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PRINCIPLES OF

ECONOMICS

Eight Edition

CHAPTER

13

The Costs of Production

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Active Learning 1   Brainstorming costs

You run Ford Motor Company.

- List three different costs you have.

- List three different business decisions that are affected by your costs

Look for the answers to these questions:

- What is a production function? What is marginal product? How are they related?

- What are the various costs? 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.

Profit = Total revenue − Total cost

the amount a firm receives from the sale of its output

TR = P×Q

the market value of the inputs a firm uses in production

Costs: Explicit vs. Implicit

- 'The cost of something is what you give up to get it.'
- Explicit costs
  - Require an outlay of money
    - E.g., paying wages to workers.
- Implicit costs
  - Do not require a cash outlay
    - E.g., the opportunity cost of the owner's time.
- Total cost = Explicit + Implicit costs

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 = $5000 interest on loan
- Case 2: use $40,000 of your savings, borrow the other $60,000
  - explicit cost = $3000 (5%) interest on the loan
  - implicit cost = $2000 (5%) foregone interest you could have earned on your $40,000.

In both cases, total (exp + imp) costs are $5000

Economic Profit vs. Accounting Profit

- Accounting profit

  =total revenue minus total explicit costs

- Economic profit

  =total revenue minus total costs (including explicit and implicit costs)

- Accounting profit ignores implicit costs, so it's higher than economic profit.

Active Learning 2

Economic profit vs. accounting profit

The equilibrium rent on office space has just increased by $500/month.

Determine the effects on accounting profit and economic profit if:

   a. you rent your office space

   b. you own your office space

Active Learning 2   Answers

The rent on office space increases $500/month.

a. You rent your office space.

- Explicit costs increase $500/month. Accounting profit & economic profit each fall $500/month.

b. You own your office space.

- Explicit costs do not change, so accounting profit does not change.

- Implicit costs increase $500/month (opp. cost of using your space instead of renting it) so economic profit falls by $500/month.

Production Function

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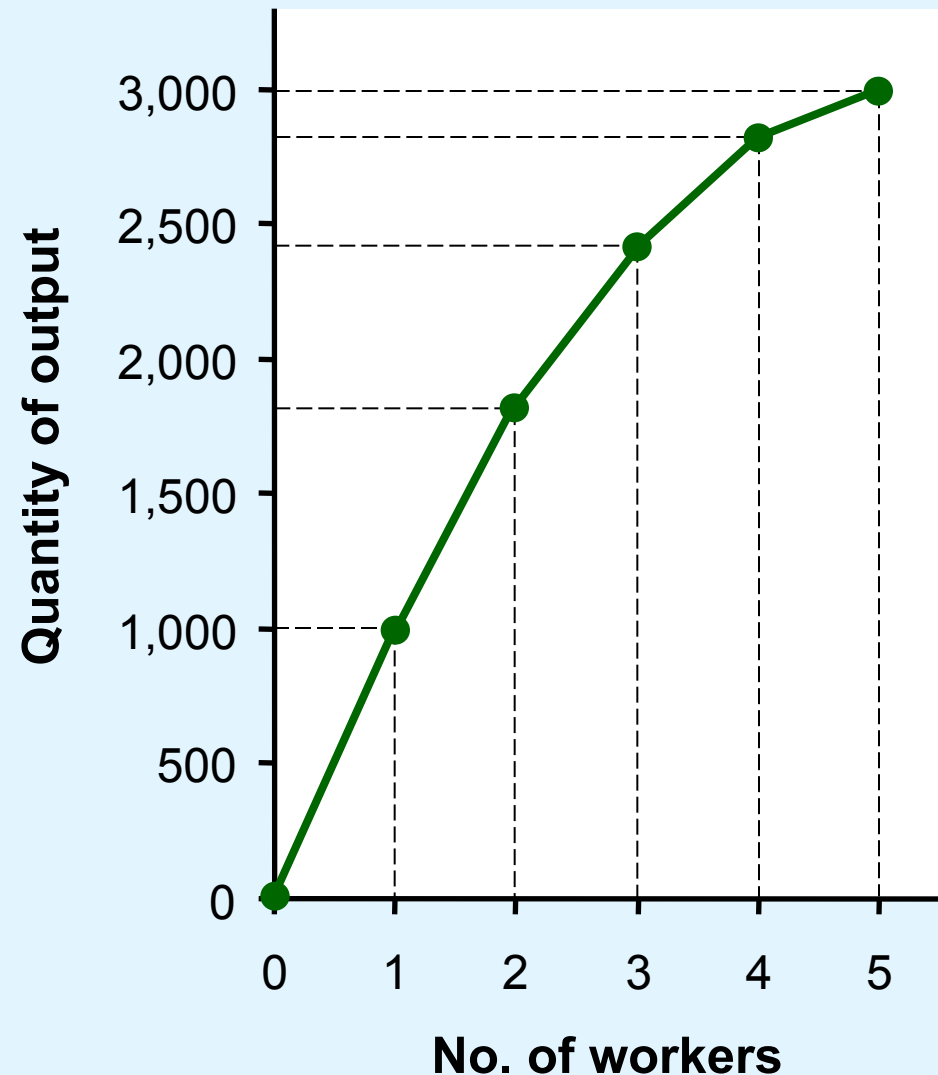 - Gets flatter as production rises

EXAMPLE 1: Farmer Jack

Example 1:

- Farmer Jack grows wheat.
- He has 5 acres of land (fixed resource).
- He can hire as many workers as he wants.
  - The quantity of output produced varies with the number of workers hired

EXAMPLE 1: Farmer Jack's Production Function

L (no. of workers)	Q (bushels of wheat)
0	0
1	1000
2	1800
3	2400
4	2800
5	3000

Marginal Product

- Marginal product
  - Increase in output that arises from an additional unit of input
    - Other inputs constant
  - Slope of the production function
- Marginal product of labor, MPL
  - MPL = $\Delta Q / \Delta L$
  - If Jack hires one more worker, his output rises by the marginal product of labor.

EXAMPLE 1: Total & Marginal Product

| L (no. of workers)	Q (bushels of wheat)		MPL
0	0		
$\Delta L = 1$		$\Delta Q = 1000$	1000
1	1000		
$\Delta L = 1$		$\Delta Q = 800$	800
2	1800		
$\Delta L = 1$		$\Delta Q = 600$	600
3	2400		
$\Delta L = 1$		$\Delta Q = 400$	400
4	2800		
$\Delta L = 1$		$\Delta Q = 200$	200
5	3000		

Diminishing MPL

- 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

EXAMPLE 1: MPL = Slope of Prod Function

L (no. of workers)	Q (bushels of wheat)	MPL
0	0	
		1000
1	1000	
		800
2	1800	
		600
3	2400	
		400
4	2800	
		200
5	3000	
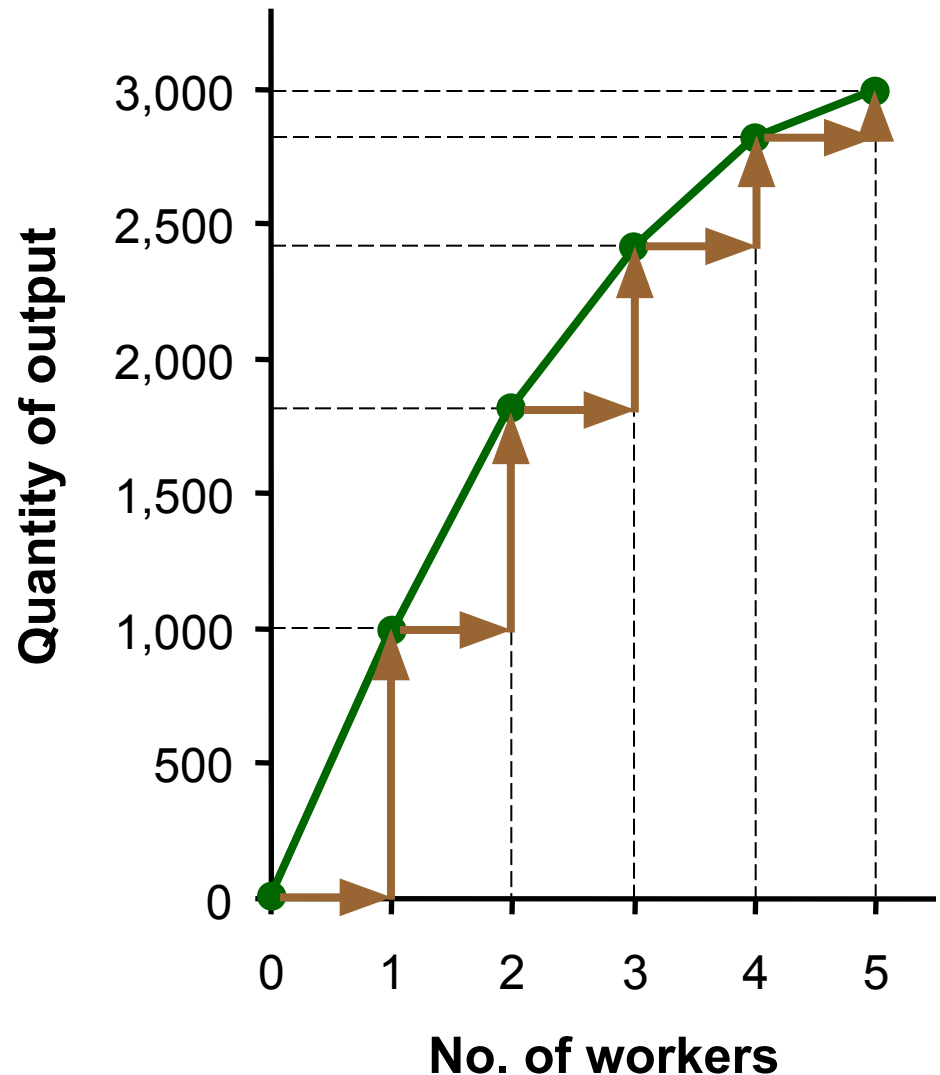
Why MPL Is Important

- 'Rational people think at the margin'
- When Farmer Jack hires an extra worker
  - His costs rise by the wage he pays the worker
  - His output rises by MPL
  - Comparing them helps Jack decide whether he should hire the worker.

Why MPL Diminishes

- Farmer Jack's output rises by a smaller and smaller amount for each additional worker. Why?

  – As Jack adds workers, the average worker has less land to work with and will be less productive.

  – In general, MPL diminishes as L rises whether the fixed input is land or capital (equipment, machines, etc.).

EXAMPLE 1: Farmer Jack's Costs

Farmer Jack must pay $1000 per month for the land, regardless of how much wheat he grows.

The market wage for a farm worker is $2000 per month.

- So Farmer Jack's costs are related to how much wheat he produces….

EXAMPLE 1: Farmer Jack's Costs

L (no. of workers)	Q (bushels of wheat)	Cost of land	Cost of labor	Total cost
0	0	$1,000	$0	$1,000
1	1000	$1,000	$2,000	$3,000
2	1800	$1,000	$4,000	$5,000
3	2400	$1,000	$6,000	$7,000
4	2800	$1,000	$8,000	$9,000
5	3000	$1,000	$10,000	$11,000

EXAMPLE 1: Farmer Jack's Total Cost Curve

| Q (bushels of wheat)	Total Cost
0	$1,000
1000	$3,000
1800	$5,000
2400	$7,000
2800	$9,000
3000	$11,000
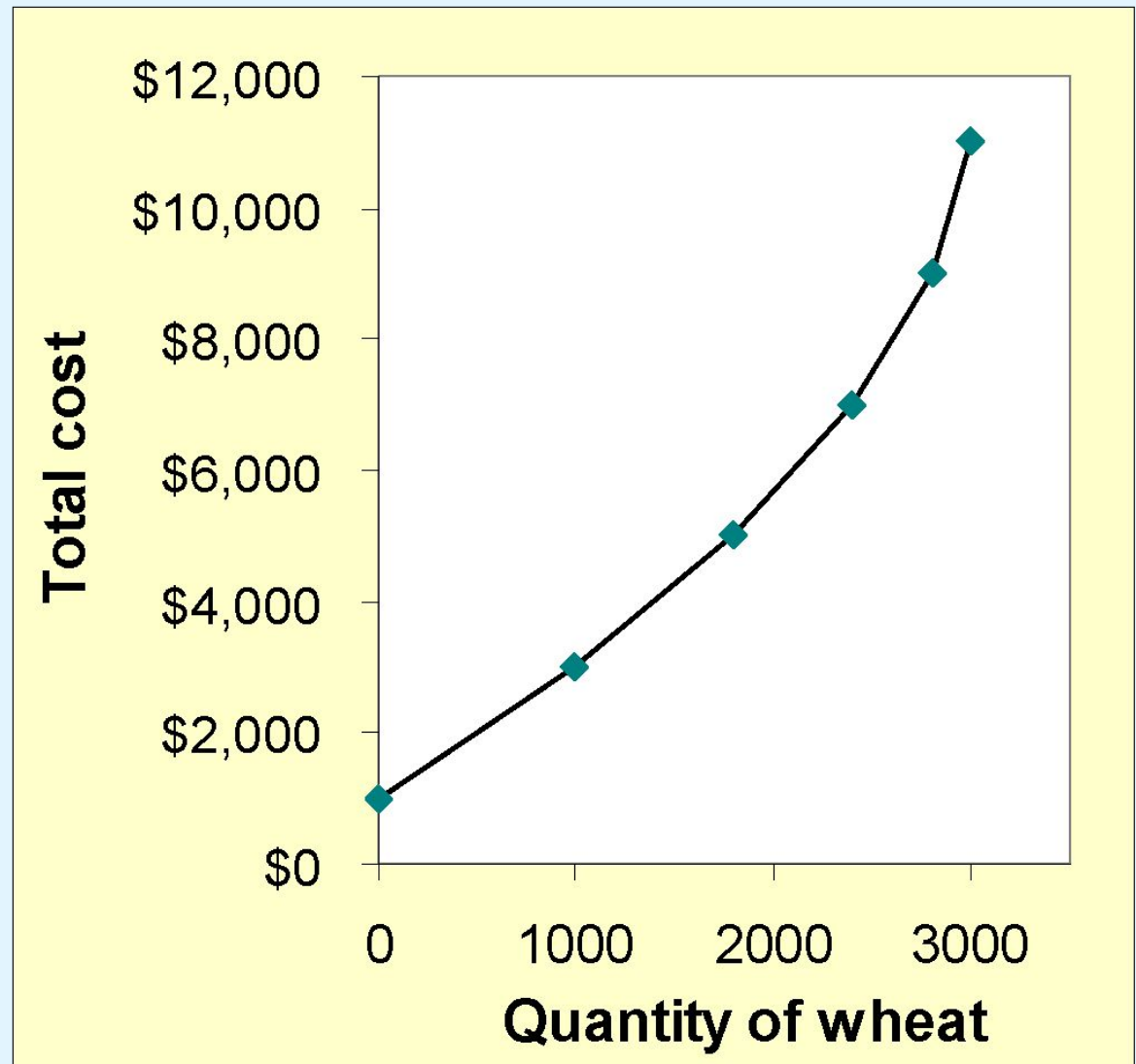
Marginal Cost

- ## 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

EXAMPLE 1: Total and Marginal Cost

Q (bushels of wheat)	Total Cost		Marginal Cost (*MC*)
0	$1,000		
ΔQ = 1000		ΔTC = $2000	$2.00
1000	$3,000		
ΔQ = 800		ΔTC = $2000	$2.50
1800	$5,000		
ΔQ = 600		ΔTC = $2000	$3.33
2400	$7,000		
ΔQ = 400		ΔTC = $2000	$5.00
2800	$9,000		
ΔQ = 200		ΔTC = $2000	$10.00
3000	$11,000		

EXAMPLE 1: The Marginal Cost Curve

Q (bushels of wheat)	TC	MC
0	$1,000	
		$2.00
1000	$3,000	
		$2.50
1800	$5,000	
		$3.33
2400	$7,000	
		$5.00
2800	$9,000	
		$10.00
3000	$11,000	
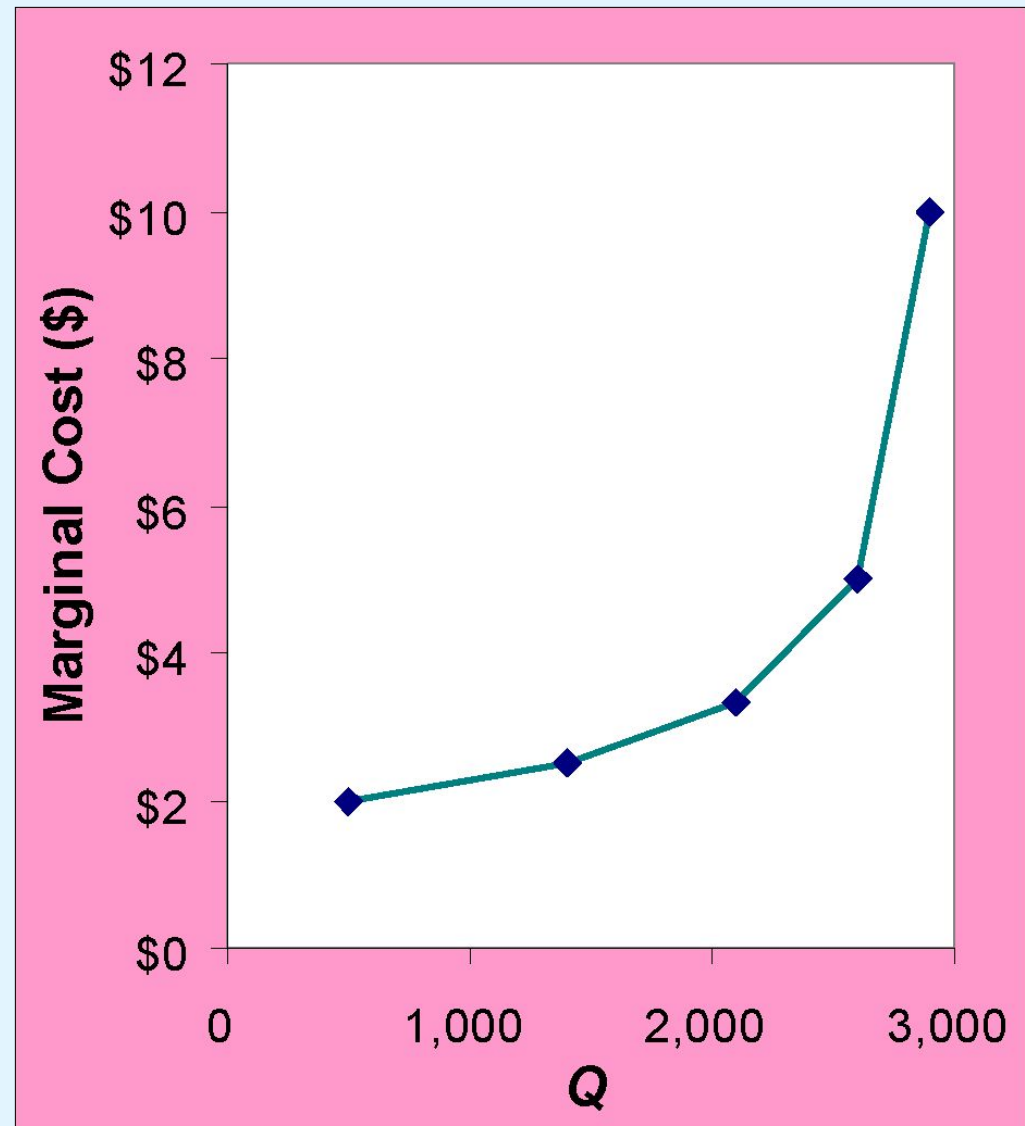
Why MC Is Important

- Farmer Jack is rational and wants to maximize his profit
  - To increase profit, should he produce more or less wheat?
    - Farmer Jack needs to "think at the margin"
  - If the cost of additional wheat (MC) is less than the revenue he would get from selling it, then Jack's profits rise if he produces more.
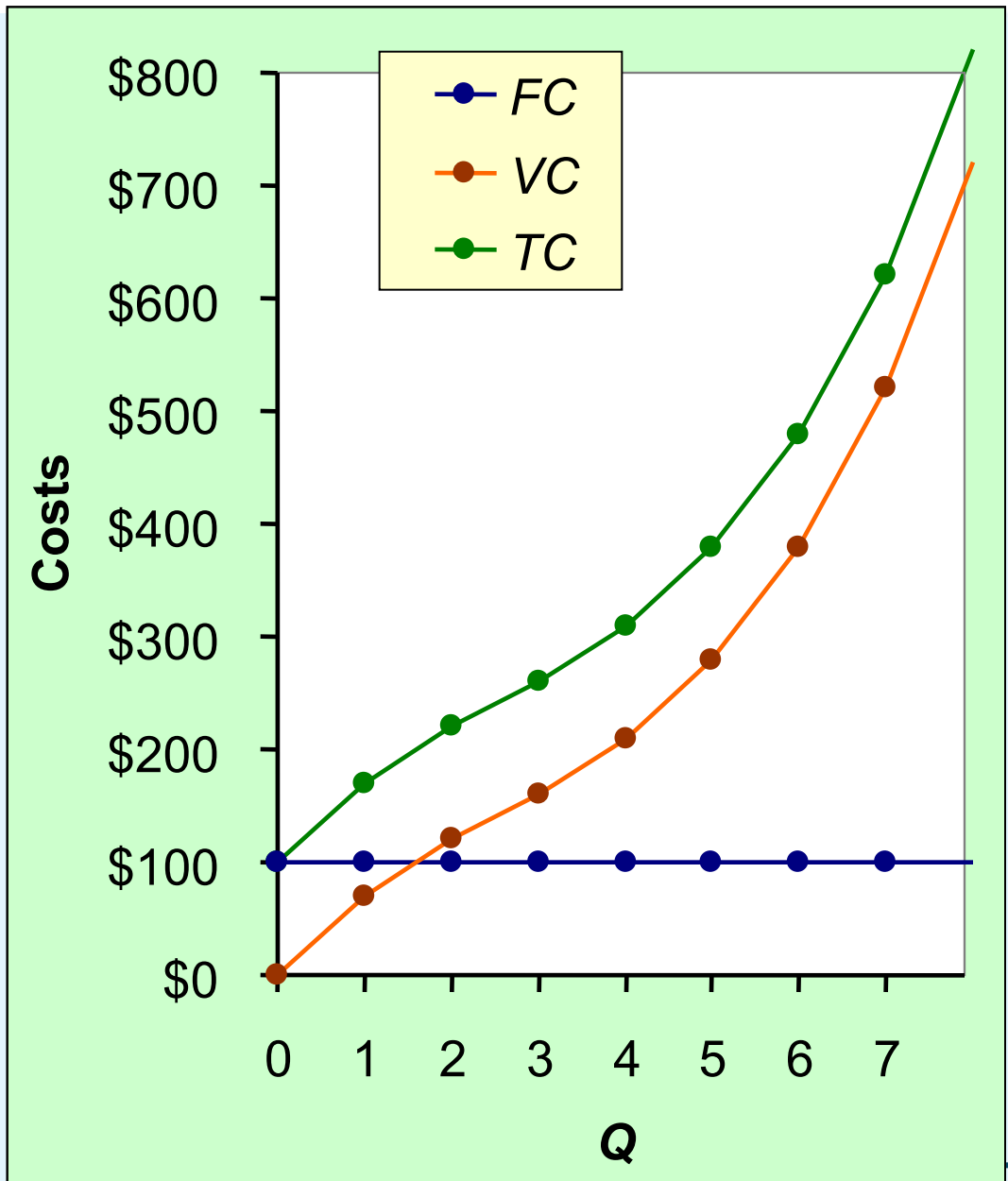
Fixed and Variable Costs

- **Fixed costs, FC,** do not vary with the quantity of output produced
  - For Farmer Jack, FC = $1000 for his land
  - Other examples: cost of equipment, loan payments, rent

- **Variable costs, VC,** vary with the quantity of output produced
  - For Farmer Jack, VC = wages he pays workers
  - Other example: cost of materials

- **Total cost = Fixed cost + Variable cost**

EXAMPLE 2: Production Costs

- Our second example is more general, applies to any type of firm producing any good with any types of inputs.

  - Calculate and graph TC knowing FC and VC

  - Calculate and graph marginal and average costs

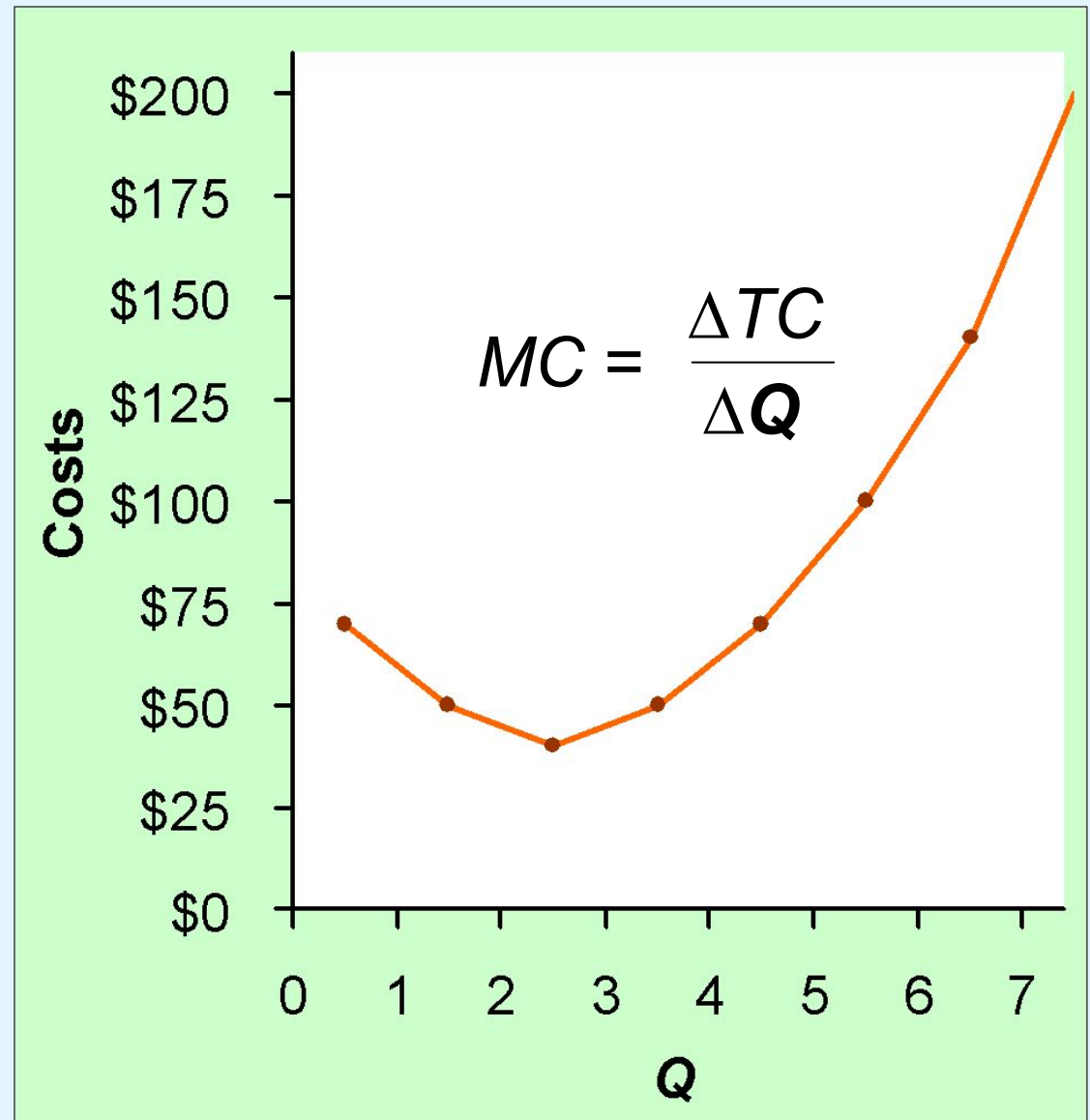 - Understand the relationship between marginal cost and average cost

EXAMPLE 2: Costs: TC = FC + VC

Q	FC	VC	TC
0	$100	$0	$100
1	100	70	170
2	100	120	220
3	100	160	260
4	100	210	310
5	100	280	380
6	100	380	480
7	100	520	620

EXAMPLE 2: Marginal Cost

Q	TC	MC
0	$100	
		$70
1	170	
		50
2	220	
		40
3	260	
		50
4	310	
		70
5	380	
		100
6	480	
		140
7	620	

$$MC = \frac{\Delta TC}{\Delta Q}$$

EXAMPLE 2: Average Fixed Cost, AFC

Q	FC	AFC
0	$100	n/a
1	100	$100
2	100	50
3	100	33.33
4	100	25
5	100	20
6	100	16.67
7	100	14.29
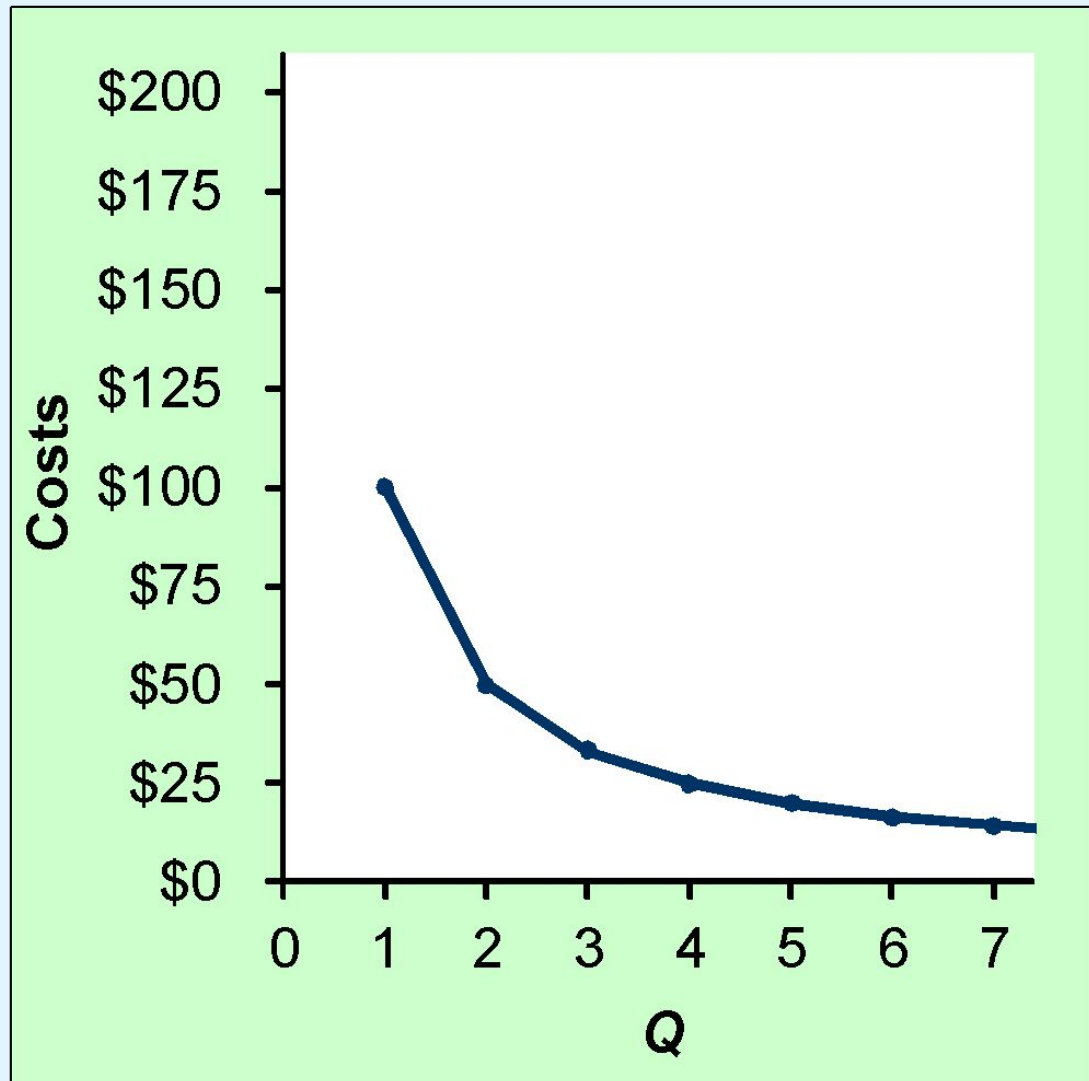
EXAMPLE 2: Average Variable Cost, AVC

Q	VC	AVC
0	$0	n/a
1	70	$70
2	120	60
3	160	53.33
4	210	52.50
5	280	56.00
6	380	63.33
7	520	74.29
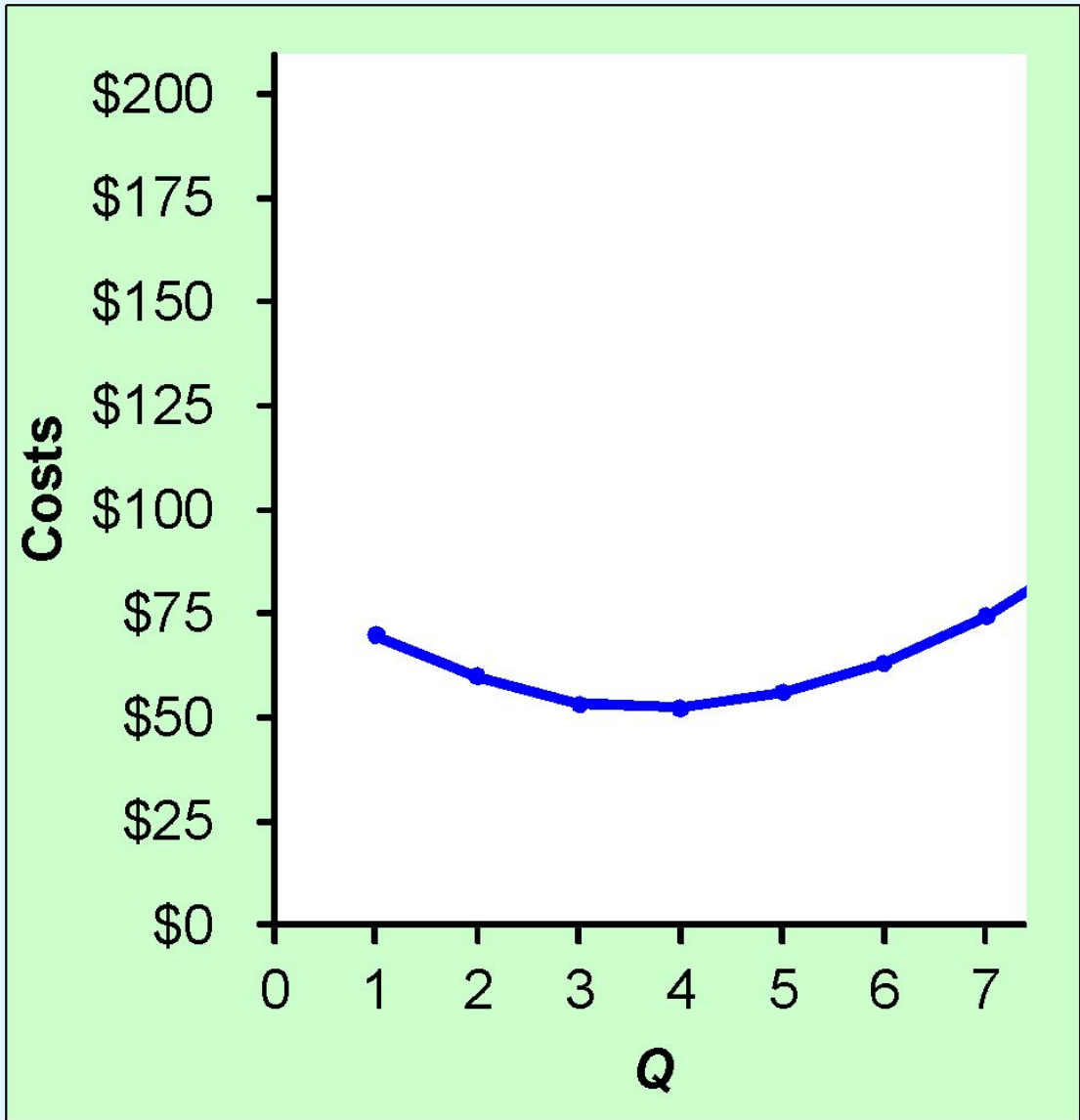
EXAMPLE 2: Average Total Cost

Q	TC	ATC	AFC	AVC
0	$100	n/a	n/a	n/a
1	170	$170	$100	$70
2	220	110	50	60
3	260	86.67	33.33	53.33
4	310	77.50	25	52.50
5	380	76	20	56.00
6	480	80	16.67	63.33
7	620	88.57	14.29	74.29

Average total cost (ATC) equals total cost divided by the quantity of output:
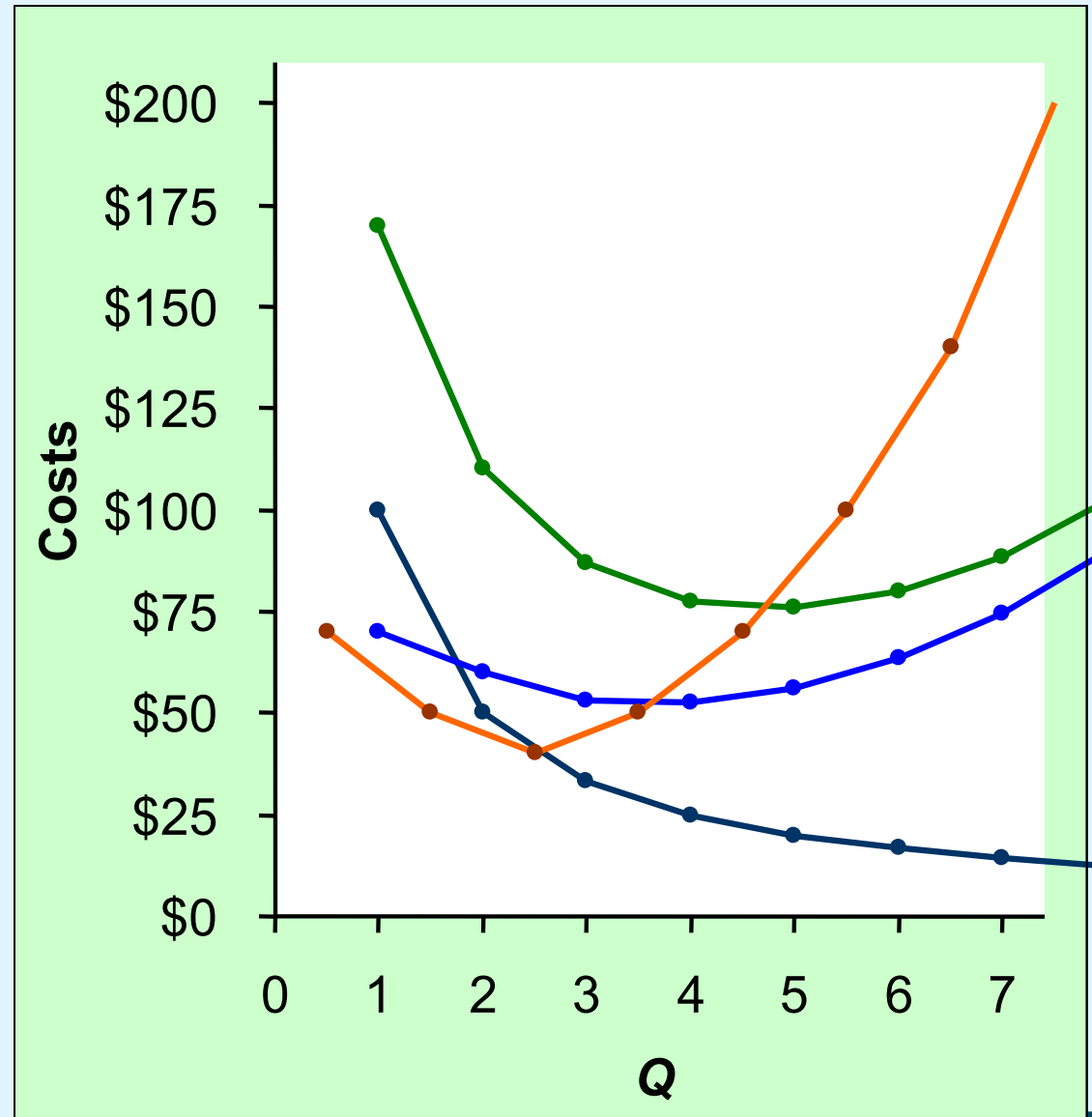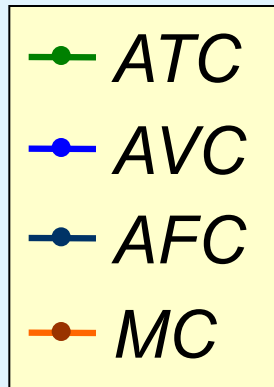
$$ATC = TC/Q$$

Also,

$$ATC = AFC + AVC$$

EXAMPLE 2: Average Total Cost, usually U-shaped

Q	TC	ATC
0	$100	n/a
1	170	$170
2	220	110
3	260	86.67
4	310	77.50
5	380	76
6	480	80
7	620	88.57

As Q rises: initially, falling AFC pulls ATC down.

Eventually, rising AVC pulls ATC up.

Efficient scale
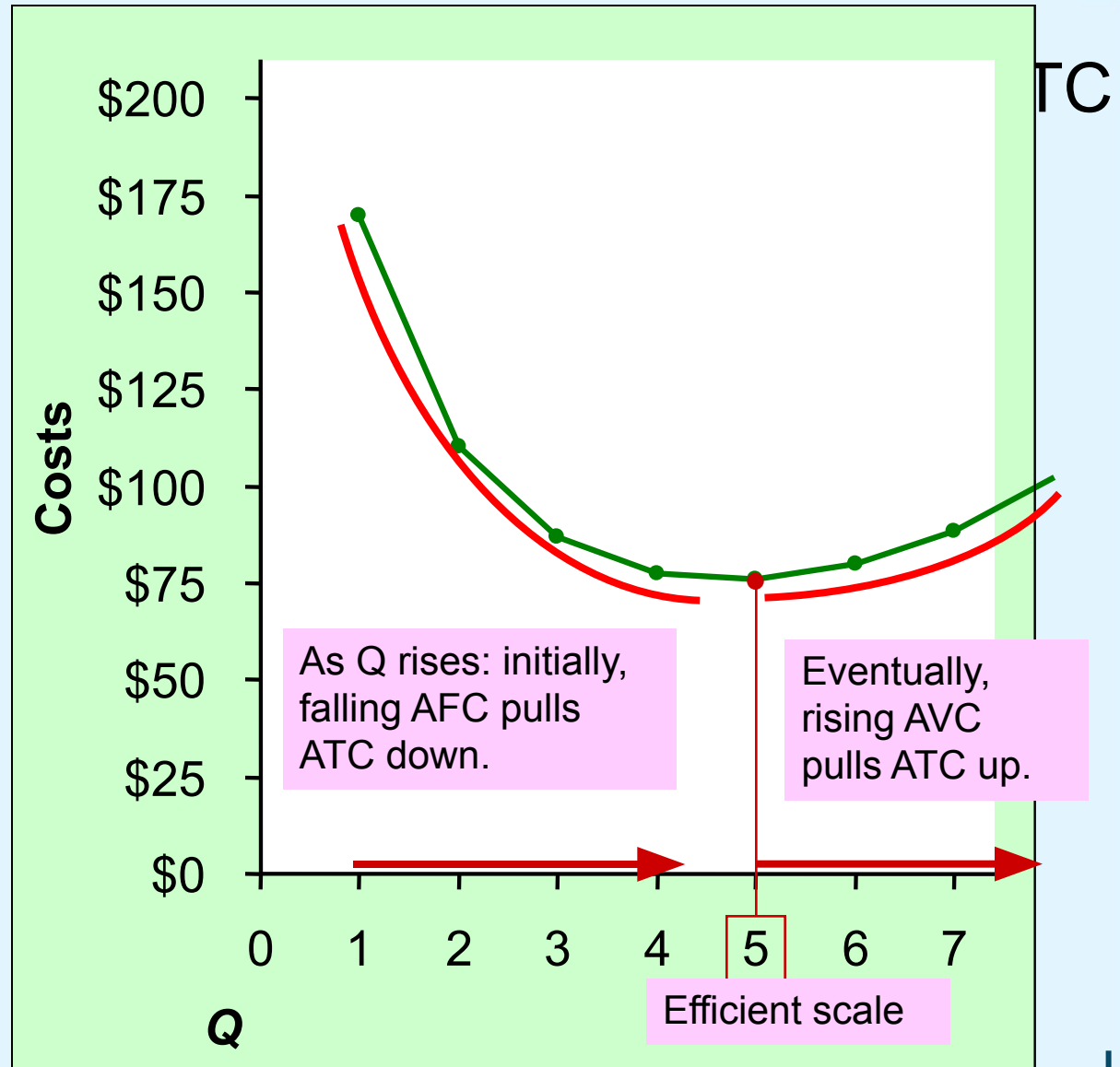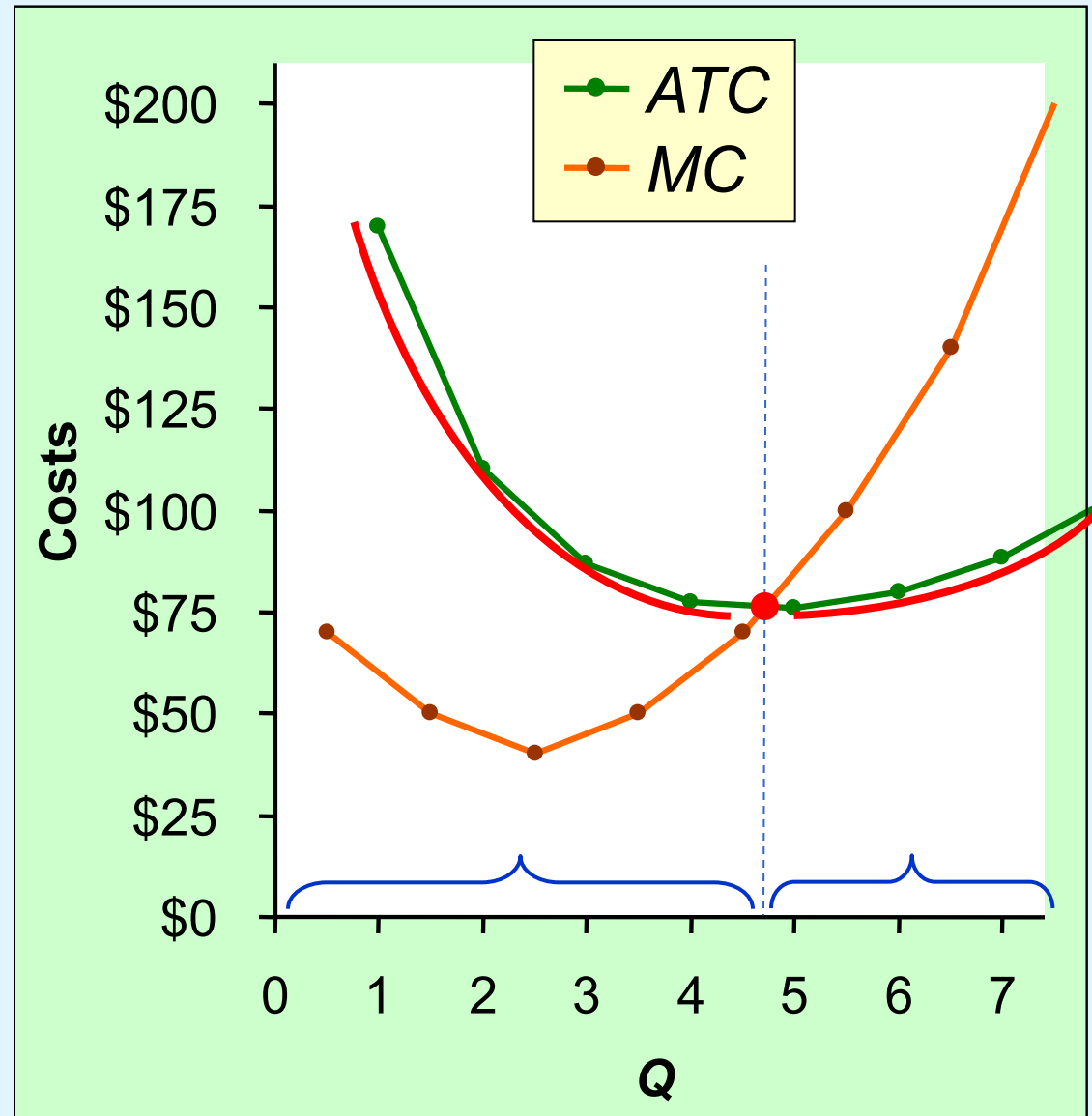
EXAMPLE 2: The Various Cost Curves Together

EXAMPLE 2: ATC and MC

When MC < ATC, ATC is falling.

When MC > ATC, ATC is rising.

The MC curve crosses the ATC curve
at the ATC curve's minimum.

Active Learning 3　Calculating costs

Fill in the blank spaces of this table.

Q	VC	TC	AFC	AVC	ATC	MC
0		$50	n/a	n/a	n/a	
						$10
1	10			$10	$60.00	
2	30	80				
						30
3			16.67	20	36.67	
4	100	150	12.50		37.50	
5	150			30		
						60
6	210	260	8.33	35	43.33	

# Costs in the Short Run & Long Run

- ## Short run:
  - Some inputs are fixed (e.g., factories, land)
  - The costs of these inputs are FC

- ## Long run:
  - All inputs are variable (e.g., firms can build more factories or sell existing ones)

- ## In the long run
  - ATC at any Q is cost per unit using the most efficient mix of inputs for that Q (e.g., the factory size with the lowest ATC)

EXAMPLE 3: LRATC with 3 factory sizes

Firm can choose from three factory sizes: S, M, L.

Each size has its own SRATC curve.

The firm can change to a different factory size in the long run, but not in the short run.

Avg Total Cost

ATC_S ATC_M ATC_L

Q
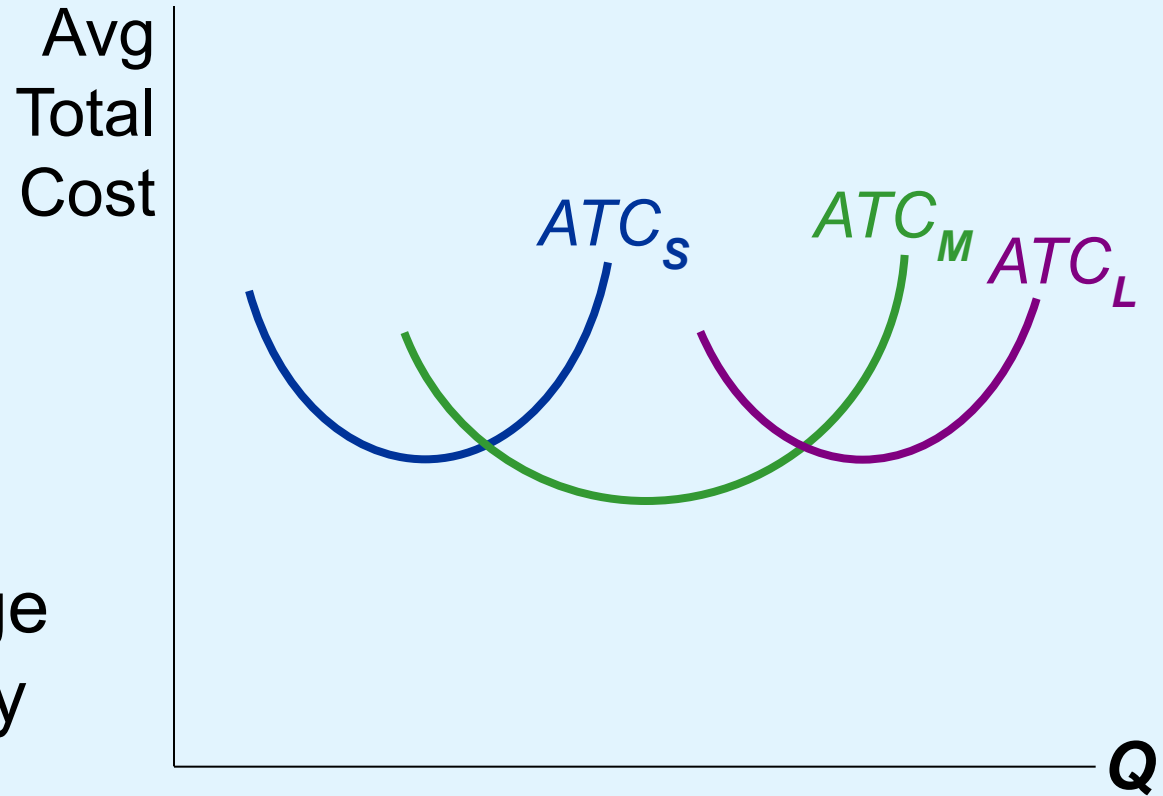
EXAMPLE 3: LRATC with 3 factory sizes

To produce less than Q_A, firm will choose size S in the long run.

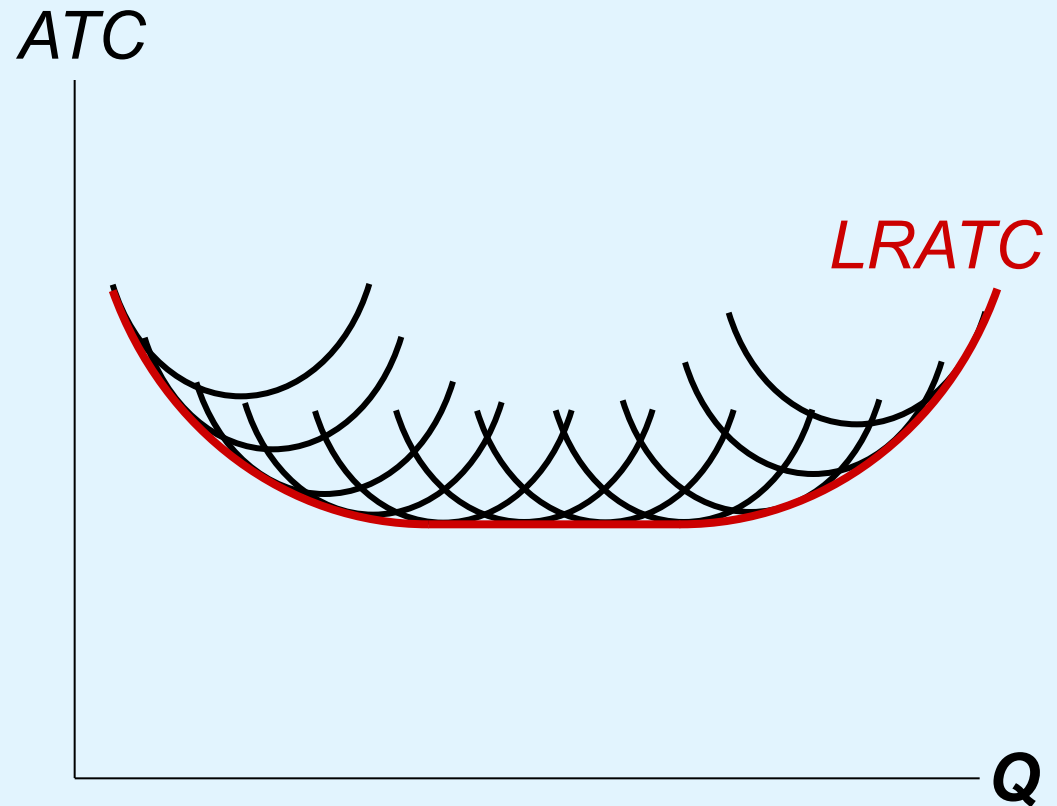To produce between Q_A and Q_B, firm will choose size M in the long run.

To produce more than Q_B, firm will choose size L in the long run.

Avg Total Cost

ATC_S ATC_M ATC_L

LRATC

Q

Q_A Q_B
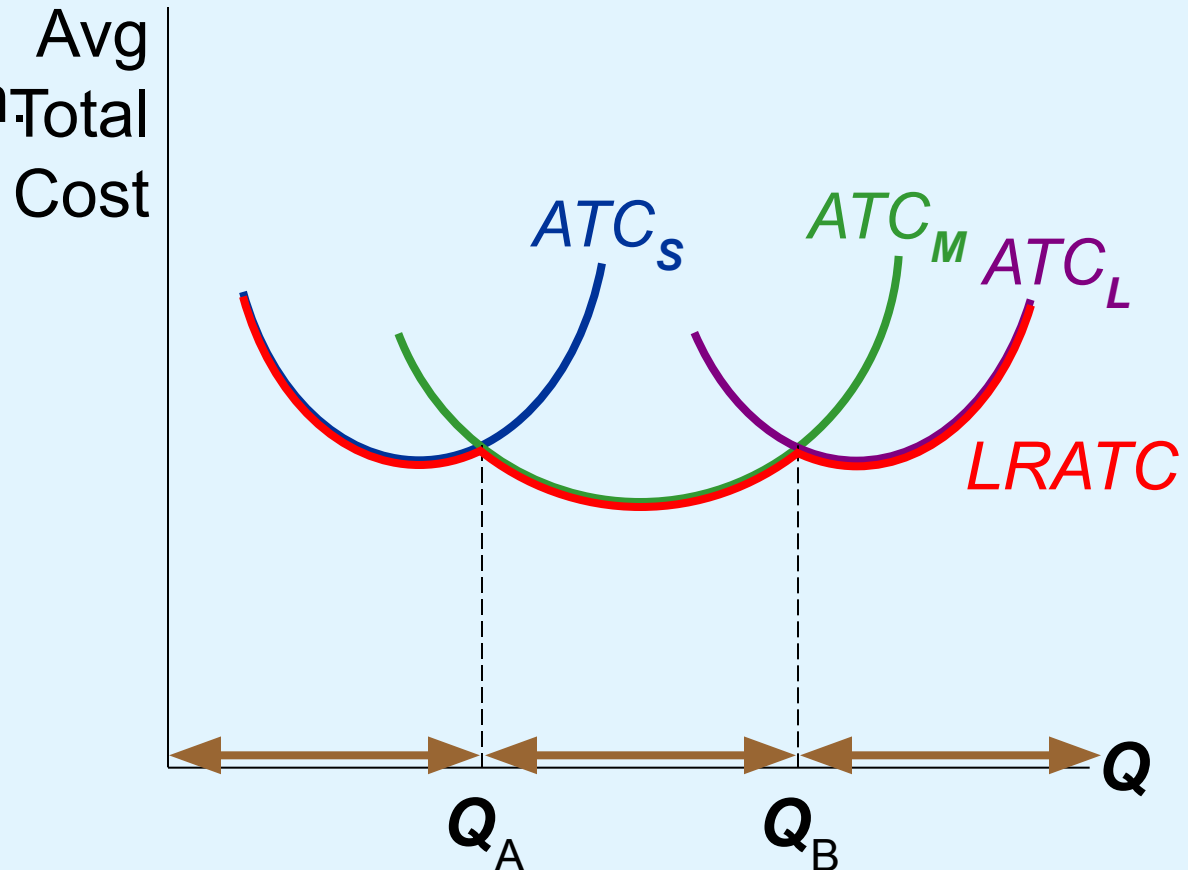
A Typical LRATC Curve

In the real world, factories come in many sizes, each with its own SRATC curve.
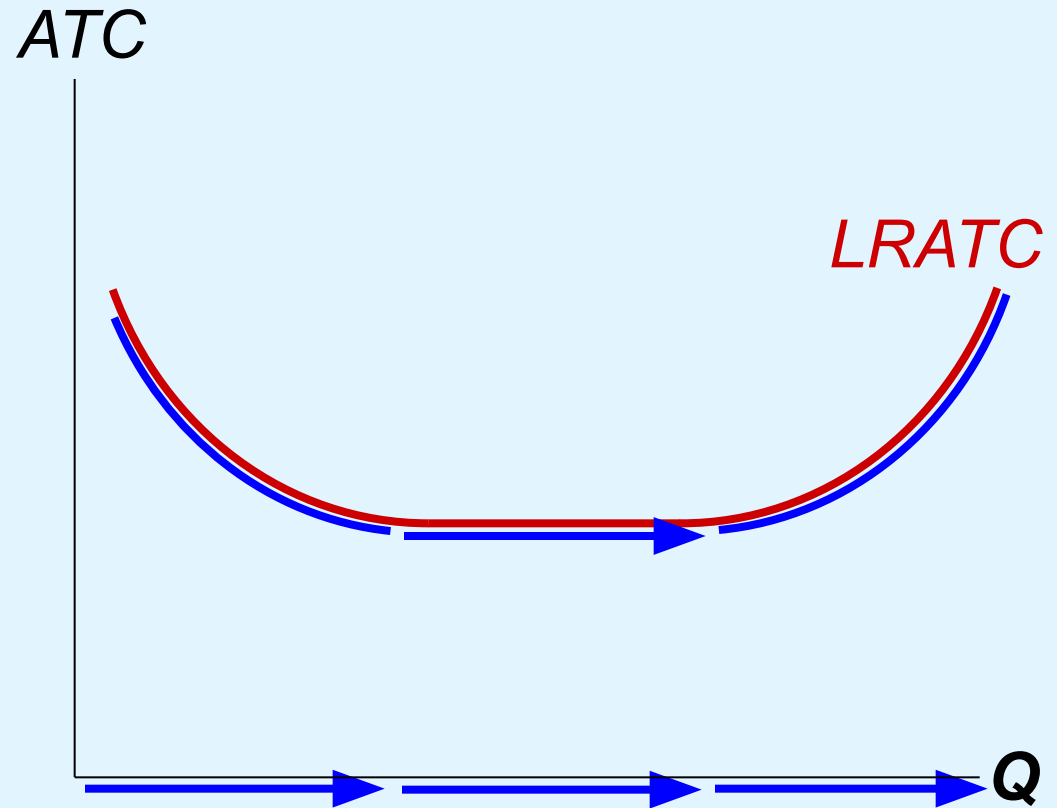
So a typical LRATC curve looks like this:

ATC

LRATC

Q

How ATC Changes as the Scale of Production Changes

Economies of scale: ATC falls as Q increases.

Constant returns to scale: ATC stays the same as Q increases.

Diseconomies of scale: ATC rises as Q increases.

ATC

LRATC

Q

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
    - More common when Q is low

- **Constant returns to scale**
  - Long-run average total cost stays the same as the quantity of output changes

Costs in Short and Long Run

- Diseconomies of scale
  - Long-run average total cost rises as the quantity of output increases
  - Increasing coordination problems in large organizations.
    - E.g., management becomes stretched, can't control costs.
    - More common when Q is high.

Summary

- The goal of firms is to maximize profit, which equals total revenue minus total cost.

- When analyzing a firm's behavior, it is important to include all the opportunity costs of production.
  - Explicit: wages a firm pays its workers
  - Implicit: wages the firm owner gives up by working at the firm rather than taking another job

- Economic profit takes both explicit and implicit costs into account, whereas accounting profit considers only explicit costs.

Summary

- A firm's costs reflect its production process.
  - Diminishing marginal product: production function gets flatter as Q of an input increases
  - Total-cost curve gets steeper as the quantity produced rises.
- Firm's total costs = fixed costs + variable costs.
  - Fixed costs: do not change when the firm alters the quantity of output produced.
  - Variable costs: change when the firm alters the quantity of output produced.

Summary

- Average total cost is total cost divided by the quantity of output.

- Marginal cost is the amount by which total cost rises if output increases by 1 unit.

- Graph average total cost and marginal cost.
  - Marginal cost rises with the quantity of output.
  - Average total cost first falls as output increases and then rises as output increases further.
  - The marginal-cost curve always crosses the average total-cost curve at the minimum of average total cost

Summary

- A firm's costs often depend on the time horizon considered.
  - In particular, many costs are fixed in the short run but variable in the long run.
  - As a result, when the firm changes its level of production, average total cost may rise more in the short run than in the long run.