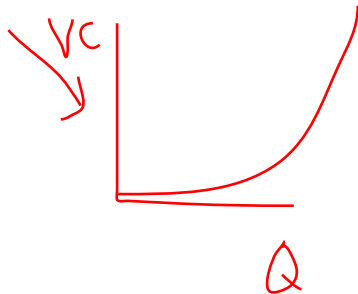
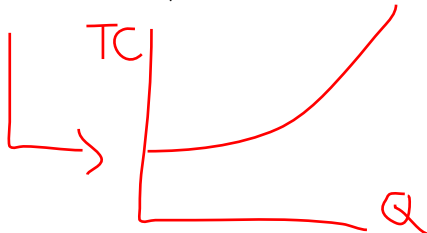
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# Various Measures of Cost

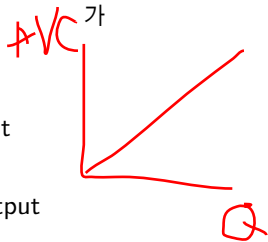
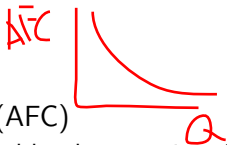


- ▶ Fixed costs
  - ▶ Costs that do not vary with the quantity of output produced
- ▶ Variable costs  $가$ 
  - ▶ Costs that vary with the quantity of output produced
- ▶ Total cost
  - ▶ Fixed cost + Variable cost

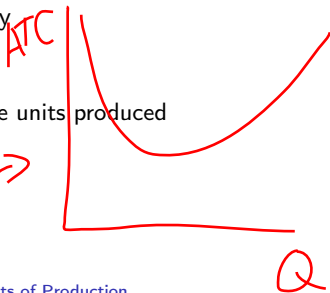
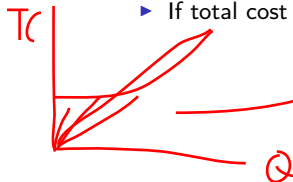


## Various Measures of Cost

$$A \rightarrow C/Q$$

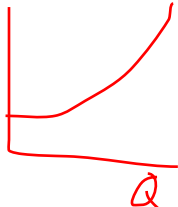


- ▶ Average fixed cost (AFC)
    - ▶ Fixed cost divided by the quantity of output
  - ▶ Average variable cost (AVC)
    - ▶ Variable cost divided by the quantity of output
  - ▶ Average total cost (ATC)
    - ▶ Total cost divided by the quantity of output
    - ▶ Average total cost = Total cost / Quantity
    - ▶  $ATC = TC/Q$
    - ▶ Cost of a typical unit of output
- ▶ If total cost is divided evenly over all the units produced

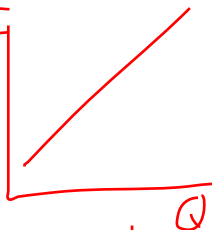


# Various Measures of Cost

TC



MC



## Marginal cost (MC)

- ▶ Increase in total cost arising from an extra unit of production
- ▶ Marginal cost = Change in total cost / Change in quantity
- ▶  $MC = \Delta TC / \Delta Q$
- ▶ Increase in total cost

▶ From producing an additional unit of output

▶ "Rational people think at the margin"

- ▶ When  $MC > p$ , it pays off to produce/sell less
- ▶ When  $MC < p$ , it pays off to produce/sell more

Quantity of Coffee (cups per hour)	Total Cost	Fixed Cost	Variable Cost	Average Fixed Cost	Average Variable Cost	Average Total Cost	Marginal Cost
0	\$ 3.00	\$3.00	\$ 0.00	—	—	—	
1	3.30	3.00	0.30	\$3.00	\$0.30	\$3.30	\$0.30
2	3.80	3.00	0.80	1.50	0.40	1.90	0.50
3	4.50	3.00	1.50	1.00	0.50	1.50	0.70
4	5.40	3.00	2.40	0.75	0.60	1.35	0.90
5	6.50	3.00	3.50	0.60	0.70	1.30	1.10
6	7.80	3.00	4.80	0.50	0.80	1.30	1.30
7	9.30	3.00	6.30	0.43	0.90	1.33	1.50
8	11.00	3.00	8.00	0.38	1.00	1.38	1.70
9	12.90	3.00	9.90	0.33	1.10	1.43	1.90
10	15.00	3.00	12.00	0.30	1.20	1.50	2.10



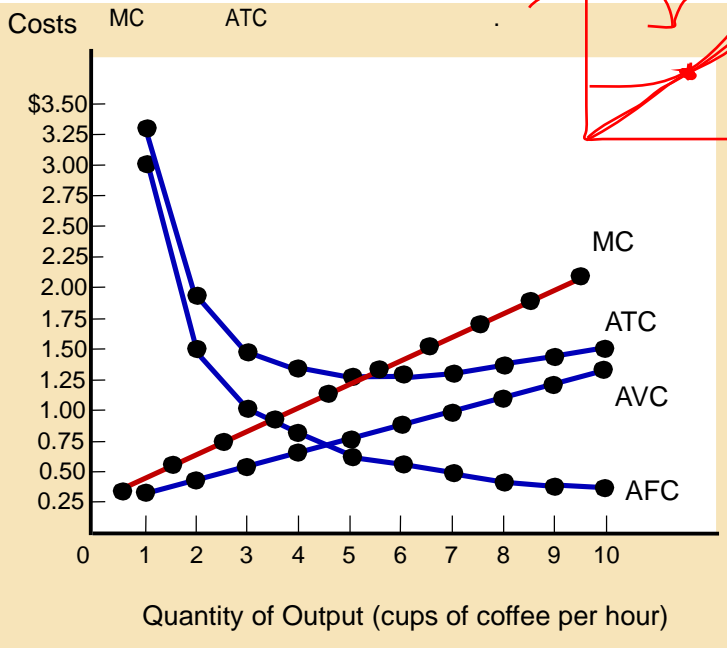
# Various Measures of Cost

- ▶ Rising marginal cost curve
  - ▶ Because of diminishing marginal product
- ▶ U-shaped average total cost curve
  - ▶  $ATC = AVC + AFC$
  - ▶ AFC – always declines as output rises
  - ▶ AVC – typically rises as output increases
    - ▶ Because of diminishing marginal product
  - ▶ The bottom of the U-shape
    - ▶ At quantity that minimizes average total cost

## Various Measures of Cost



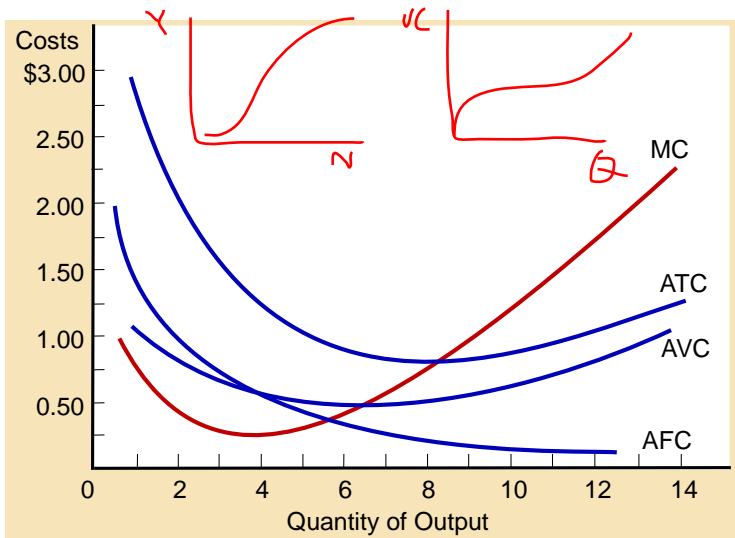
- ▶ Efficient scale
  - ▶ Quantity of output that minimizes ATC
- ▶ Relationship between MC and ATC
  - ▶ When  $MC < ATC$ : average total cost is falling
  - ▶ When  $MC > ATC$ : average total cost is rising
  - ▶ The marginal-cost curve crosses the average-total-cost curve at its minimum



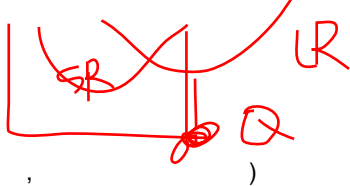
# Various Measures of Cost

- ▶ Typical cost curves      MC    Q가    가    가    .
    - ▶ Marginal cost eventually rises with the quantity of output
    - ▶ Average-total-cost curve is U-shaped
    - ▶ Marginal-cost curve crosses the average-total-cost curve at the minimum of average total cost
- FC      가      가,      VC      가

= AVC, MC  $\rightarrow$  U



# Costs in Short and Long Run



- ▶ Many decisions
  - ▶ Fixed in the short run
  - ▶ Variable in the long run
- ▶ Firms –greater flexibility in the long-run
  - ▶ Long-run cost curves
    - ▶ Differ from short-run cost curves
    - ▶ Much flatter than short-run cost curves
  - ▶ Short-run cost curves
    - ▶ Lie on or above the long-run cost curves

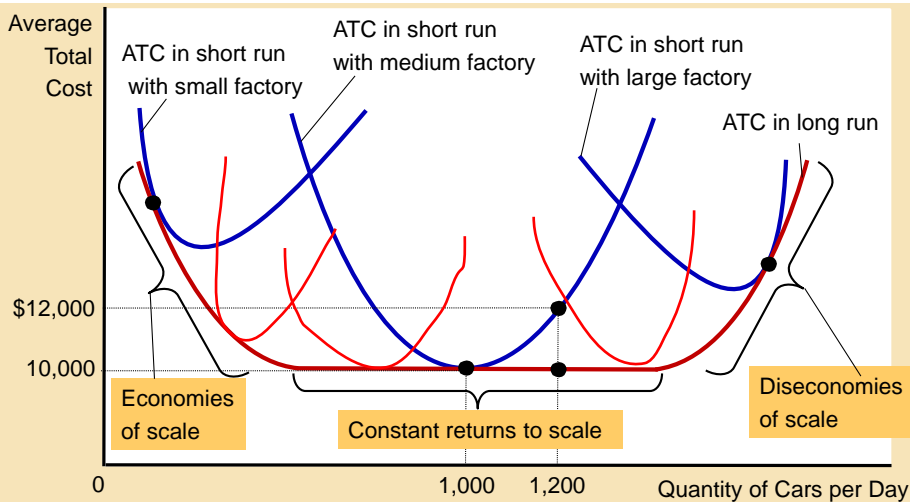
# Short Run vs Long Run

LR  
LR

SR

Q

가 ATC가



# Costs in Short and Long Run

- ▶ Economies of scale
  - ▶ Long-run average total cost falls as the quantity of output increases
  - ▶ Increasing specialization among workers
- ▶ Constant returns to scale
  - ▶ Long-run average total cost stays the same as the quantity of output changes
- ▶ Diseconomies of scale
  - ▶ Long-run average total cost rises as the quantity of output increases
  - ▶ Increasing coordination problems