N. GREGORY
MANKIW

PRINCIPLES OF

ECONOMICS

Eight Edition

CHAPTER

13

The Costs of Production

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What are Costs?, Part 1

- ## Industrial organization
  - The study of how firms' decisions about prices and quantities depend on the market conditions they face

- ## Assumption
  - The goal of a firm is to maximize profit

- ## Profit
  - Total revenue minus total cost

What are Costs?, Part 2

- Total revenue, TR = P × Q
  - Amount a firm receives for the sale of its output
  - Quantity of output the firm produces times the price at which it sells its output

- Total cost, TC
  - Market value of the inputs a firm uses in production

What are Costs?, Part 3

- Costs as opportunity costs
  - The cost of something is what you give up to get it

- Firm's cost of production
  - Include all the opportunity costs of making its output of goods and services
  - Explicit costs
  - Implicit costs

What are Costs?, Part 4

- Explicit costs
  - Input costs that require an outlay of money by the firm

- Implicit costs
  - Input costs that do not require an outlay of money by the firm
  - Ignored by accountants

- Total costs

  = Explicit costs + Implicit costs

- The cost of financial capital as an opportunity cost
  - Implicit cost
  - Interest income not earned on financial capital
    - Owned as saving
    - Invested in business
  - Not shown as cost by an accountant

What are Costs?, Part 6

- ## Economic profit
  - Total revenue minus total cost
    - Total costs includes both explicit and implicit costs

- ## Accounting profit
  - Total revenue minus total explicit cost
  - Usually larger than economic profit

Figure 1   Economists versus Accountants
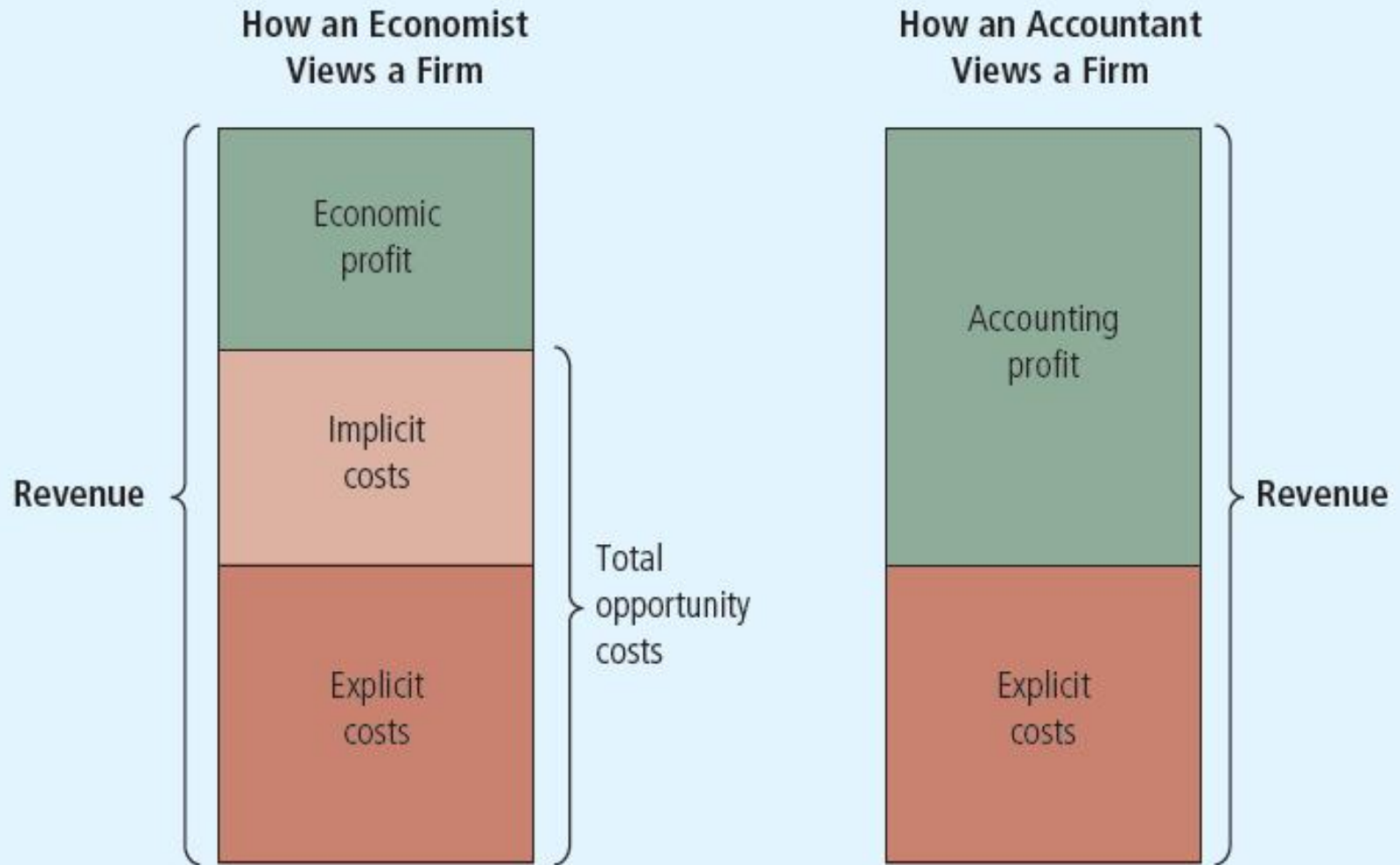
Economists include all opportunity costs when analyzing a firm, whereas accountants measure only explicit costs. Therefore, economic profit is smaller than accounting profit.

Production and Costs, Part 1

- 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

- Marginal product
  - Increase in output that arises from an additional unit of input
  - Slope of the production function

Table 1 A Production Function and Total Cost: Caroline's Cookie Factory

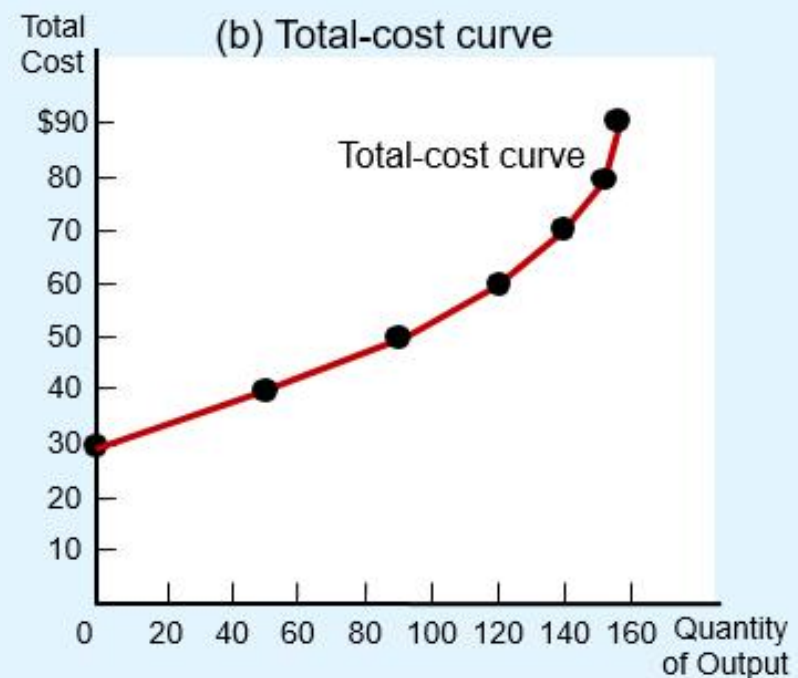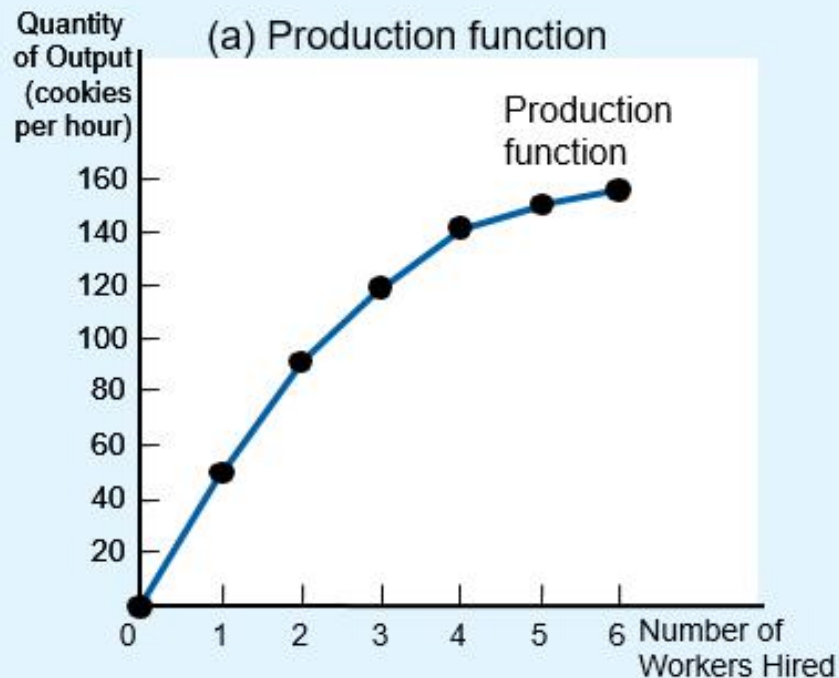| (1) Number of Workers	(2) Output (quantity of cookies produced per hour)	(3) Marginal Product of Labor	(4) Cost of Factory	(5) Cost of Workers	(6) Total Cost of Inputs (cost of factory plus cost of workers)
0	0		$30	$0	$30
1	50	50	30	10	40
2	90	40	30	20	50
3	120	30	30	30	60
4	140	20	30	40	70
5	150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

Production and Costs, Part 2

- Diminishing marginal product
    - Marginal product of an input declines as the quantity of the input increases
    - Production function gets flatter as more inputs are being used
    - The slope of the production function decreases

Production and Costs, Part 3

- ## Total-cost curve

  - Relationship between quantity produced and total costs

  - Gets steeper as the amount produced rises

    - Diminishing marginal product

    - Producing one additional unit of output requires a lot of additional units of inputs: very costly

Figure 2 Caroline's Production Function and Total-Cost Curve

(a) Production function — Quantity of Output (cookies per hour) on the vertical axis (20 to 160), Number of Workers Hired on the horizontal axis (0 to 6). Curve labeled "Production function."

(b) Total-cost curve — Total Cost on the vertical axis ($10 to $90), Quantity of Output on the horizontal axis (0 to 160). Curve labeled "Total-cost curve."

The production function in panel (a) shows the relationship between the number of workers hired and the quantity of output produced. Here the number of workers hired (on the horizontal axis) is from column (1) in Table 1, and the quantity of output produced (on the vertical axis) is from column (2). The production function gets flatter as the number of workers increases, reflecting diminishing marginal product.

The total-cost curve in panel (b) shows the relationship between the quantity of output produced and total cost of production. Here the quantity of output produced (on the horizontal axis) is from column (2) in Table 1, and the total cost (on the vertical axis) is from column (6). The total-cost curve gets steeper as the quantity of output increases because of diminishing marginal product.

- ## Fixed costs, FC
    - Costs that do not vary with the quantity of output produced

- ## Variable costs, VC
    - Costs that vary with the quantity of output produced
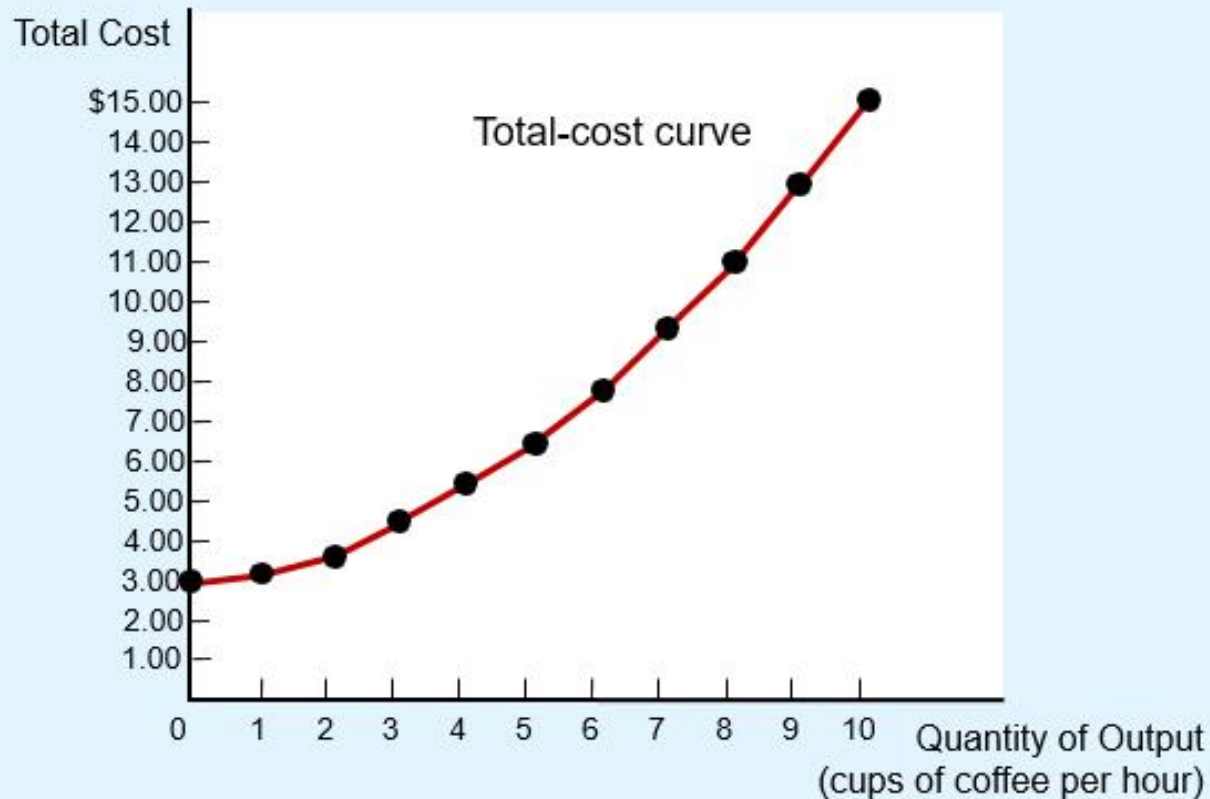
- ## Total cost, TC
    = Fixed cost + Variable cost

The Various Measures of Cost, Part 2

- ## Average fixed cost, AFC
  - Fixed cost divided by the quantity of output

- ## Average variable cost, AVC
  - Variable cost divided by the quantity of output

Table 2 The Various Measures of Cost: Conrad's Coffee Shop

(1) Output (cups of coffee per hour)	(2) Total Cost	(3) Fixed Cost	(4) Variable Cost	(5) Average Fixed Cost	(6) Average Variable Cost	(7) Average Total Cost	(8) 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

Figure 3   Conrad's Total-Cost Curve

Here the quantity of output produced (on the horizontal axis) is from column (1) in Table 2, and the total cost (on the vertical axis) is from column (2). As in Figure 2, the total-cost curve gets steeper as the quantity of output increases because of diminishing marginal product.

The Various Measures of Cost, Part 3

- 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

- 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

The Various Measures of Cost, Part 5

- **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

The Various Measures of Cost, Part 6

- ## 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

Figure 4 Conrad's Average-Cost and Marginal-Cost Curves

Costs

Quantity of Output (cups of coffee per hour)
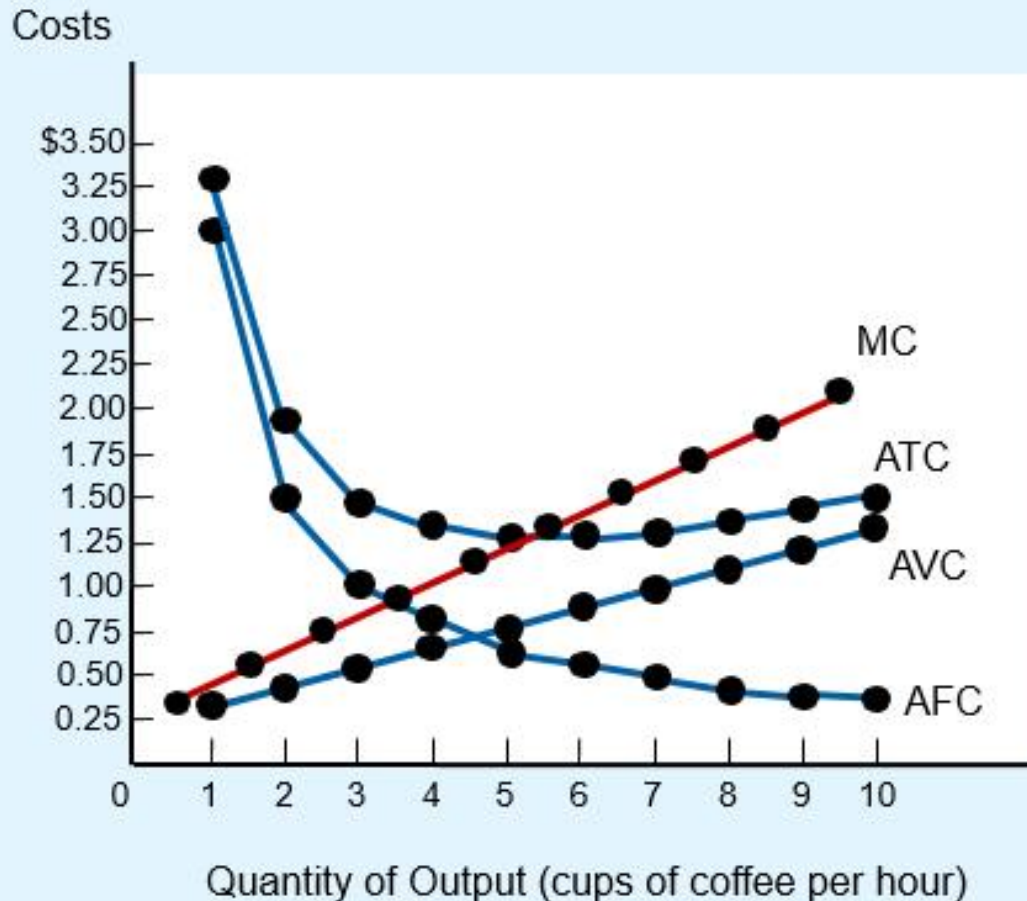
This figure shows the average total cost (ATC), average fixed cost (AFC), average variable cost (AVC), and marginal cost (MC) for Conrad's Coffee Shop.

All of these curves are obtained by graphing the data in Table 2. These cost curves show three common features:

(1) Marginal cost rises with the quantity of output.
(2) The average-total-cost curve is U-shaped.
(3) The marginal-cost curve crosses the average-total-cost curve at the minimum of average total cost.

- Typical cost curves
  - 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

# Figure 5 Cost Curves for a Typical Firm
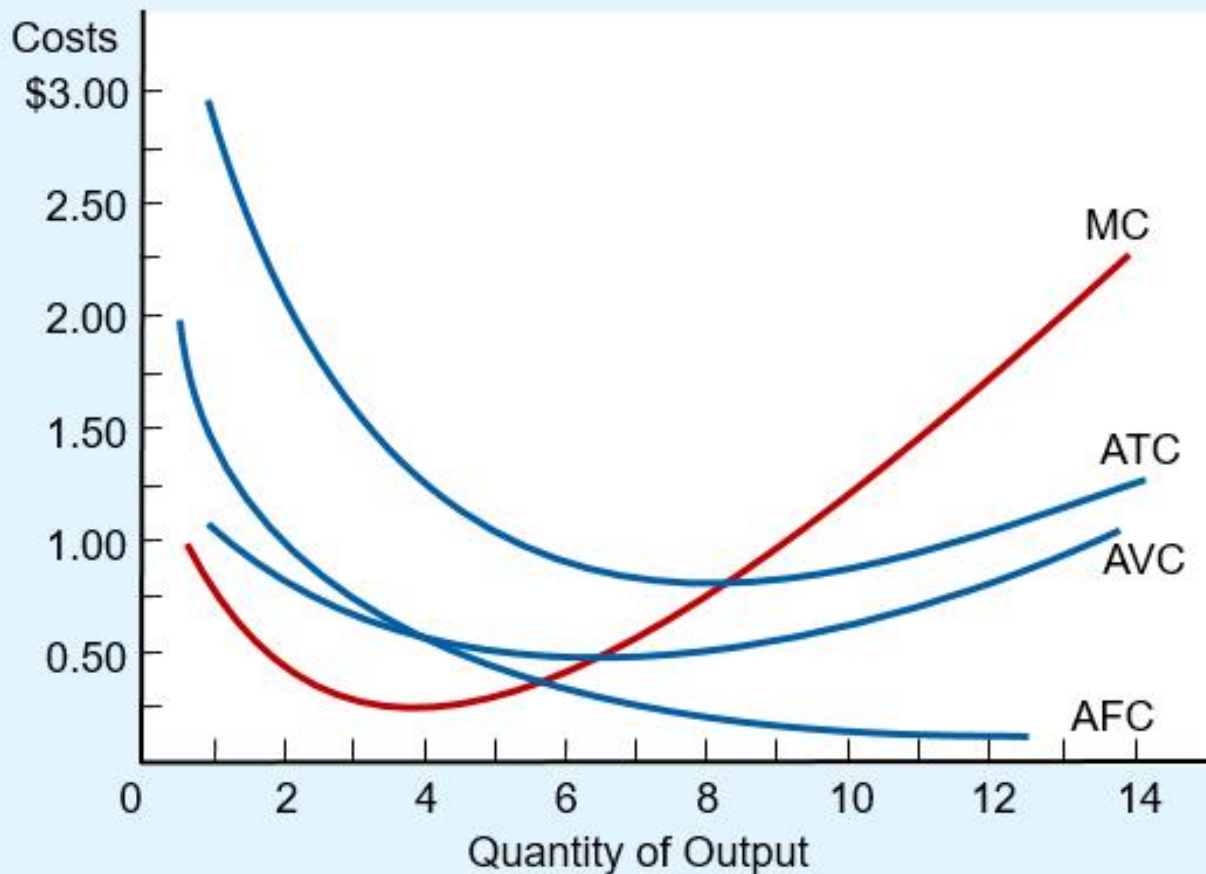
Many firms experience increasing marginal product before diminishing marginal product. As a result, they have cost curves shaped like those in this figure. Notice that marginal cost and average variable cost fall for a while before starting to rise.

- **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

Figure 6   Average Total Cost in Short & Long Runs
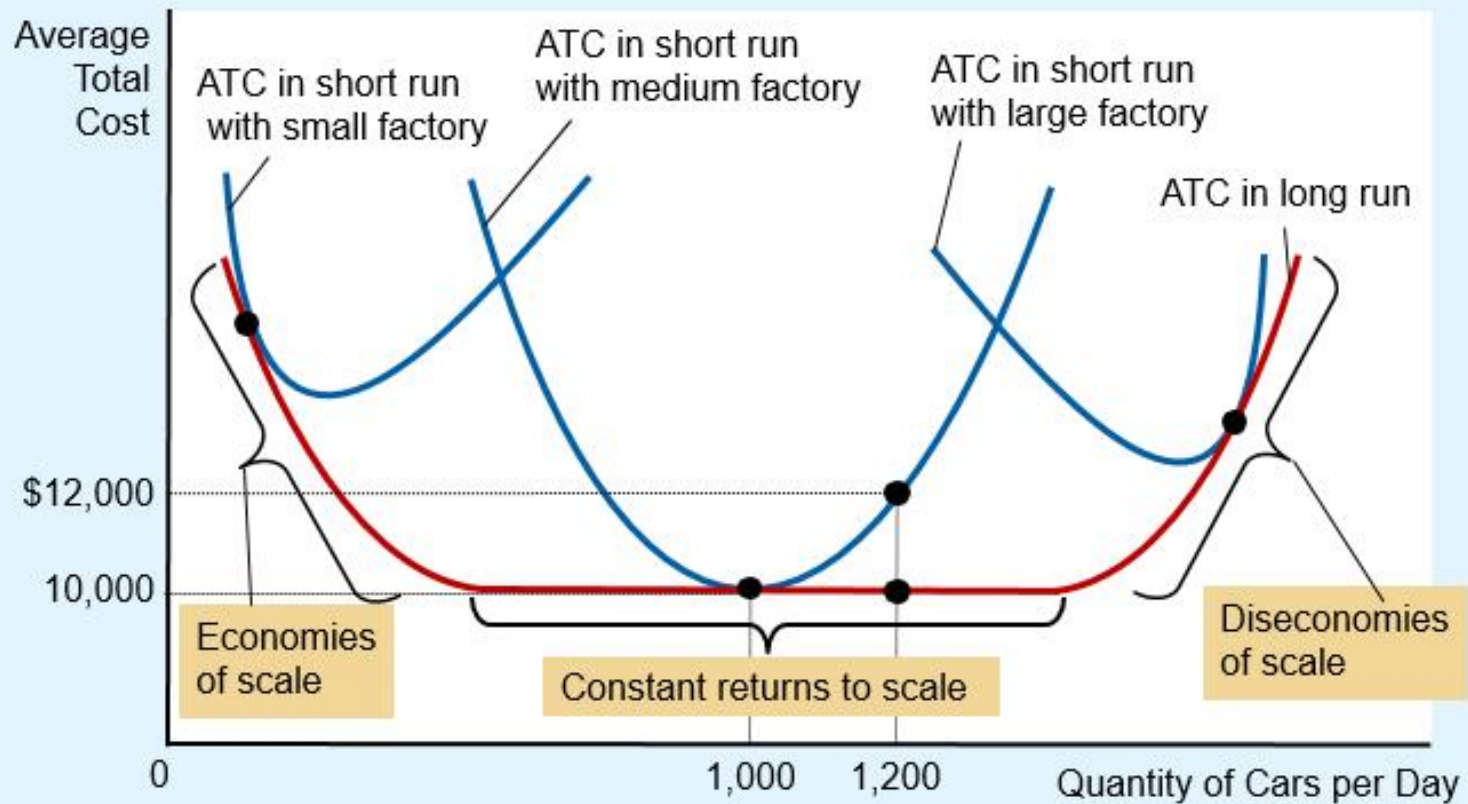
Because fixed costs are variable in the long run, the average-total-cost curve in the short run differs from the average-total-cost curve in the long run

- ## 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

Table 3 The Many Types of Cost: A Summary

Term	Definition	Mathematical Description
Explicit costs	Costs that require an outlay of money by the firm	
Implicit costs	Costs that do not require an outlay of money by the firm	
Fixed costs	Costs that do not vary with the quantity of output produced	FC
Variable costs	Costs that vary with the quantity of output produced	VC
Total cost	The market value of all the inputs that a firm uses in production	$TC = FC + VC$
Average fixed cost	Fixed cost divided by the quantity of output	$AFC = FC / Q$
Average variable cost	Variable cost divided by the quantity of output	$AVC = VC / Q$
Average total cost	Total cost divided by the quantity of output	$ATC = TC / Q$
Marginal cost	The increase in total cost that arises from an extra unit of production	$MC = \Delta TC / \Delta Q$