CHAPTER 13

The Costs of Production

PRINCIPLES OF
Microeonomics

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In this chapter, 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, 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 <u>the firm's goal is to maximize profit</u>.

Profit = Total revenue – Total cost

Total revenue: the amount a firm receives from the sale of its output

Total cost: the market value of the inputs a firm uses in production

Costs: Explicit vs. Implicit

- **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.
- Remember one of the Ten Principles:

  The cost of something is what you give up to get it.
- This is true whether the costs are implicit or explicit. Both matter for firms' decisions.

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.

Compare 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.

The Production Function

- A **production function** shows the relationship between the quantity of inputs used to produce a good and the quantity of output of that good.
- It can be represented by a table, equation, or graph.

$$Y = f\ (Land, Labor, Capital)$$
$$Y = f\ (L, K)$$

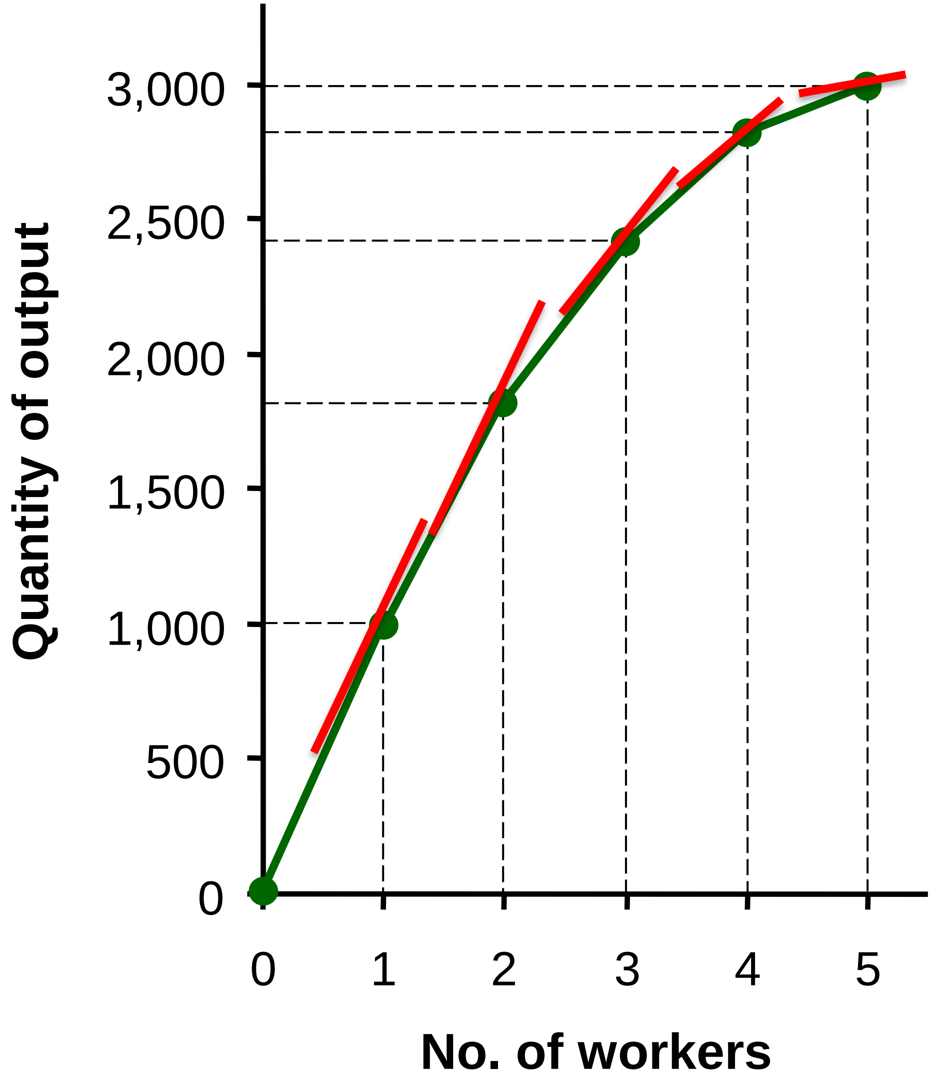
Y = Output

$$Y = 3L + 5K$$

- Example 1:
  - Farmer Jack grows wheat.
  - He has 5 acres of land.
  - He can hire as many workers as he wants.

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

- If Jack hires one more worker, his output rises by the *marginal product of labor*.
- The **marginal product** of any input is the increase in output arising from an additional unit of that input, holding all other inputs constant.
- Notation:
  Δ (delta) = "change in…"

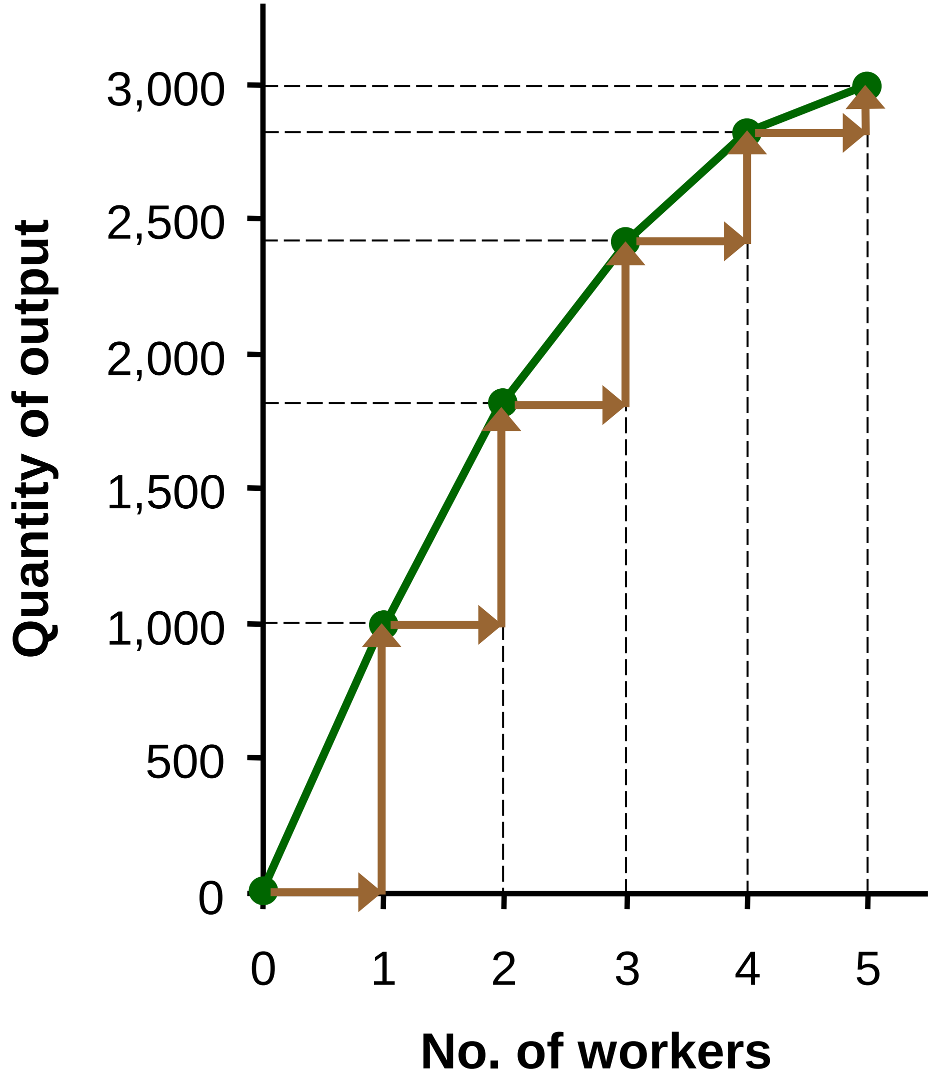
  Examples:
  $\Delta \boldsymbol{Q}$ = change in output, $\Delta \boldsymbol{L}$ = change in labor
- Marginal product of labor (*MPL*) = $\dfrac{\Delta \boldsymbol{Q}}{\Delta \boldsymbol{L}}$

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		

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

- Recall one of the Ten Principles:
  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 would benefit from hiring 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.).
- **Diminishing marginal product**:
  the marginal product of an input declines as the quantity of the input increases (other things equal)

EXAMPLE 1: Farmer Jack's Costs

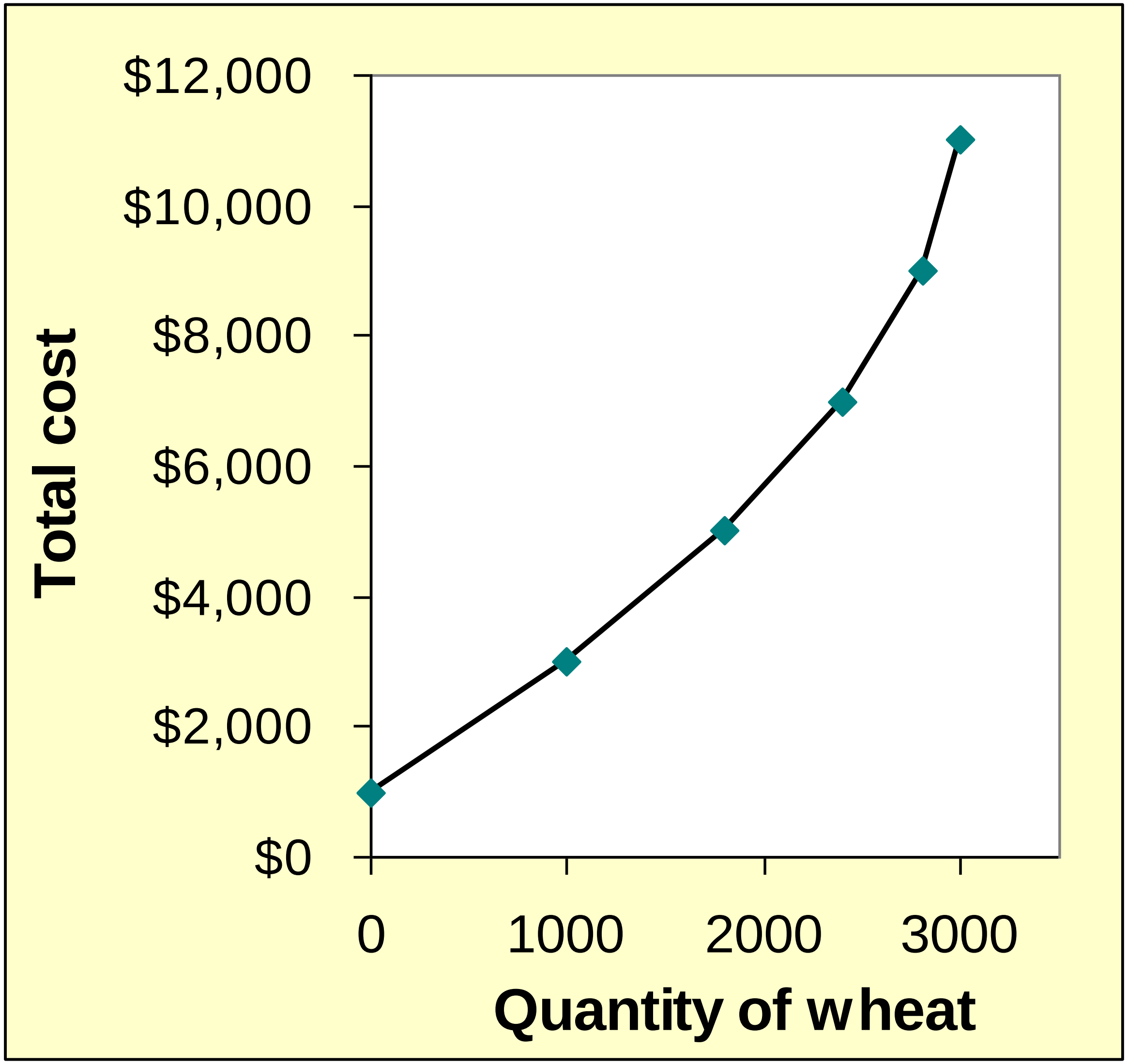
- Farmer Jack must pay $1000 per month for the land, regardless of how much wheat he grows.
- The market wage for a farm worker is $2000 per month.
- So Farmer Jack's costs are related to how much wheat he produces….

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*)
  is the increase in Total Cost from producing one more unit:

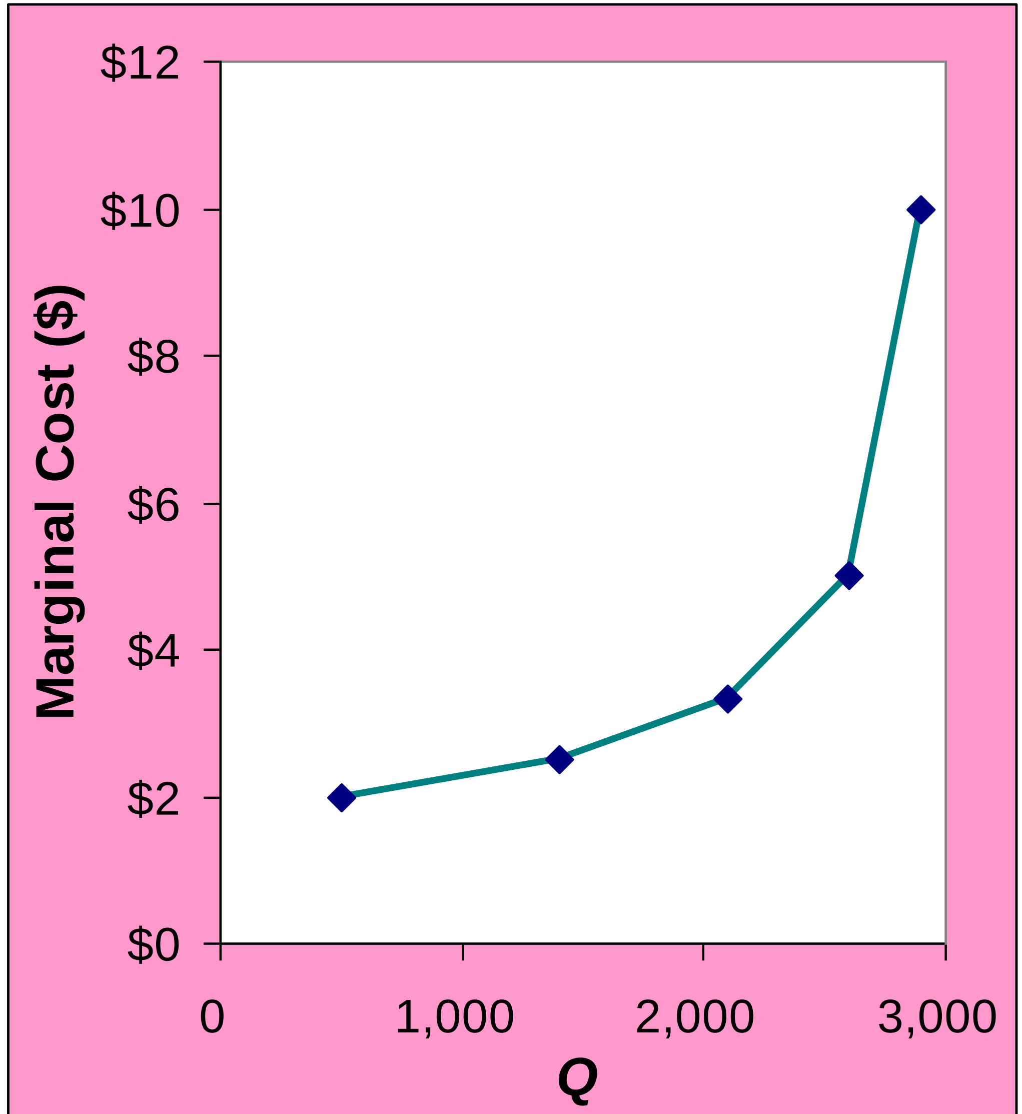
$$MC = \frac{\Delta TC}{\Delta \boldsymbol{Q}}$$

EXAMPLE 1: Total and Marginal Cost

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



EXAMPLE 1: Farmer Jack's Total Cost Curve

Q (bushels of wheat)	Total Cost
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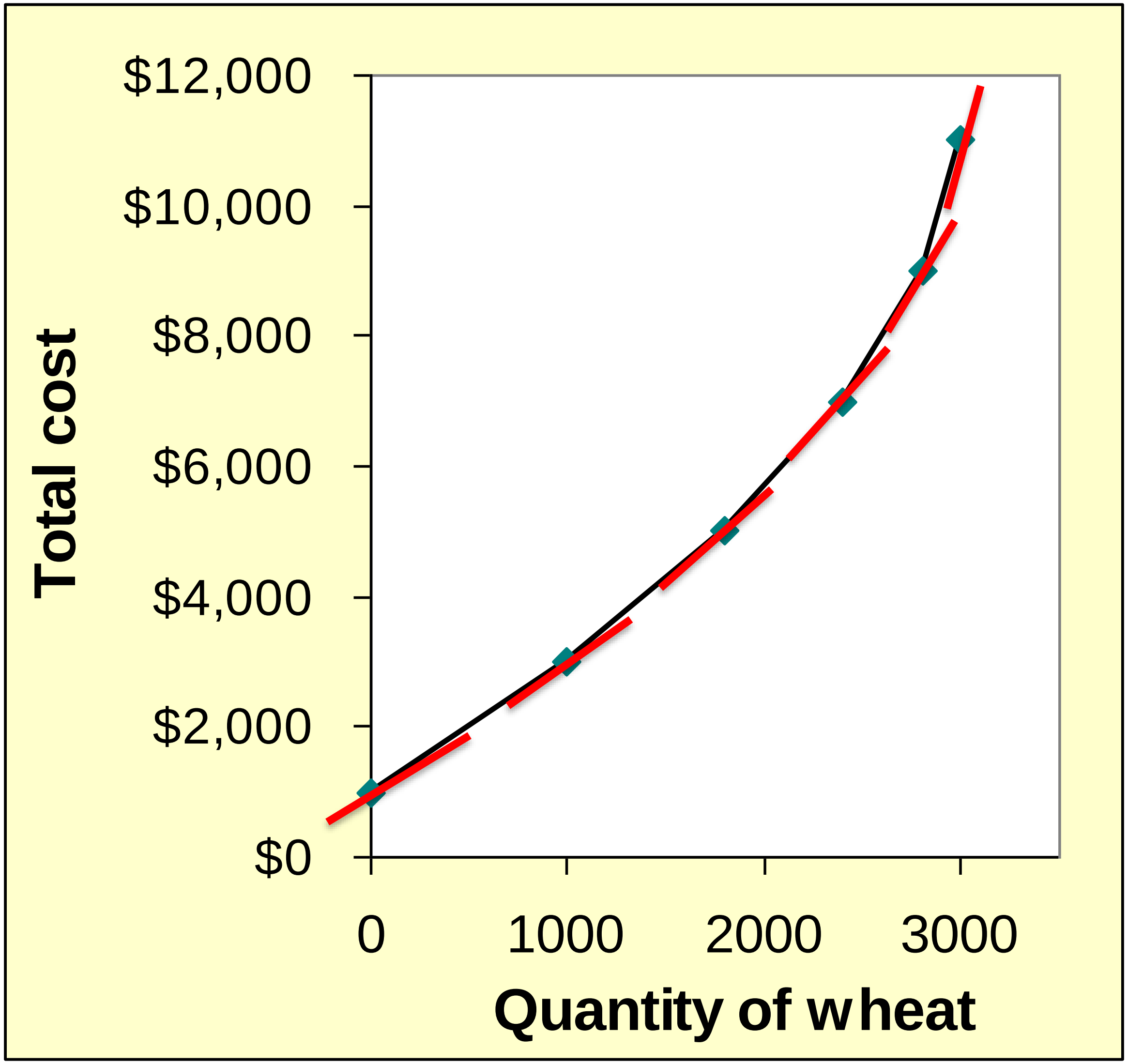


Why MC Is Important

- Farmer Jack is rational and wants to maximize his profit. To increase profit, should he produce more or less wheat?
- To find the answer, 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

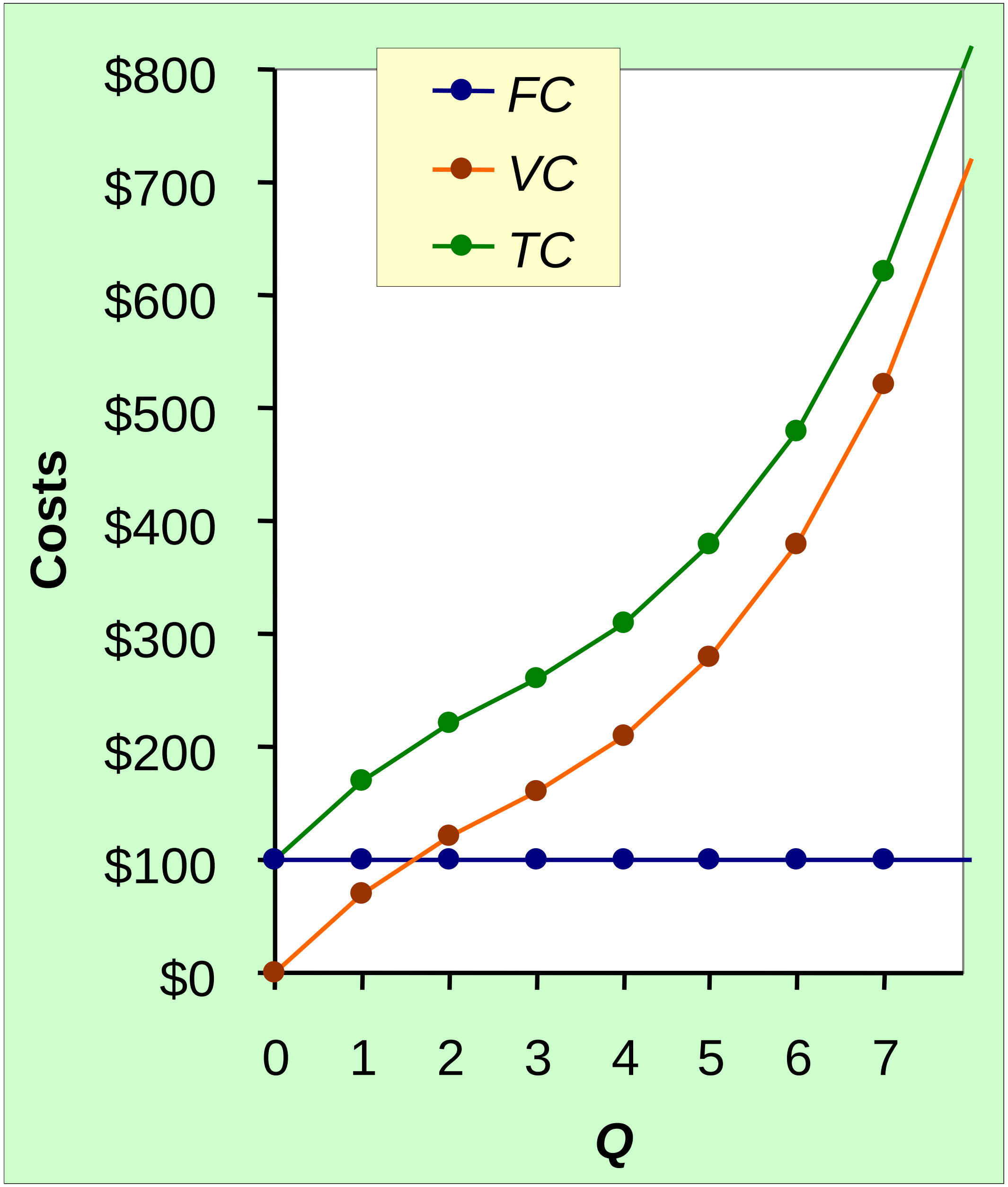
- **Fixed costs (*FC*)** do not vary with the quantity of output produced.
  - For Farmer Jack, *FC* = $1000 for his land
  - Other examples:
    cost of equipment, loan payments, rent
- **Variable costs (*VC*)** vary with the quantity produced.
  - For Farmer Jack, *VC* = wages he pays workers
  - Other example: cost of materials
- **Total cost (*TC*)** = *FC* + *VC*

EXAMPLE 2

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

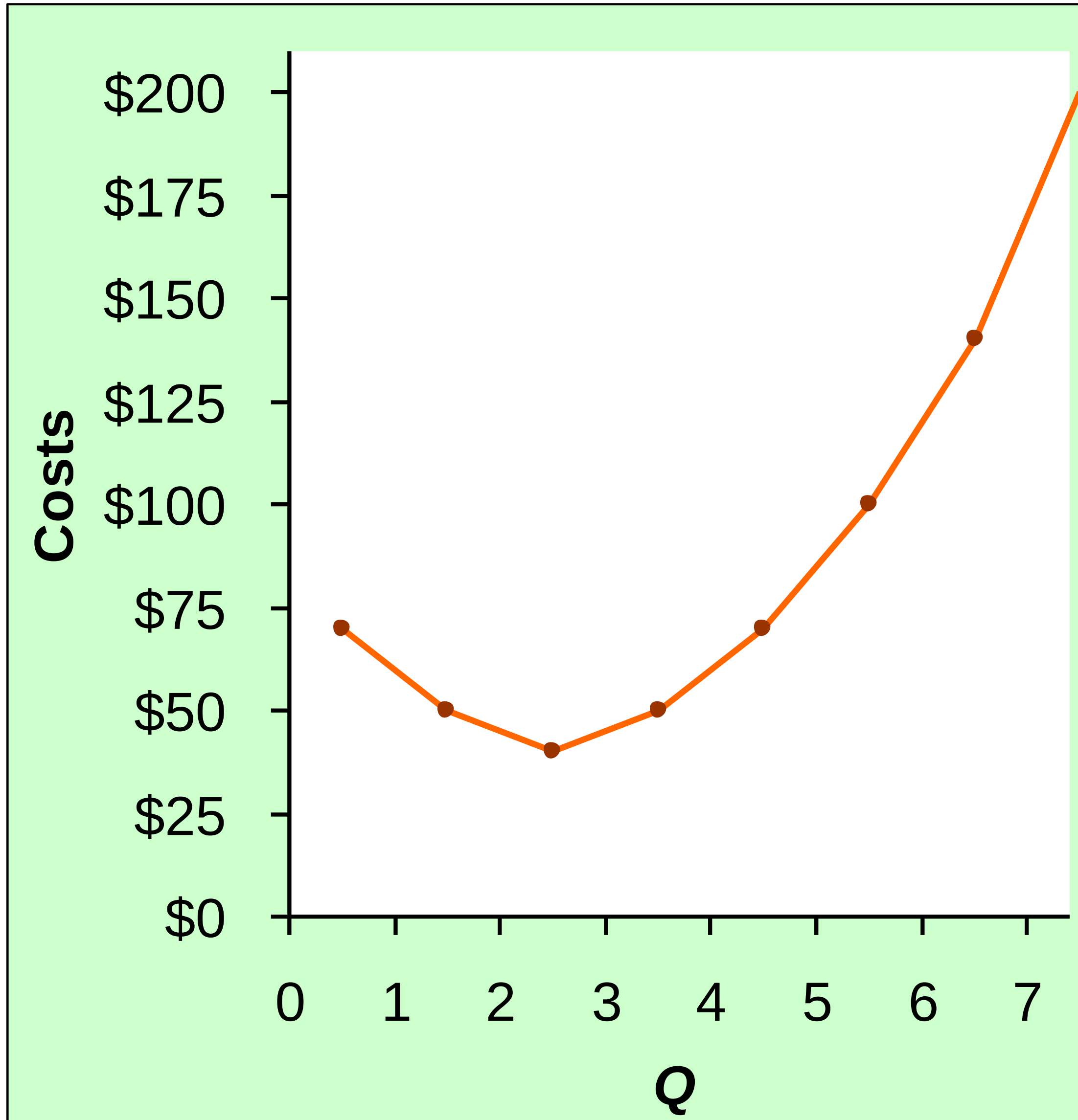
EXAMPLE 2: Costs

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



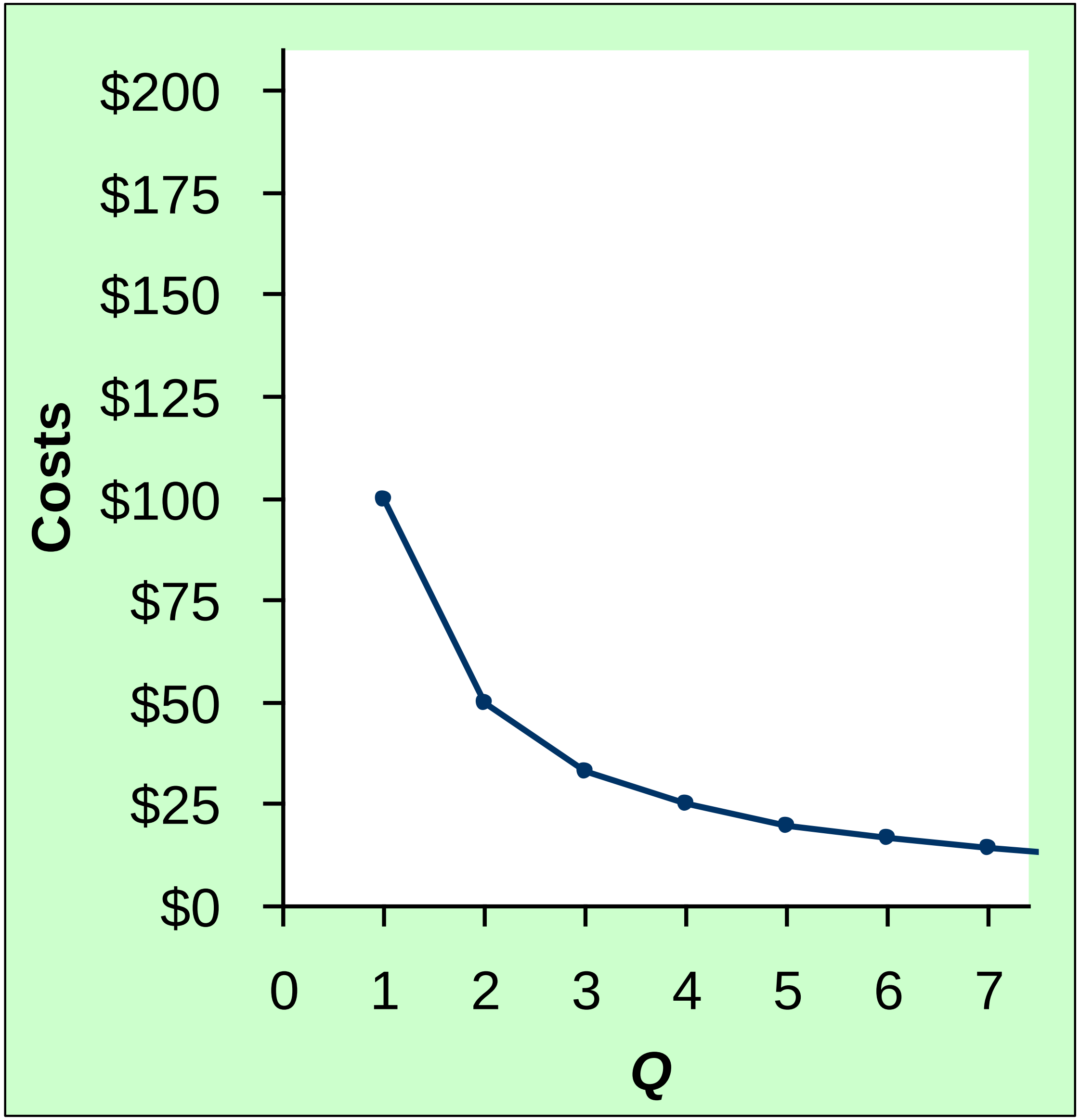
EXAMPLE 2: Marginal Cost

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



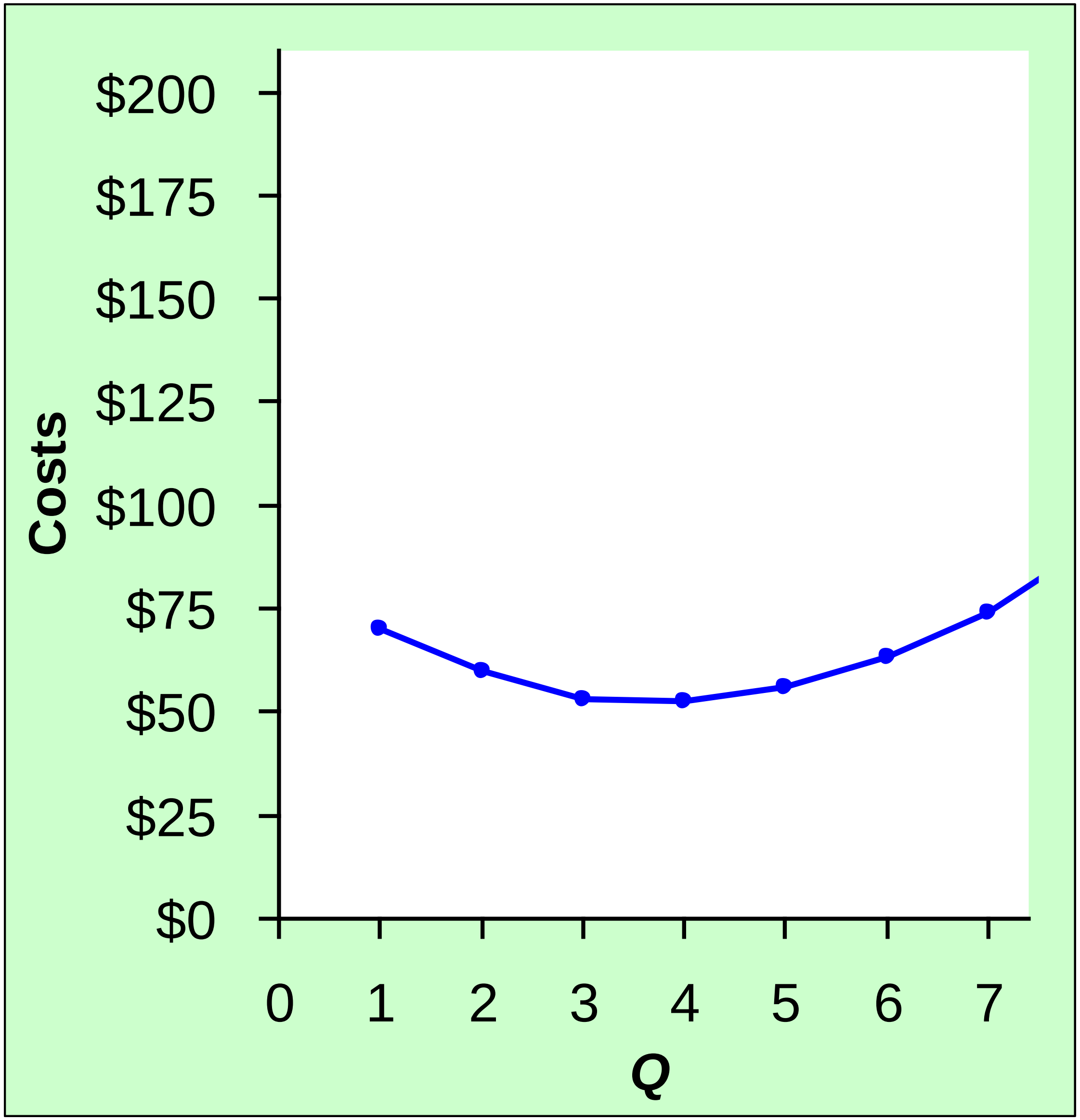
EXAMPLE 2: Average Fixed Cost = FC/Q

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 = VC/Q

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:

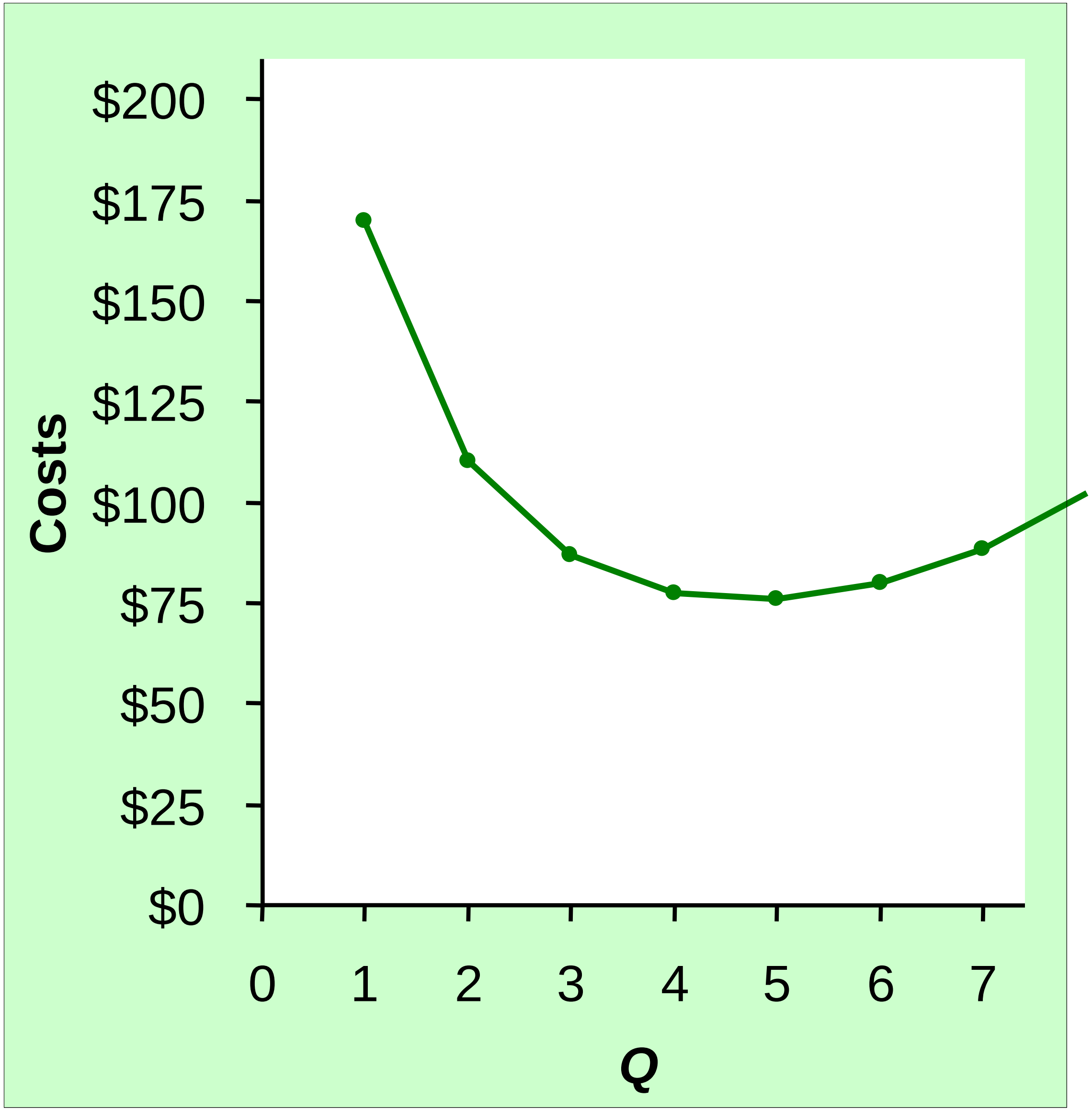
$$ATC = TC/\boldsymbol{Q}$$

Also,

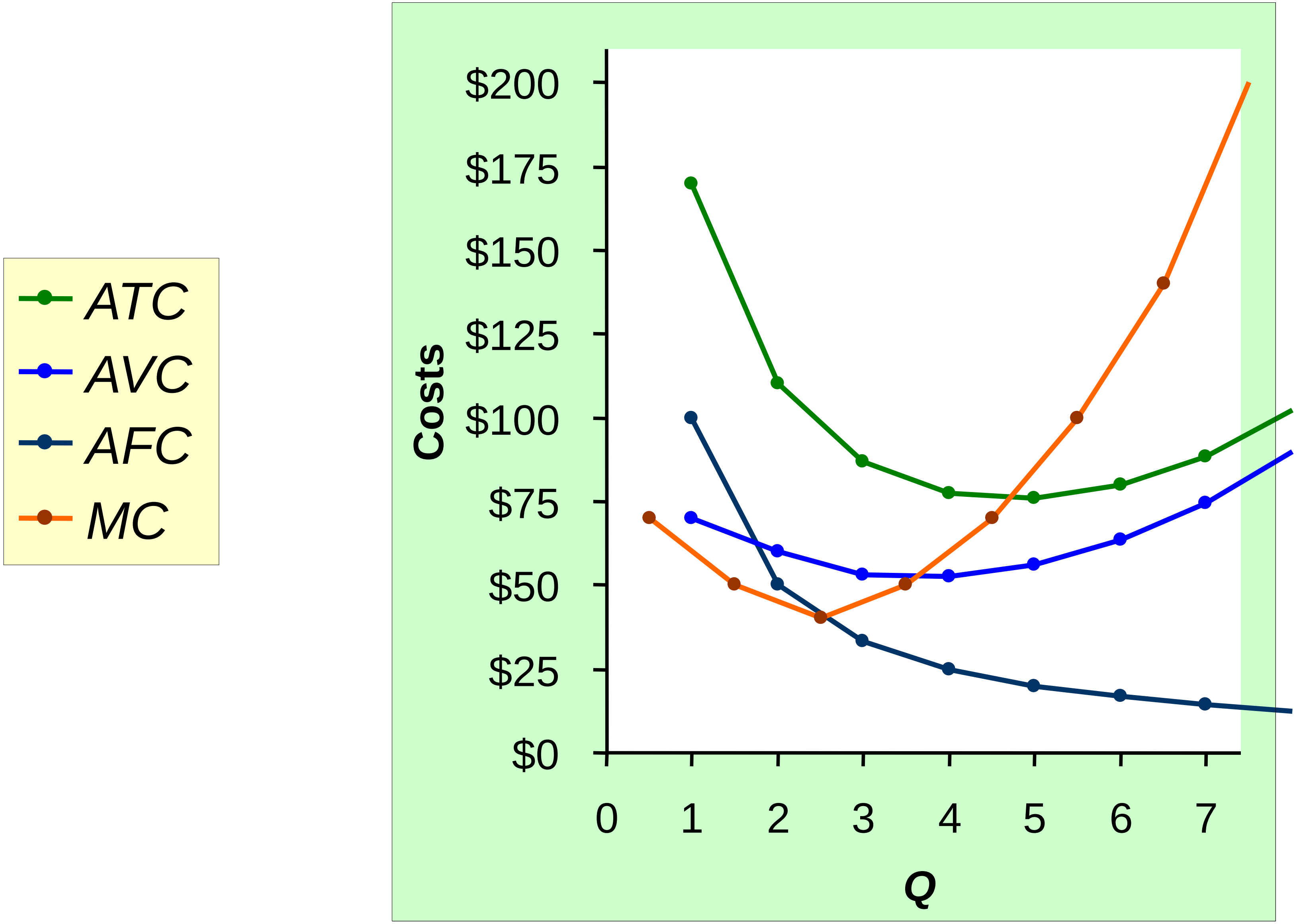
$$ATC = AFC + AVC$$

EXAMPLE 2: Average Total Cost

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



EXAMPLE 2: The Various Cost Curves Together



Calculating costs

Fill in the blank spaces of this table.

Q	*VC*	*TC*	*AFC*	*AVC*	*ATC*	*MC*
0	$0	$50	*n/a*	*n/a*	*n/a*	
1	10					$10
2	30					
3				20		30
4	100					
5				30		
6				35		60

ACTIVE LEARNING **3**

Answers

First, deduce *FC* = $50 and use *FC* + *VC* = *TC*.

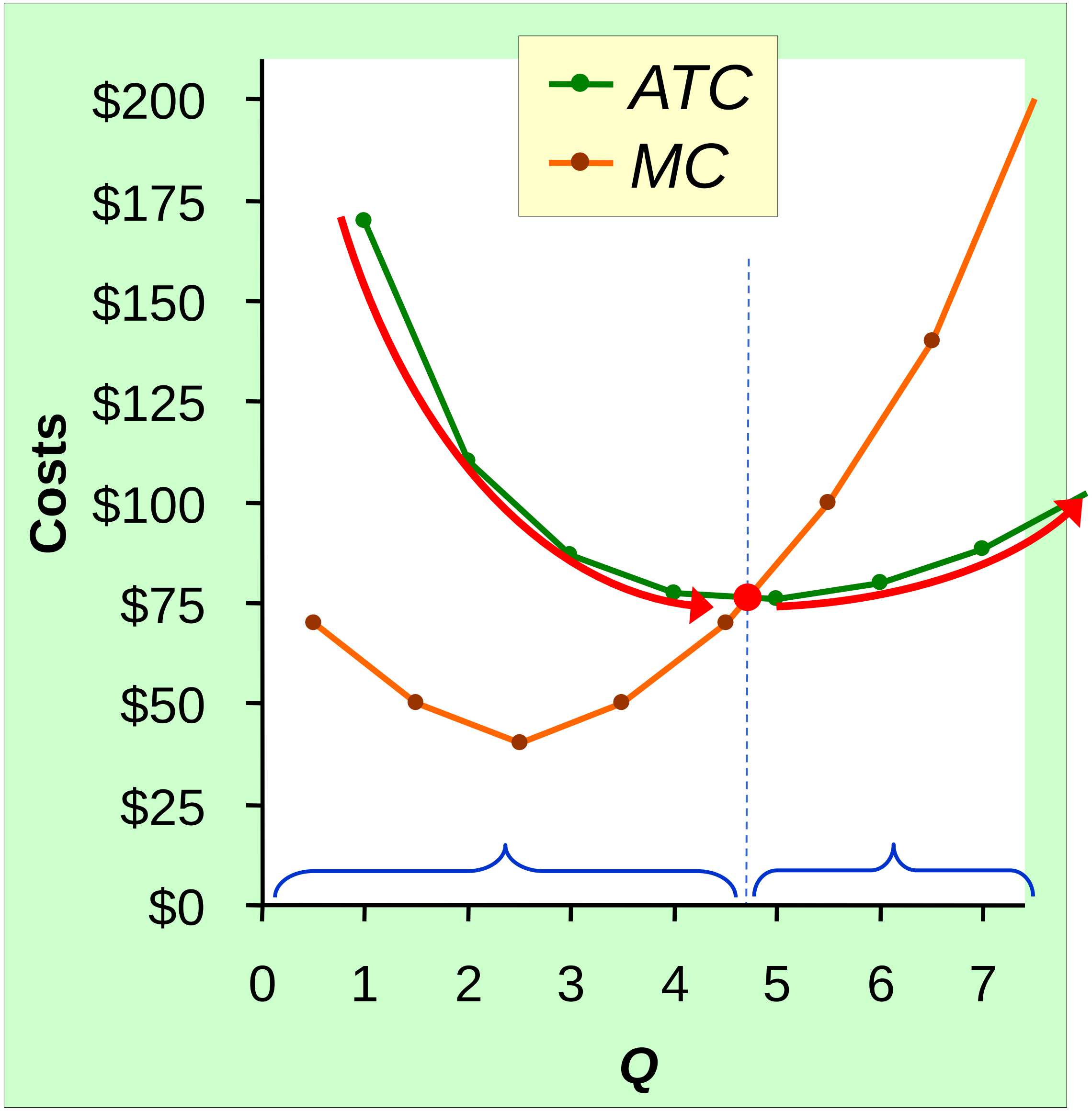
Q	*VC*	*TC*	*AFC*	*AVC*	*ATC*	*MC*
0	$0	$50	*n/a*	*n/a*	*n/a*	
1	10	60	$50.00	$10	$60.00	$10
2	30	80	25.00	15	40.00	20
3	60	110	16.67	20	36.67	30
4	100	150	12.50	25	37.50	40
5	150	200	10.00	30	40.00	50
6	210	260	8.33	35	43.33	60

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.



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).

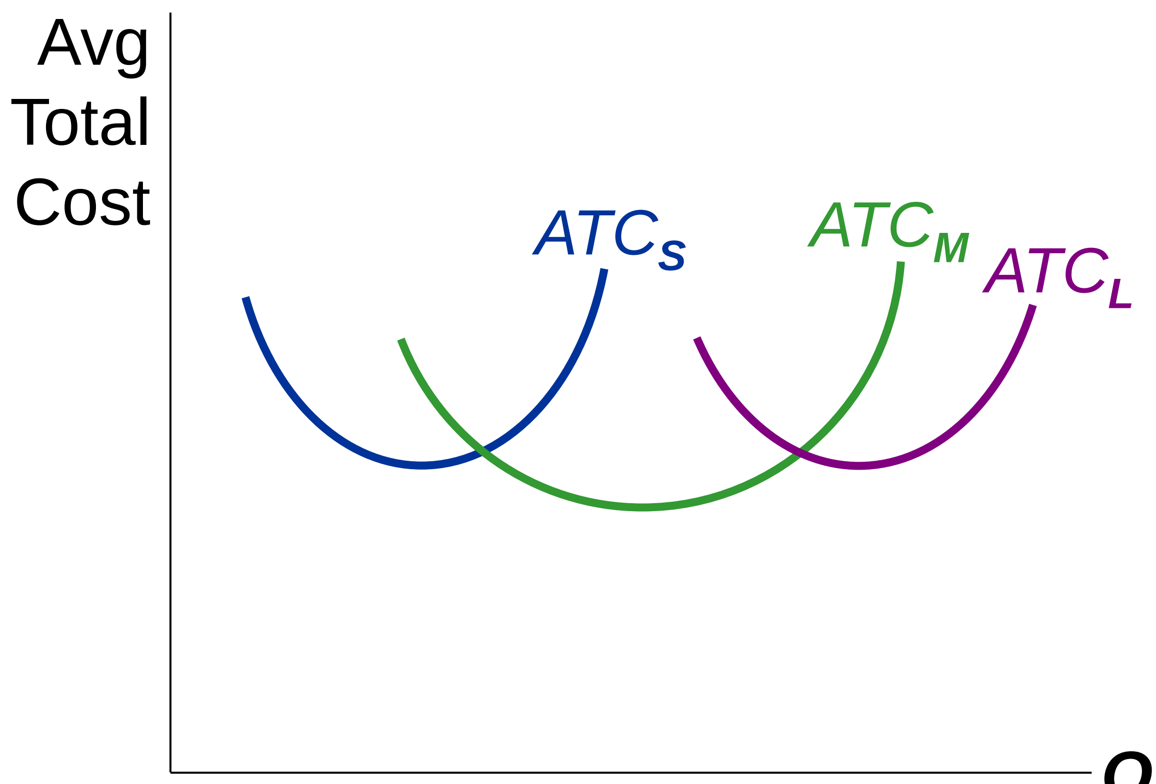
- In the long run, *ATC* at any ***Q*** is cost per unit using the most efficient mix of inputs for that ***Q*** (*e.g*., the factory size with the lowest *ATC*).

EXAMPLE 3: LRATC with 3 factory Sizes

Firm can choose from 3 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.

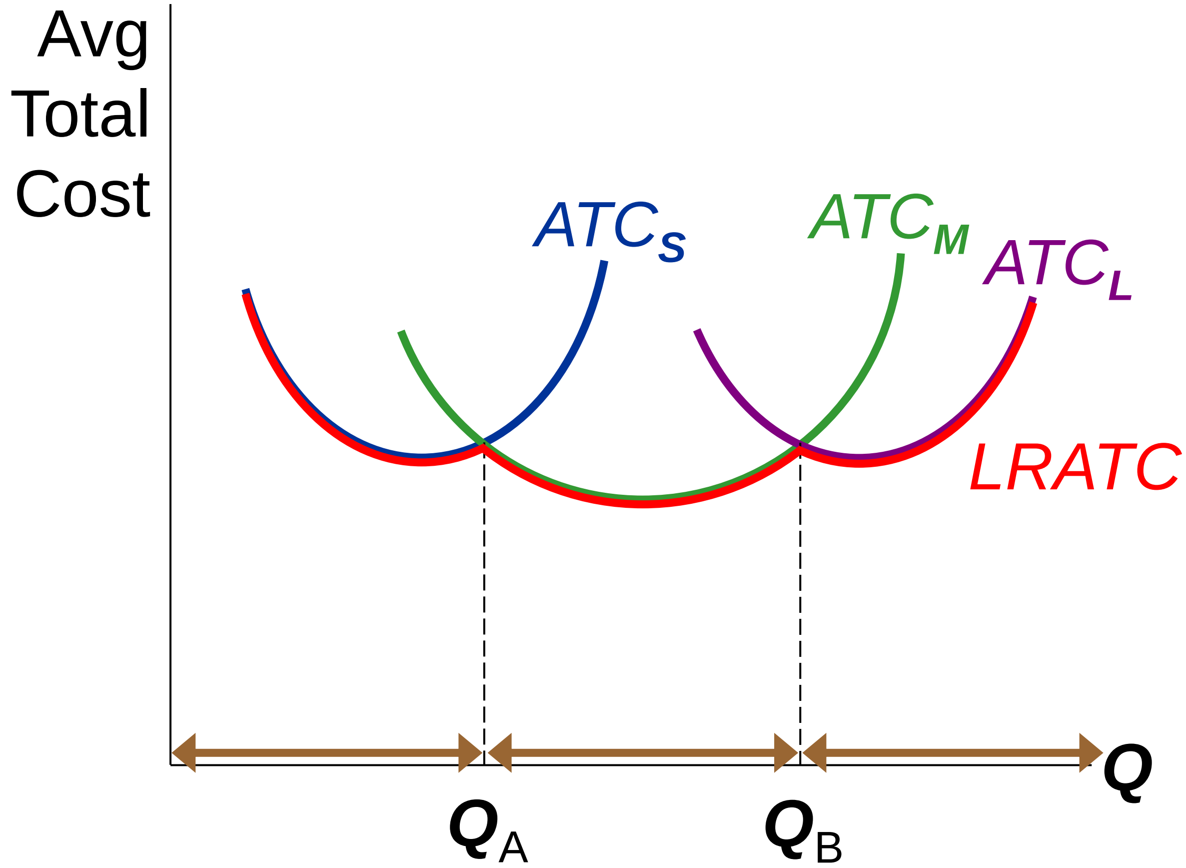


EXAMPLE 3: LRATC with 3 factory Sizes

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.

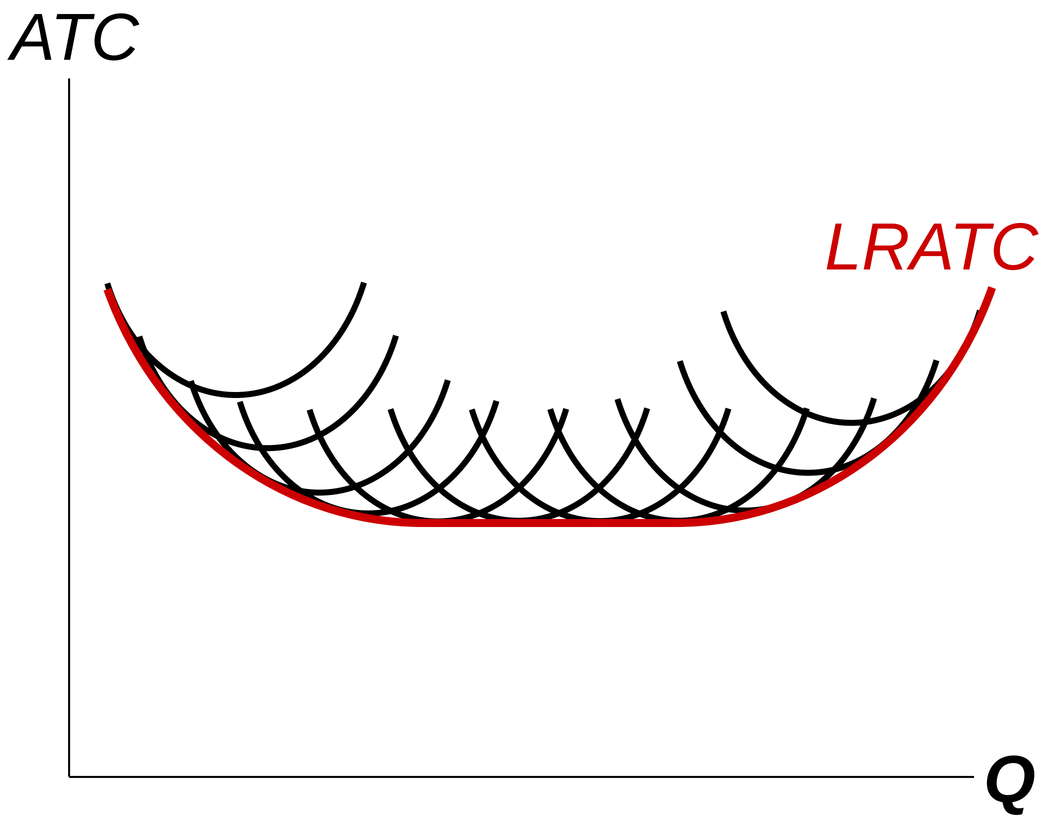
To produce more than Q_B, firm will choose size **L** in the long run.



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:

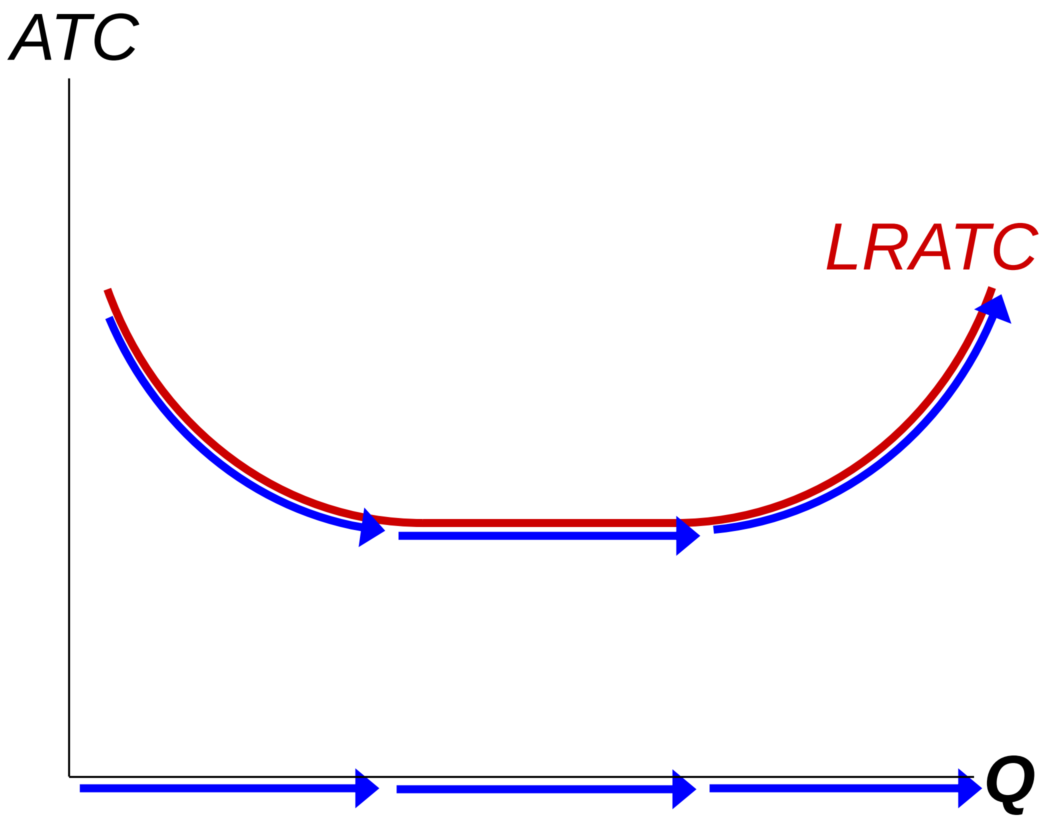


How ATC Changes as the Scale of Production Changes

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.



How ATC Changes as the Scale of Production Changes

- Economies of scale occur when increasing production allows greater specialization: workers more efficient when focusing on a narrow task.
  - More common when ***Q*** is low.
- Diseconomies of scale are due to coordination problems in large organizations.
  E.g., management becomes stretched, can't control costs.
  - More common when ***Q*** is high.