

Chapter 13 – The Costs of Production

***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 the firm's goal is to maximize profit.

$$\text{Profit} = \text{Total revenue} - \text{Total cost}$$

the amount a
firm receives
from the sale
of its output

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

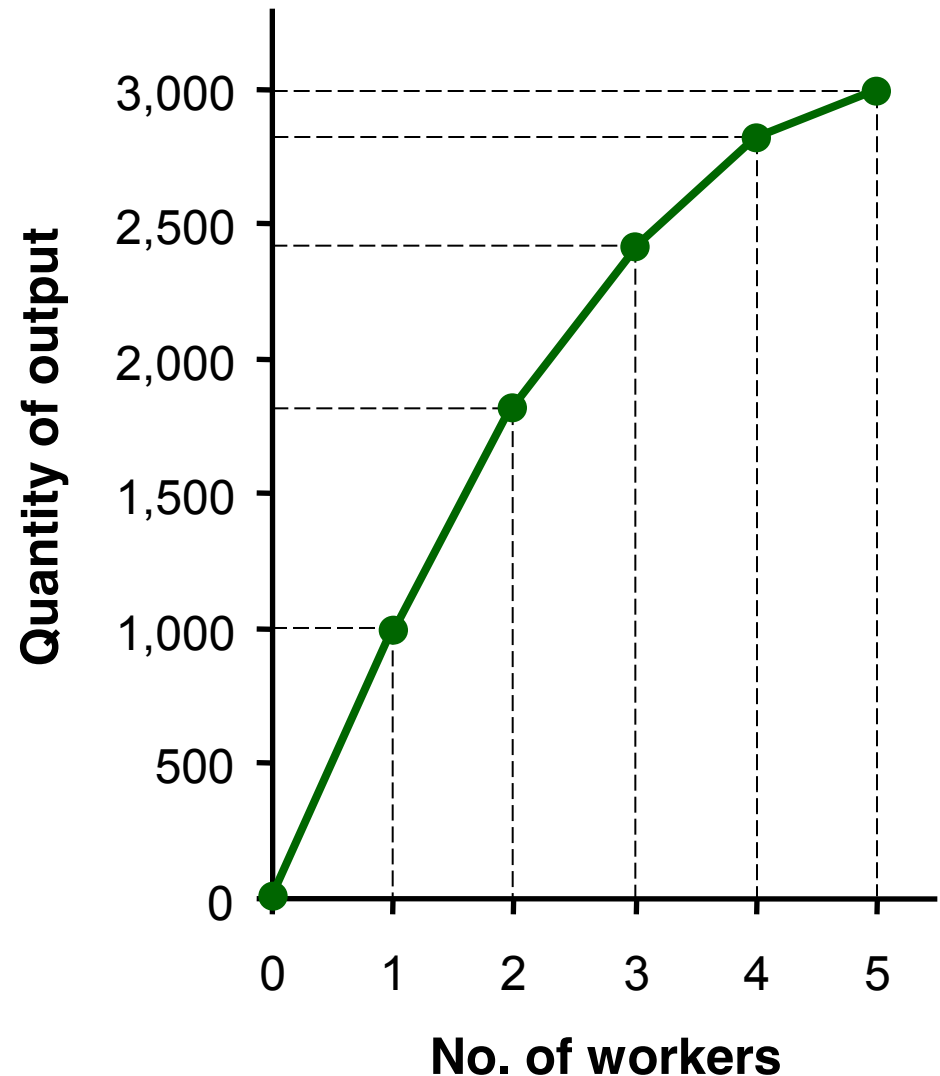
- **Accounting profit**
= total revenue minus total explicit costs
- **Economic profit**
= total revenue minus total costs (including explicit and implicit costs)
- Accounting profit ignores implicit costs, so it's higher than economic profit.

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.
- 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

<i>L</i> (no. of workers)	<i>Q</i> (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:

ΔQ = change in output, ΔL = change in labor

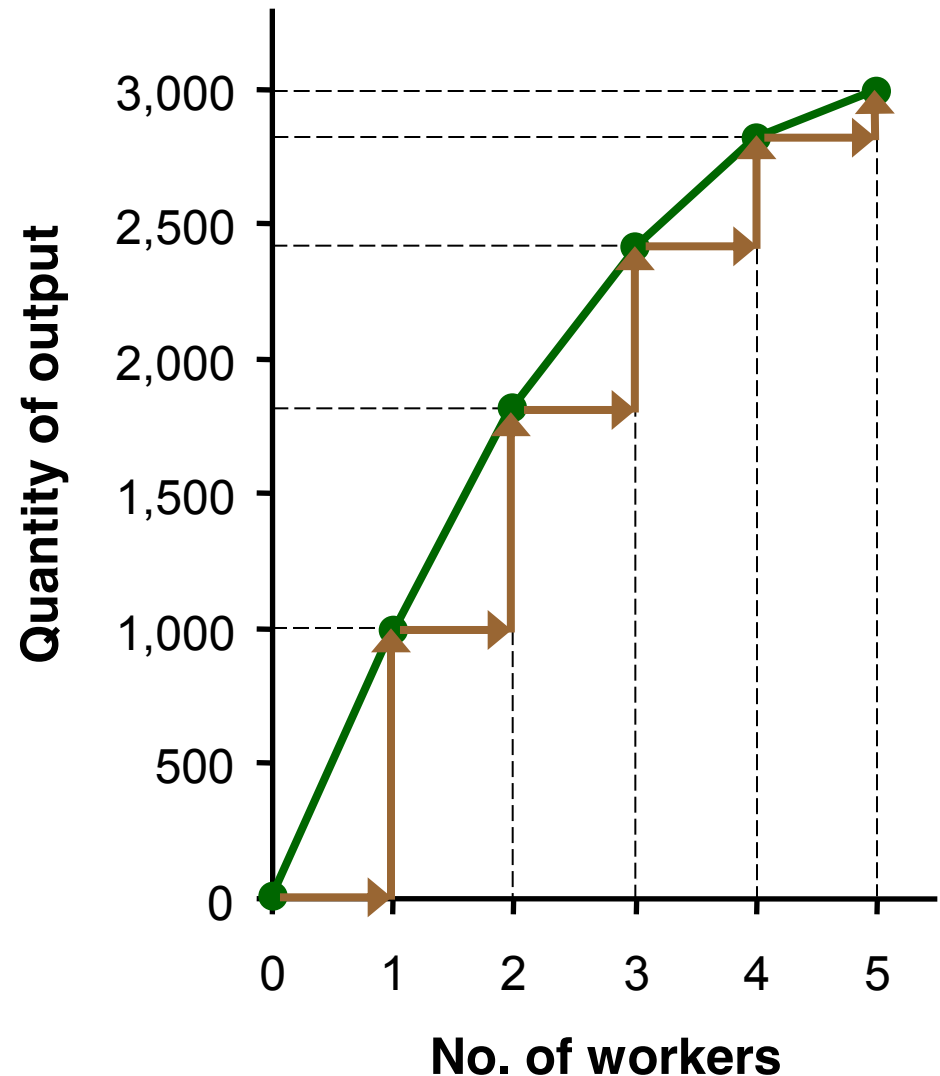
- Marginal product of labor (MPL) = $\frac{\Delta Q}{\Delta L}$

EXAMPLE 1: Total & Marginal Product

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

EXAMPLE 1: $MPL = \text{Slope of Prod Function}$

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



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 should hire the worker.

Why MPL Diminishes

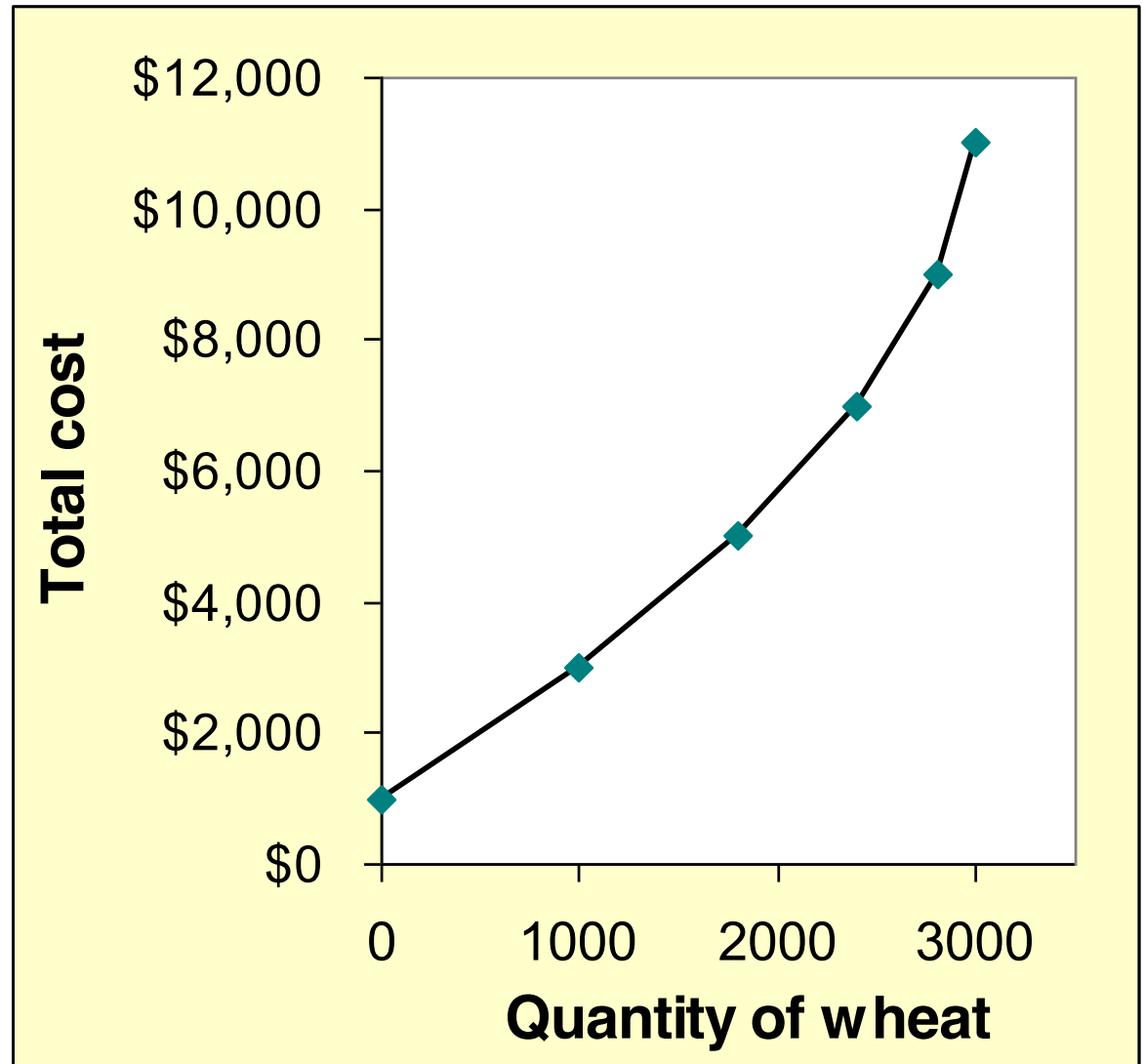
- Farmer Jack's output rises by a smaller and smaller amount for each additional worker. Why?
- As Jack adds workers, the average worker has less land to work with and will be less productive.
- In general, *MPL* diminishes as *L* rises whether the fixed input is land or capital (equipment, machines, etc.).
- **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

<i>L</i> (no. of workers)	<i>Q</i> (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:

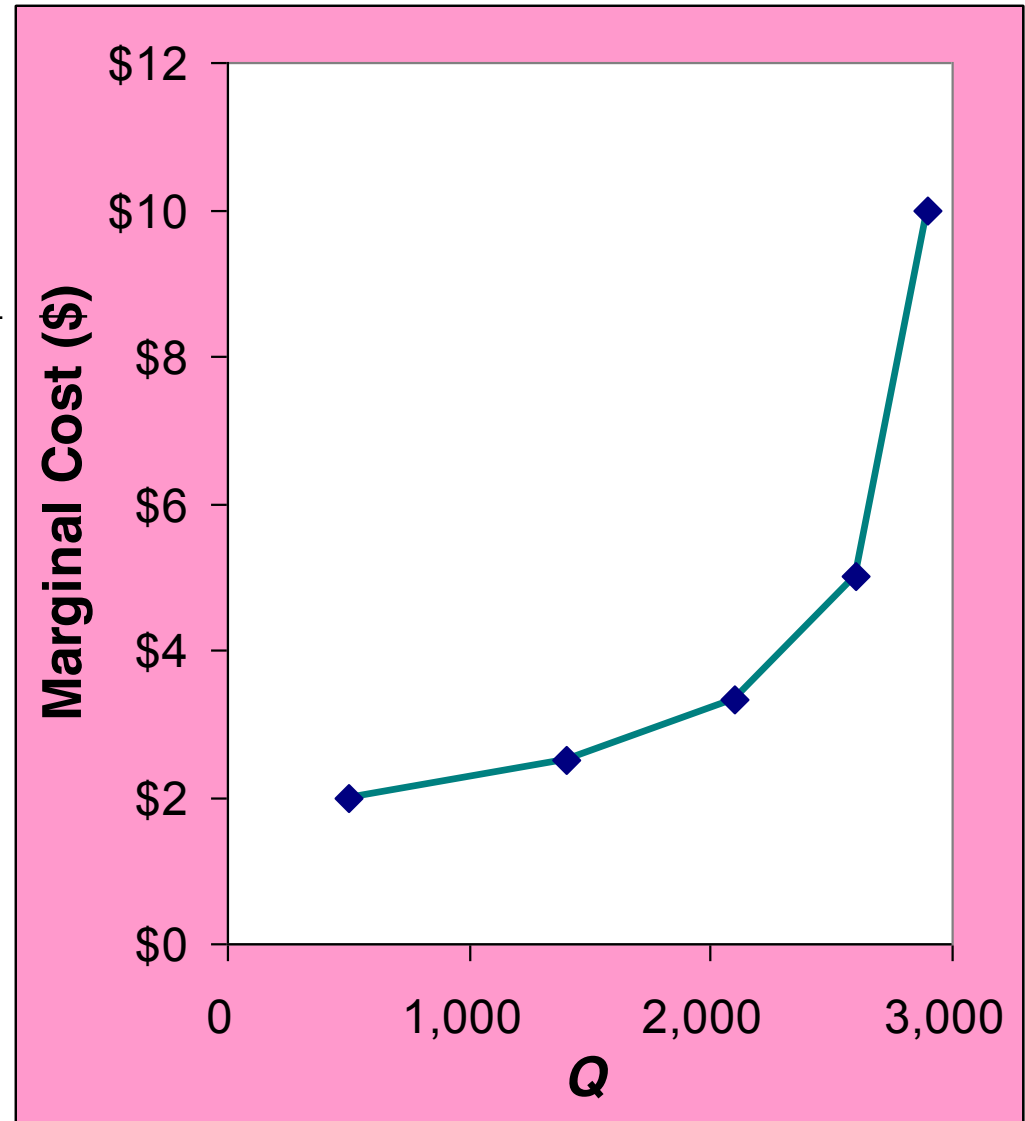
$$MC = \frac{\Delta TC}{\Delta Q}$$

EXAMPLE 1: Total and Marginal Cost

	Q (bushels of wheat)	Total Cost		Marginal Cost (<i>MC</i>)
	0	\$1,000		
$\Delta Q = 1000$	1000	\$3,000	$\Delta TC = \$2000$	\$2.00
$\Delta Q = 800$	1800	\$5,000	$\Delta TC = \$2000$	\$2.50
$\Delta Q = 600$	2400	\$7,000	$\Delta TC = \$2000$	\$3.33
$\Delta Q = 400$	2800	\$9,000	$\Delta TC = \$2000$	\$5.00
$\Delta Q = 200$	3000	\$11,000	$\Delta TC = \$2000$	\$10.00

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	



Fixed and Variable Costs

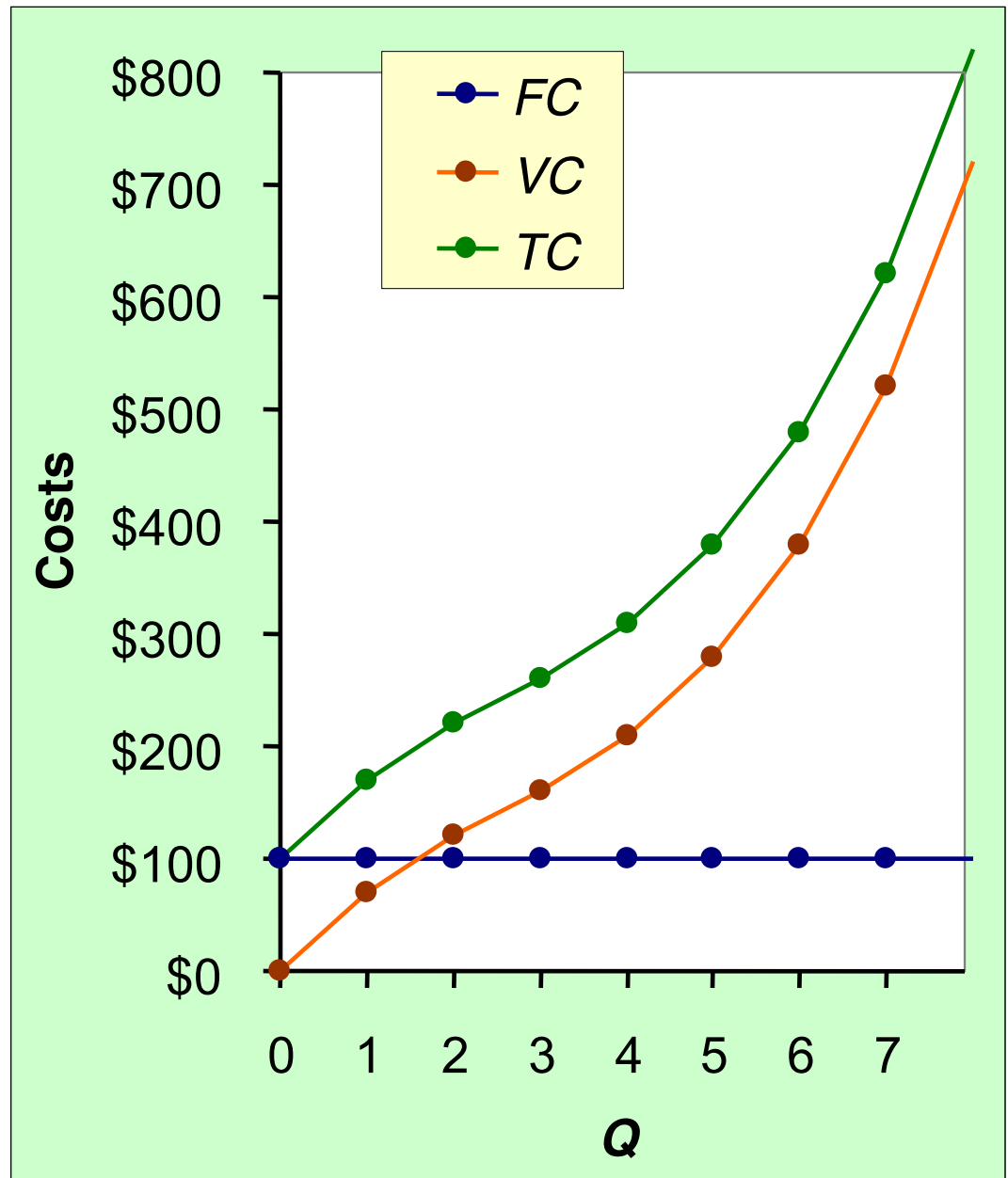
- **Fixed costs (FC)** do not vary with the quantity of output produced.
 - For Farmer Jack, $FC = \$1000$ for his land
 - Other examples:
cost of equipment, loan payments, rent
- **Variable costs (VC)** vary with the quantity produced.
 - For Farmer Jack, $VC =$ wages he pays workers
 - Other example: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

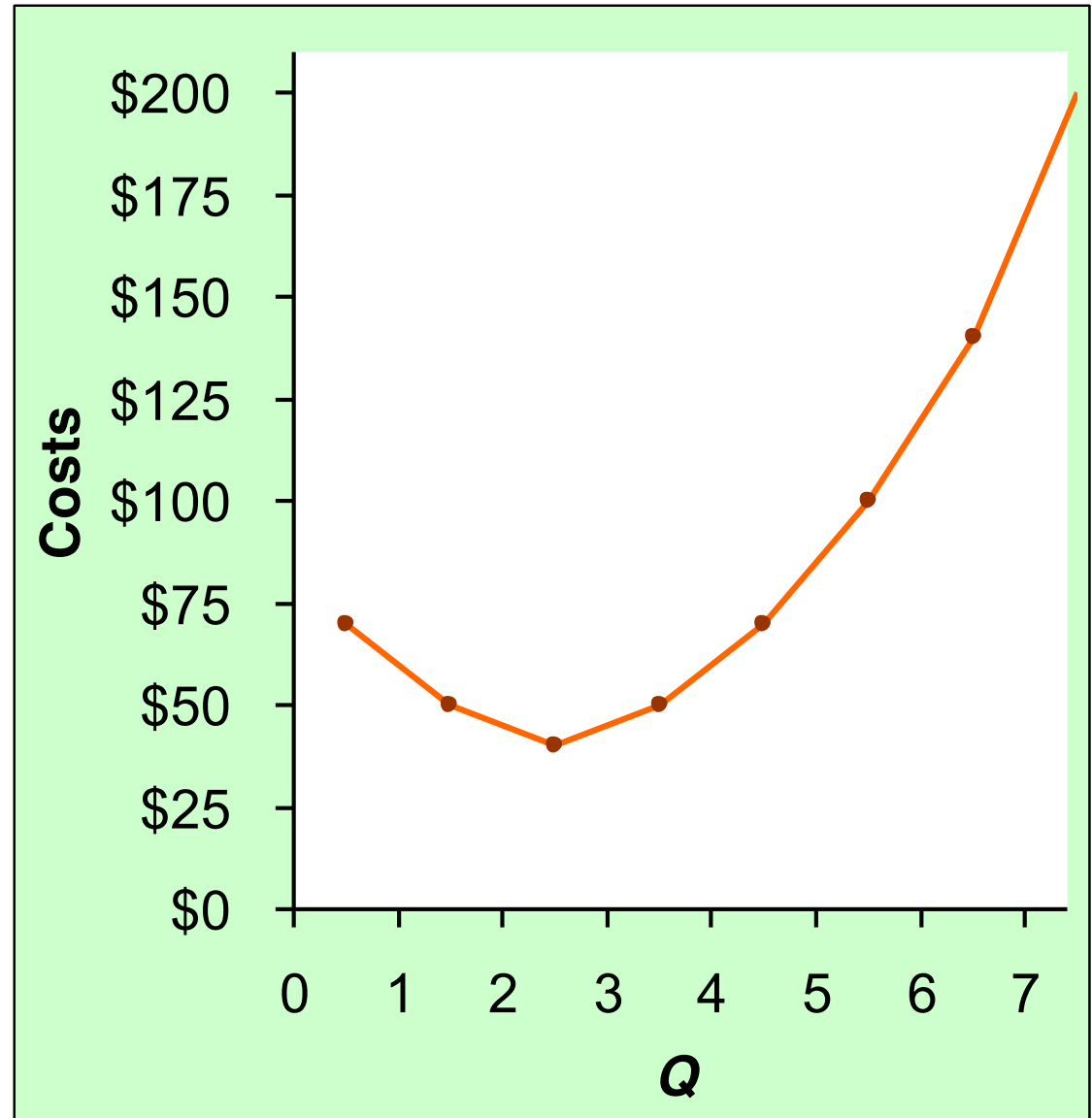
EXAMPLE 2: Costs

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



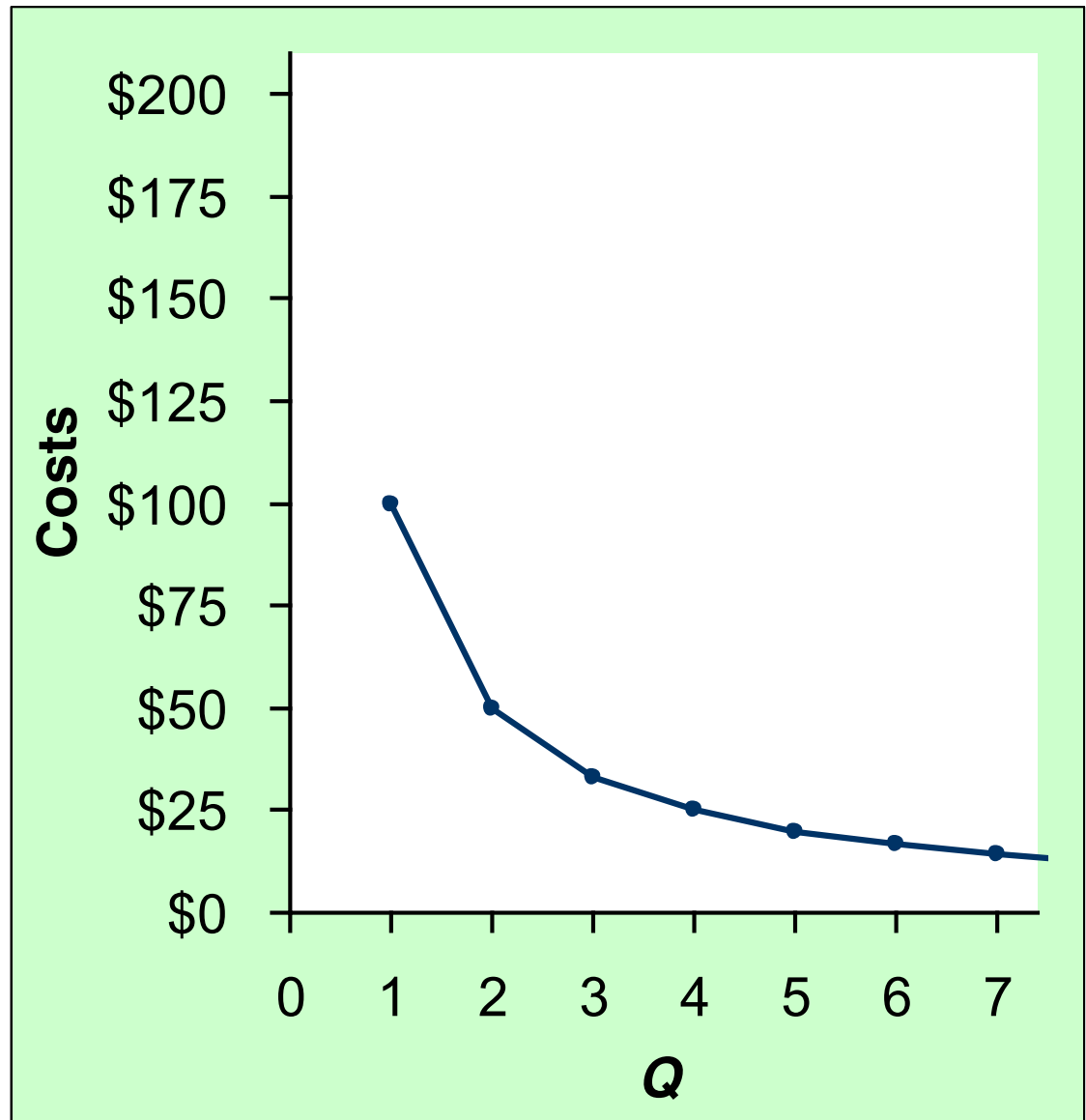
EXAMPLE 2: Marginal Cost

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



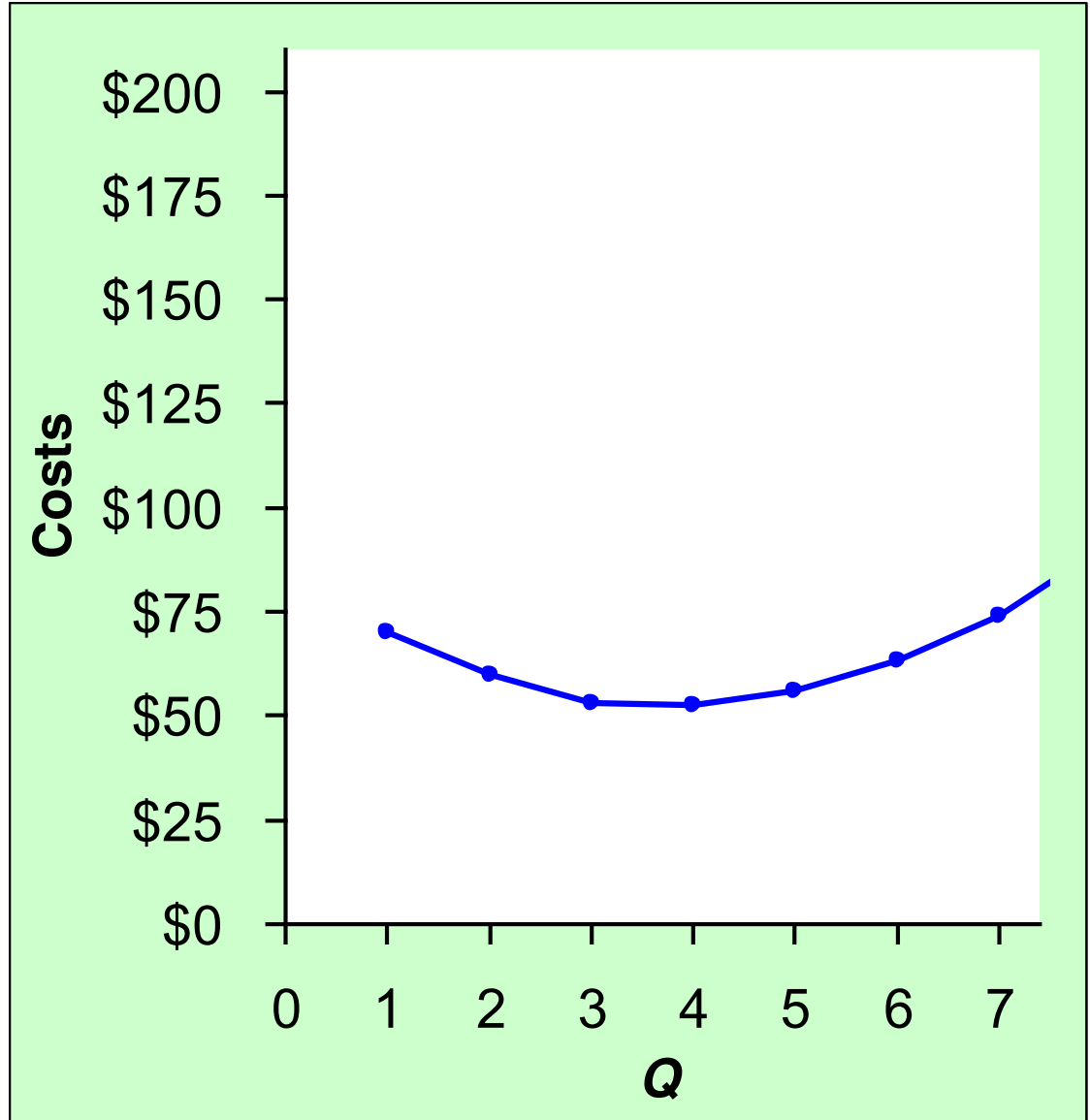
EXAMPLE 2: Average Fixed Cost

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

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

<i>Q</i>	<i>TC</i>	<i>ATC</i>	<i>AFC</i>	<i>AVC</i>
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:

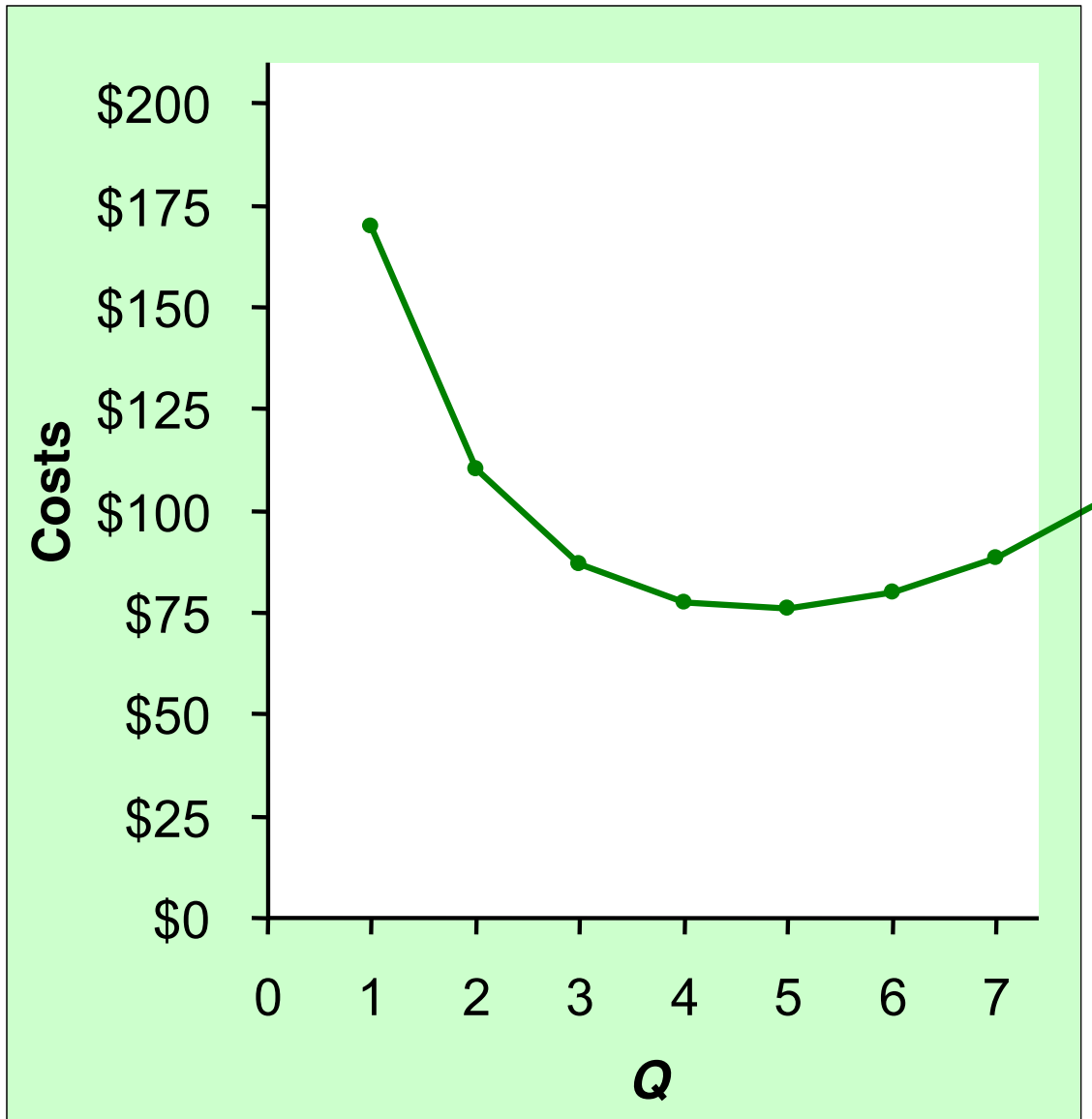
$$ATC = TC/Q$$

Also,

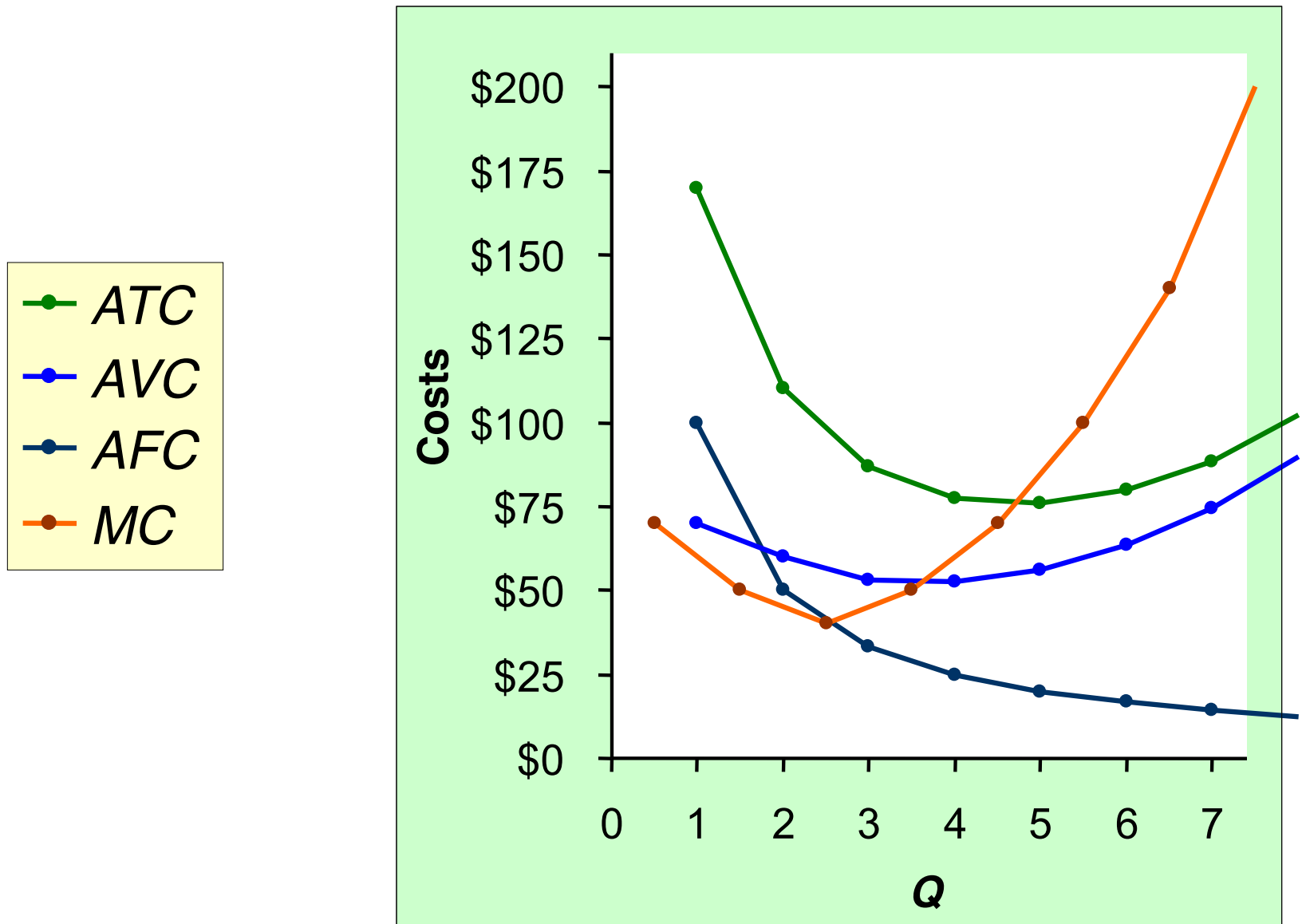
$$ATC = AFC + AVC$$

EXAMPLE 2: Average Total Cost

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



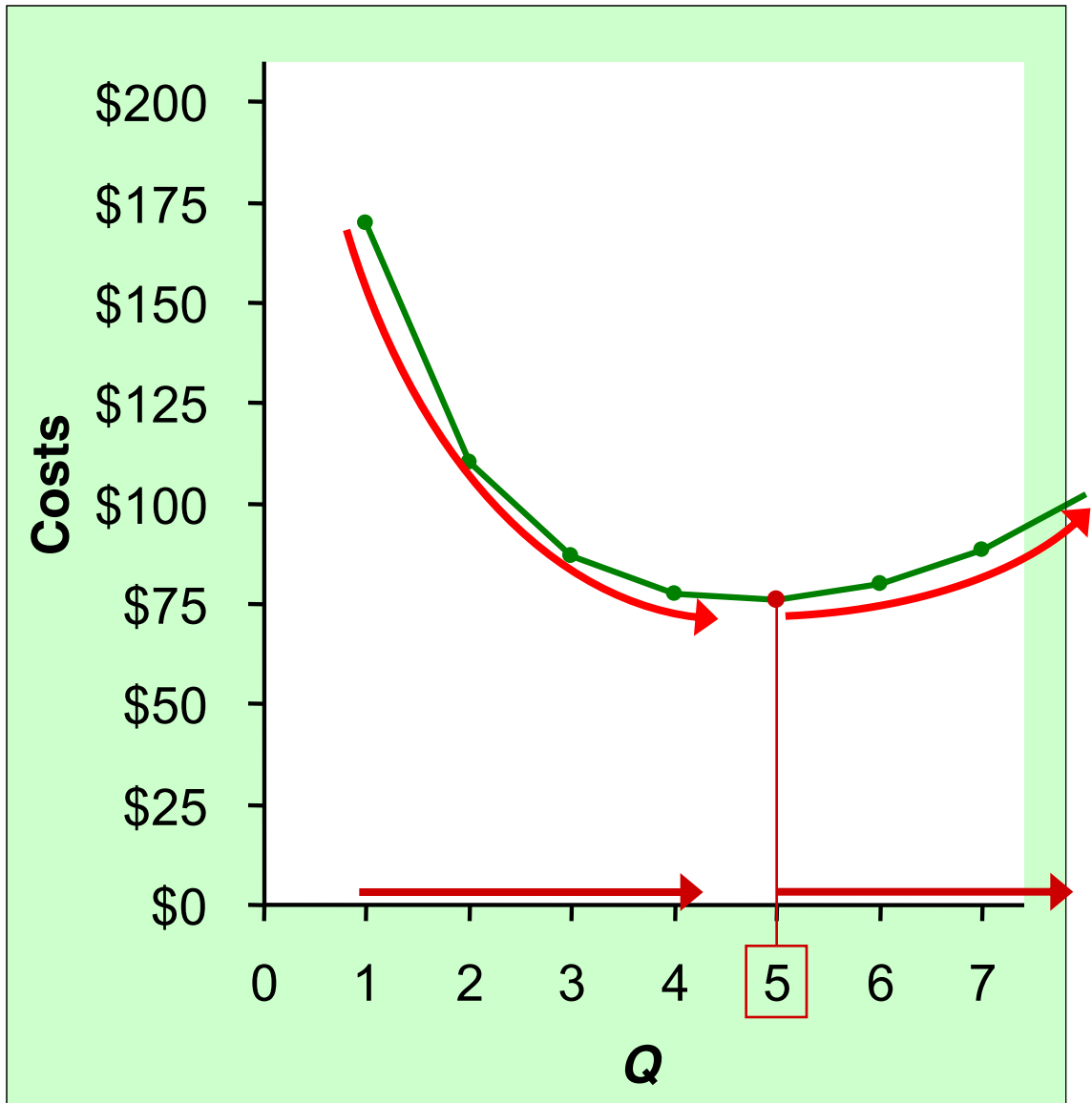
EXAMPLE 2: Why ATC Is Usually U-Shaped

As Q rises:

Initially,
falling AFC
pulls ATC down.

Eventually,
rising AVC
pulls ATC up.

Efficient scale:
The quantity that
minimizes ATC .

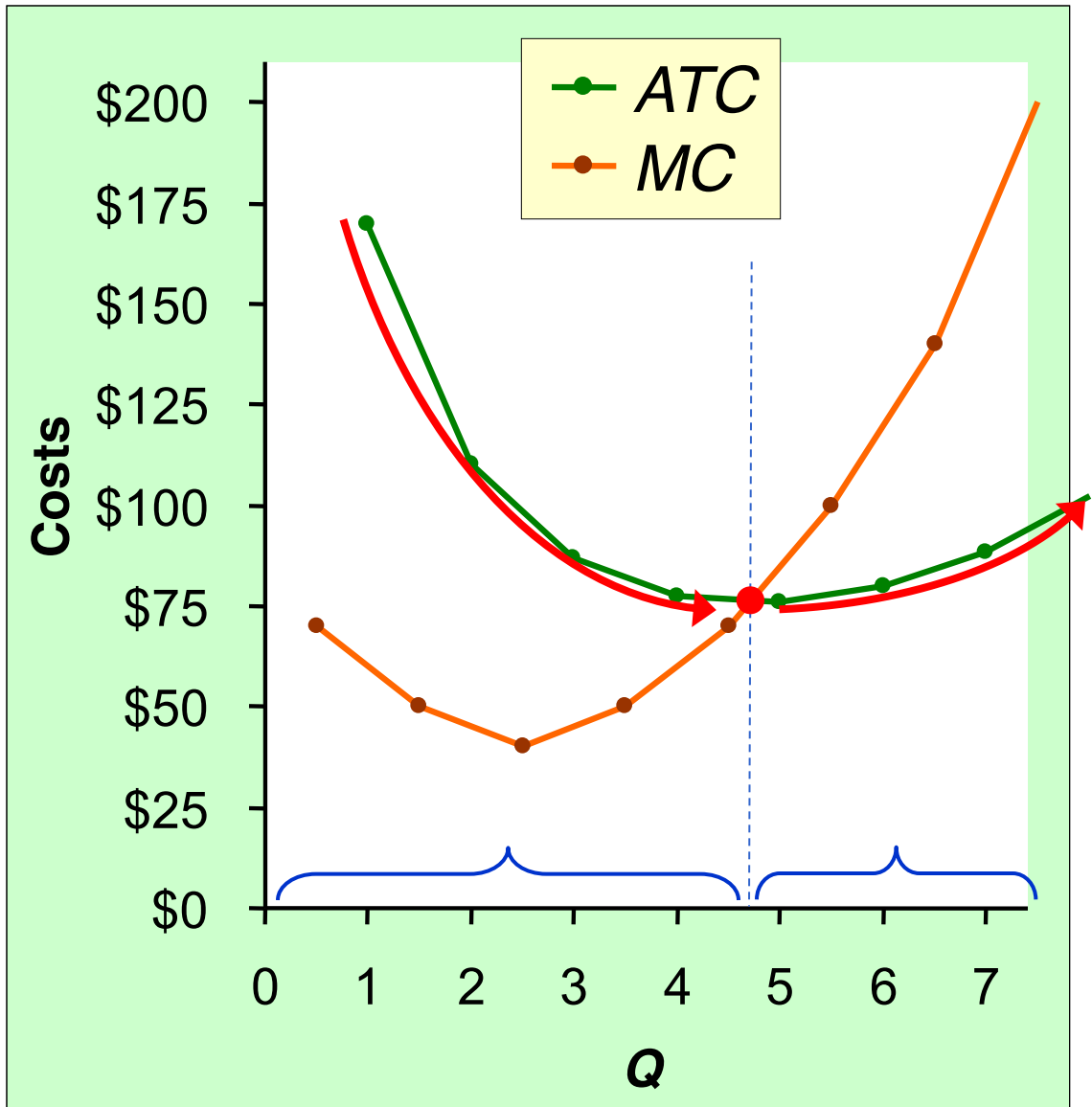


EXAMPLE 2: ATC and MC

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

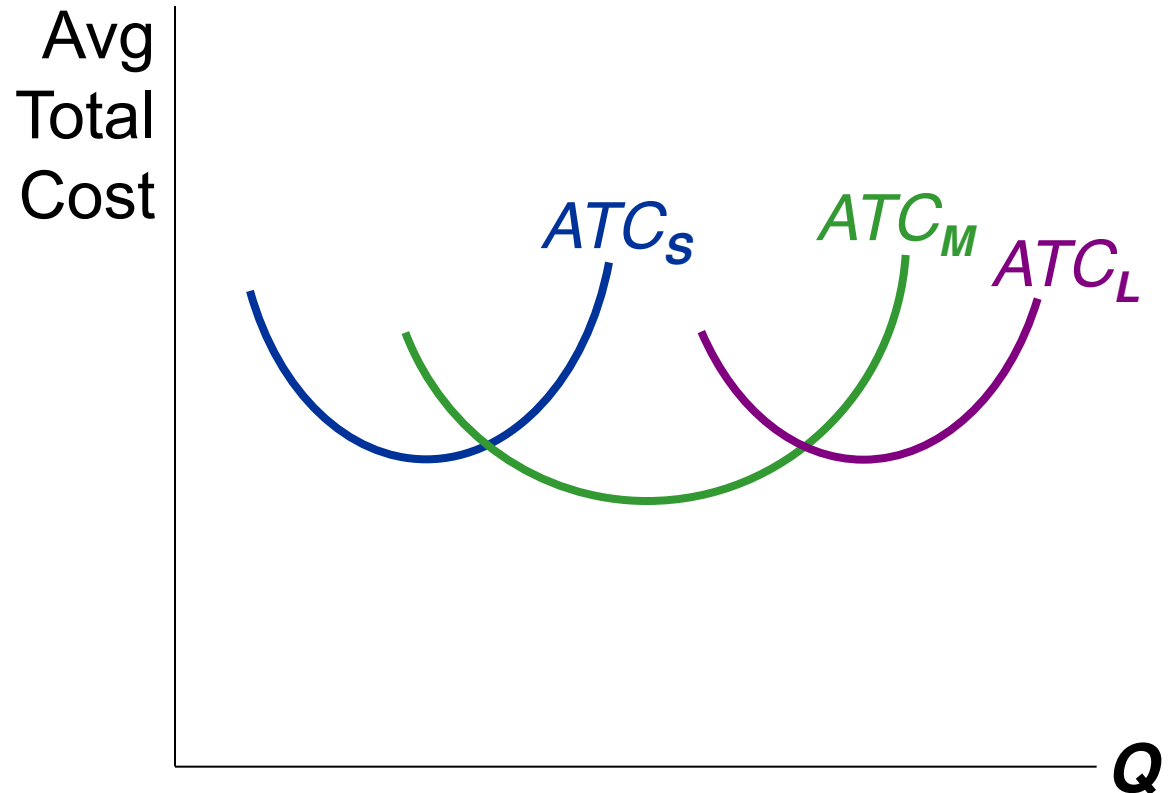
- Short run:
Some inputs are fixed (e.g., factories, land).
The costs of these inputs are FC .
- Long run:
All inputs are variable
(e.g., firms can build more factories,
or sell existing ones).
- In the long run, ATC at any Q is cost per unit
using the most efficient mix of inputs for that Q
(e.g., the factory size with the lowest ATC).

EXAMPLE 3: LRATC with 3 factory sizes

Firm can choose from 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.

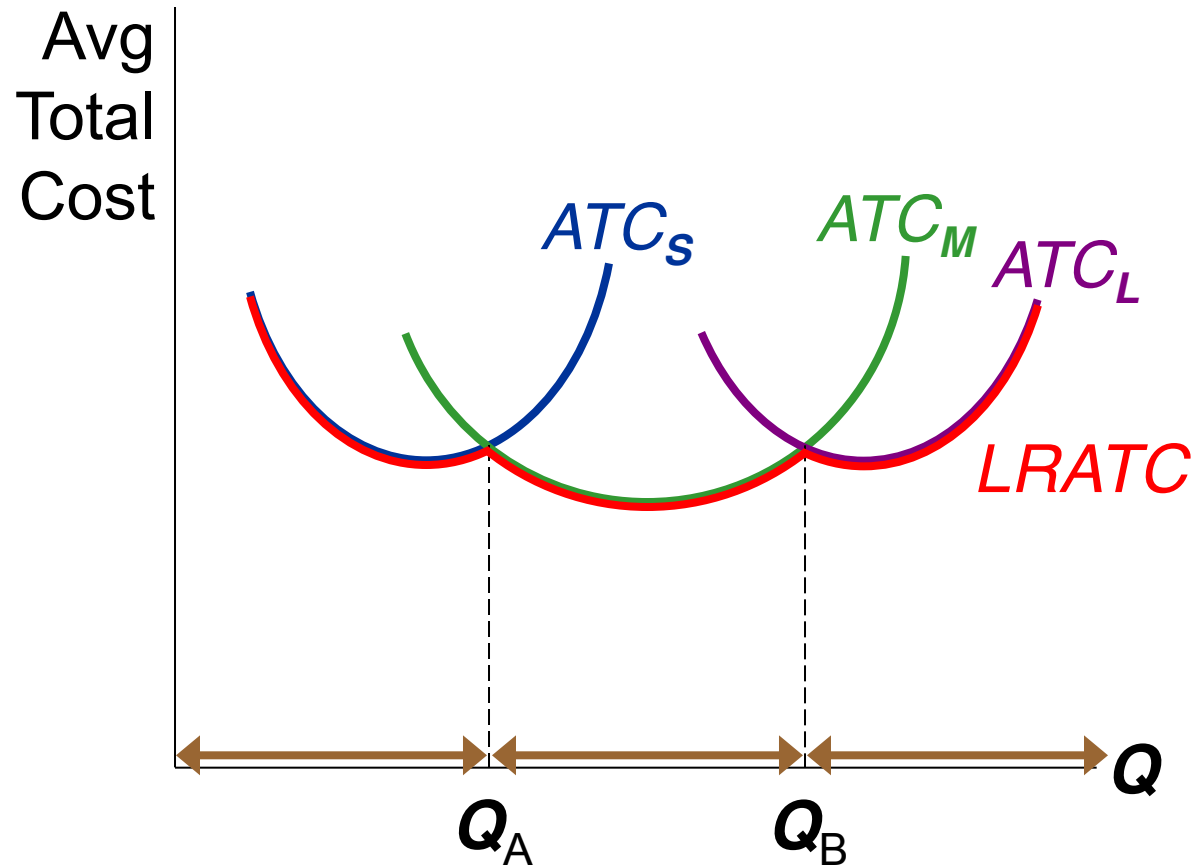


EXAMPLE 3: LRATC with 3 factory sizes

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.

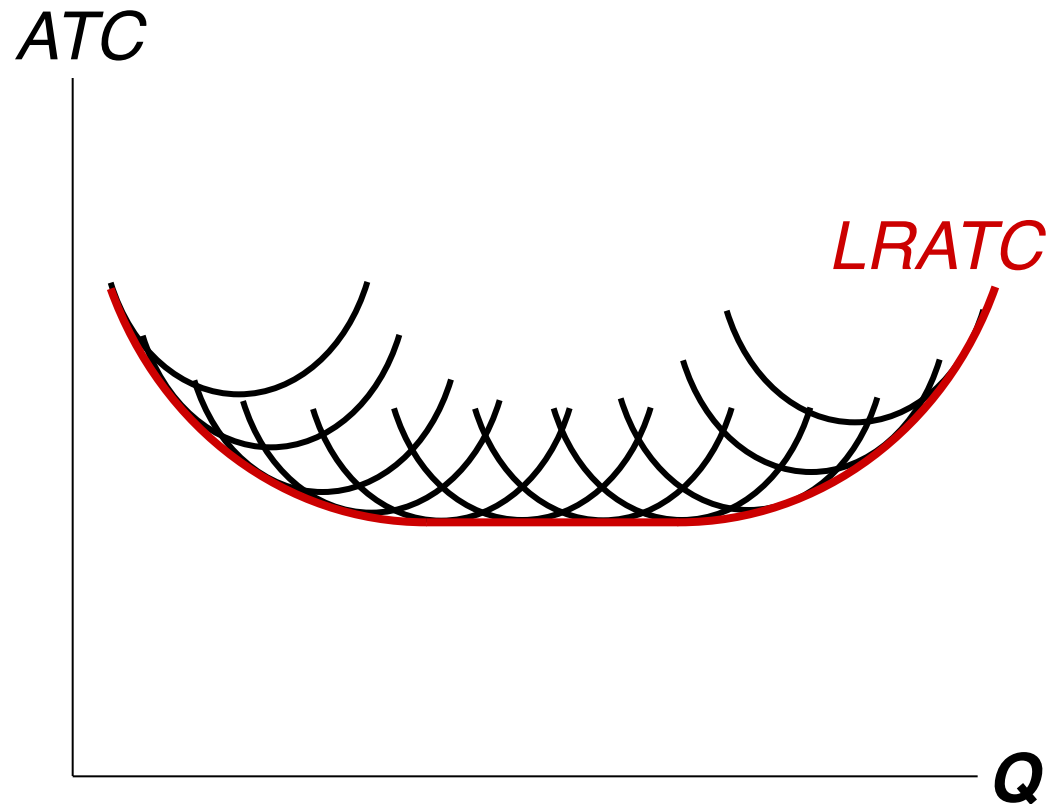
To produce more than Q_B , firm will choose size **L** in the long run.



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:

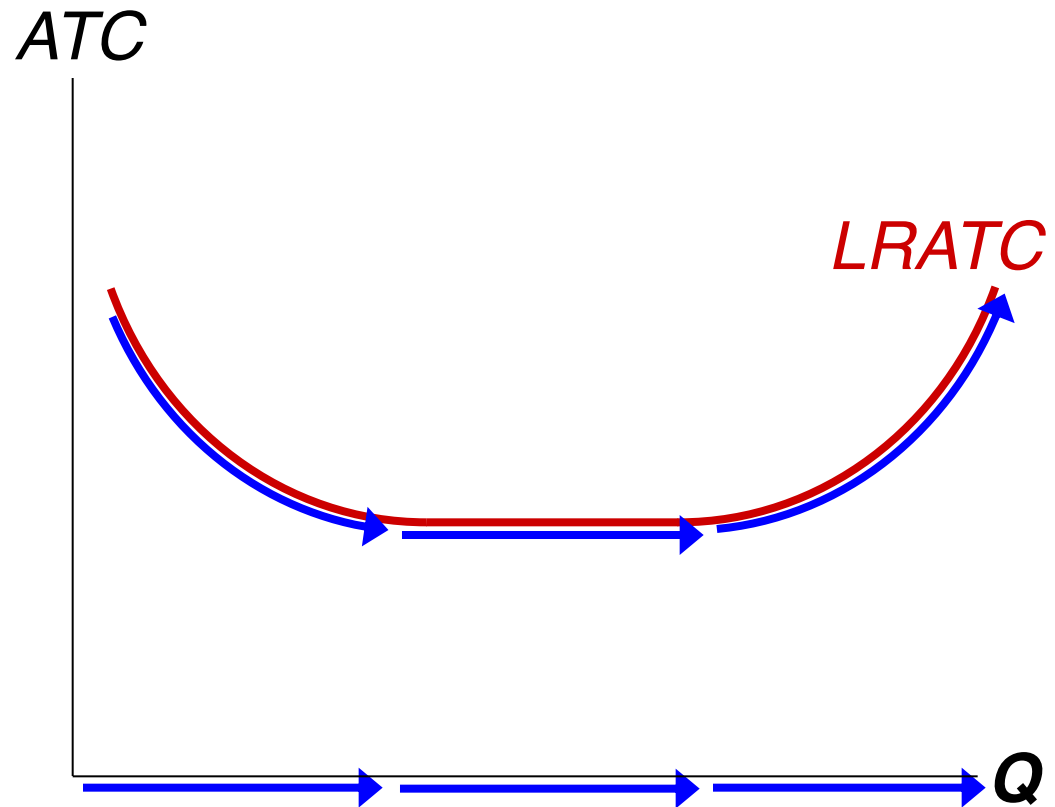


How ATC Changes as the Scale of Production Changes

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.

CONCLUSION

- Costs are critically important to many business decisions, including production, pricing, and hiring.
- This chapter has introduced the various cost concepts.
- The following chapters will show how firms use these concepts to maximize profits in various market structures.

SUMMARY

- Implicit costs do not involve a cash outlay, yet are just as important as explicit costs to firms' decisions.
- Accounting profit is revenue minus explicit costs. Economic profit is revenue minus total (explicit + implicit) costs.
- The production function shows the relationship between output and inputs.

SUMMARY

- The marginal product of labor is the increase in output from a one-unit increase in labor, holding other inputs constant. The marginal products of other inputs are defined similarly.
- Marginal product usually diminishes as the input increases. Thus, as output rises, the production function becomes flatter, and the total cost curve becomes steeper.
- Variable costs vary with output; fixed costs do not.

SUMMARY

- Marginal cost is the increase in total cost from an extra unit of production. The *MC* curve is usually upward-sloping.
- Average variable cost is variable cost divided by output.
- Average fixed cost is fixed cost divided by output. *AFC* always falls as output increases.
- Average total cost (sometimes called “cost per unit”) is total cost divided by the quantity of output. The *ATC* curve is usually U-shaped.

SUMMARY

- The MC curve intersects the ATC curve at minimum average total cost.
When $MC < ATC$, ATC falls as Q rises.
When $MC > ATC$, ATC rises as Q rises.
- In the long run, all costs are variable.
- Economies of scale: ATC falls as Q rises.
Diseconomies of scale: ATC rises as Q rises.
Constant returns to scale: ATC remains constant as Q rises.