Microeconomics

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Wojciech Gerson (1831-1901)

LECTURE
5

The Costs of Production

Chapter 13

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.

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Lecture Today

- 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**

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.

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.

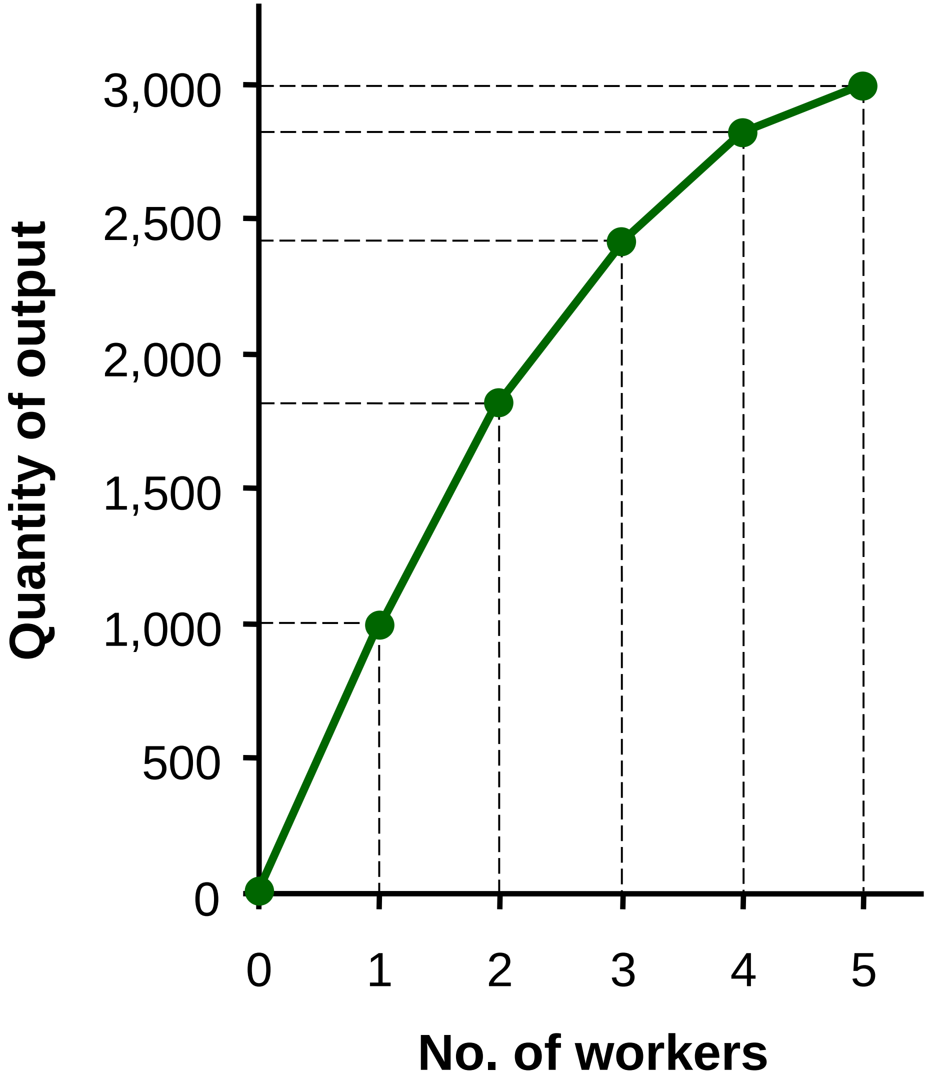
Implicit costs increase $500/month (opp. cost of using your space instead of renting it)
so economic profit falls by $500/month.

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 Slavko grows wheat.
  - He has 5 acres of land.
  - He can hire as many workers as he wants.

EXAMPLE 1: Farmer Slavko'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 Slavko 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:

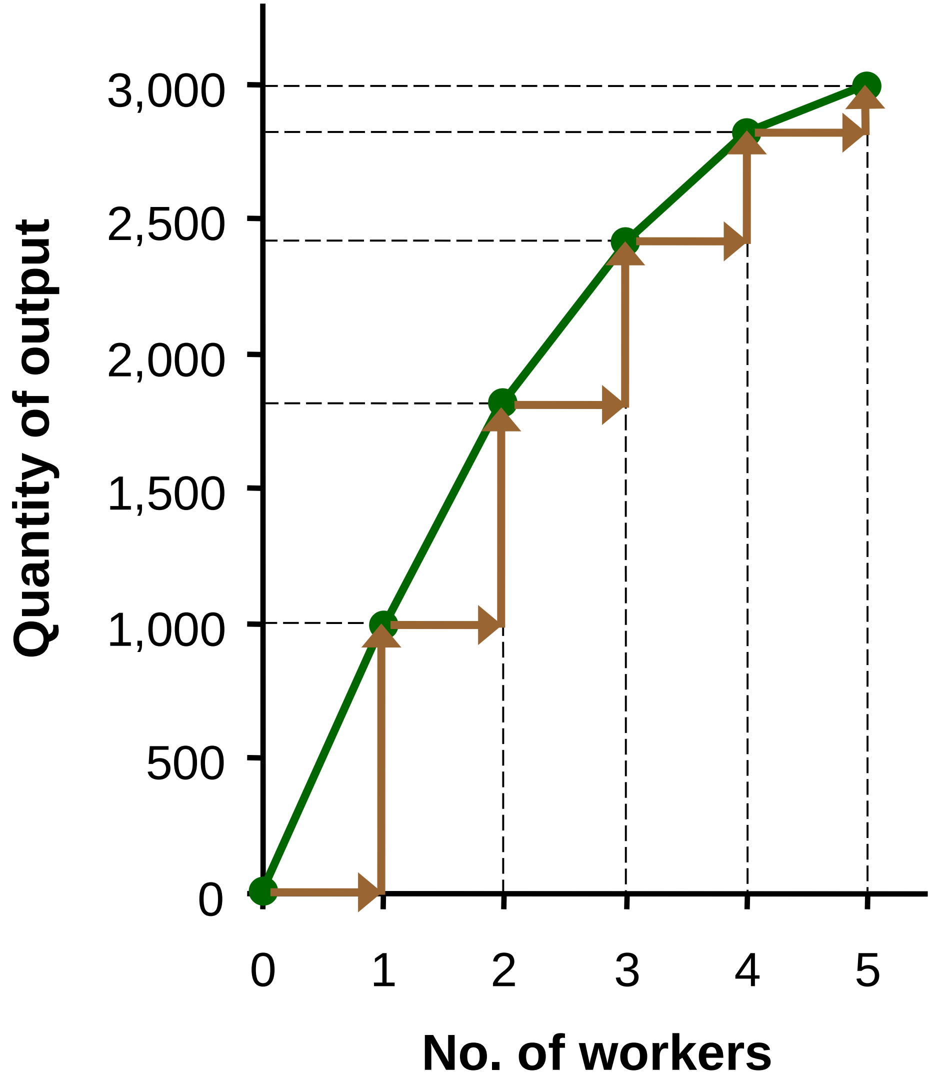
  $\boldsymbol{\Delta Q}$ = change in output, $\boldsymbol{\Delta L}$ = change in labor
- Marginal product of labor (*MPL*) = $\dfrac{\boldsymbol{\Delta Q}}{\boldsymbol{\Delta L}}$

EXAMPLE 1: Total & Marginal Product

	L (no. of workers)	***Q*** (bushels of wheat)		*MPL*
	0	0		
Δ*L* = 1			**Δ*Q*** = 1000	1000
	1	1000		
Δ*L* = 1			**Δ*Q*** = 800	800
	2	1800		
Δ*L* = 1			**Δ*Q*** = 600	600
	3	2400		
Δ*L* = 1			**Δ*Q*** = 400	400
	4	2800		
Δ*L* = 1			**Δ*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 Slavko hires an extra worker,
  - his costs rise by the wage he pays the worker
  - his output rises by *MPL*
- Comparing them helps Slavko decide whether he should hire the worker.

Why MPL Diminishes

- Farmer Slavko's output rises by a smaller and smaller amount for each additional worker. Why?
- As he 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 Slavko's Costs

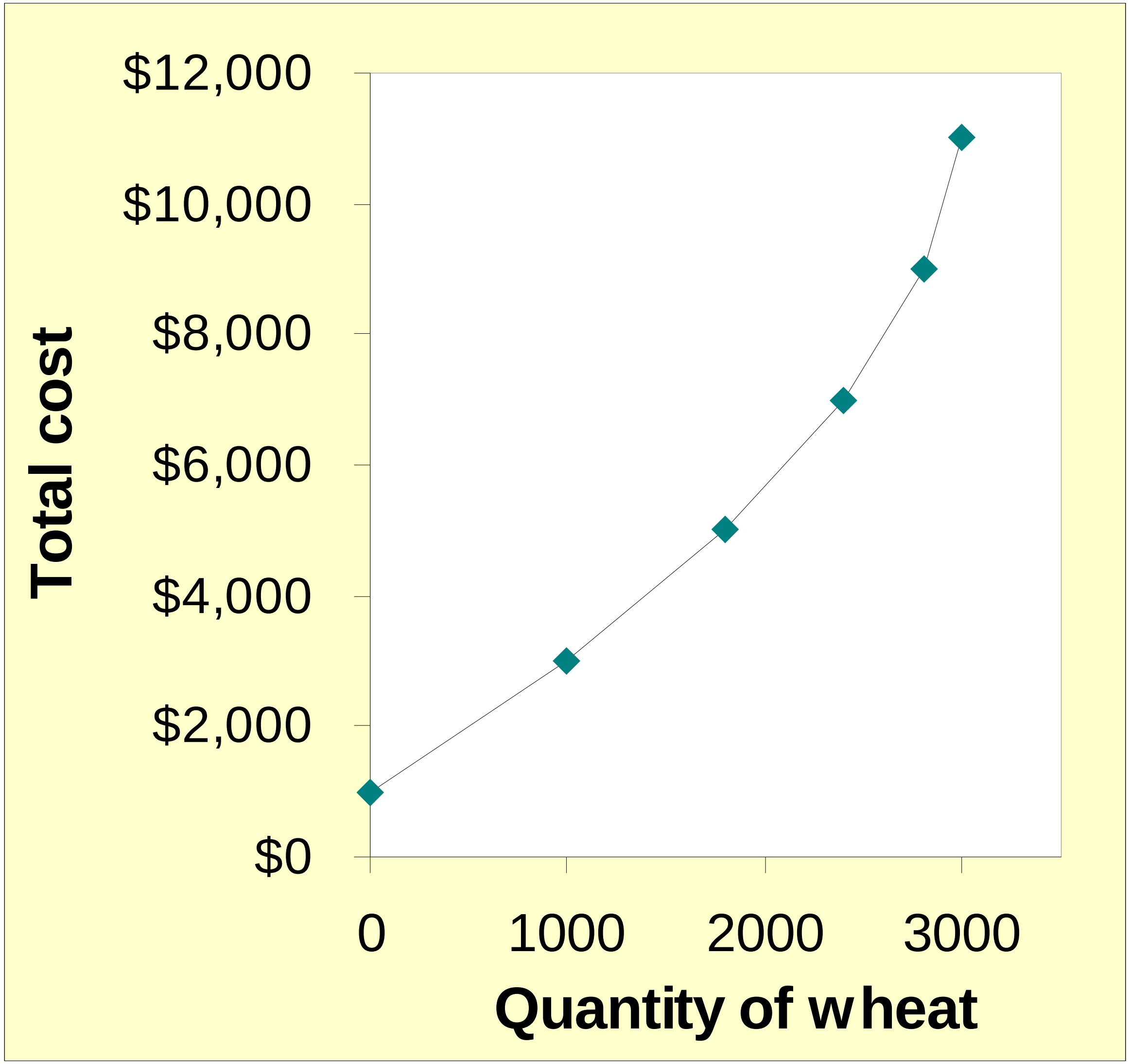
- Farmer must pay $1000 per month for the land, regardless of how much wheat he grows.
- The market wage for a farm worker is $2000 per month.
- So Slavko's costs are related to how much wheat he produces….

EXAMPLE 1: Farmer Slavko'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: Slavko'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:

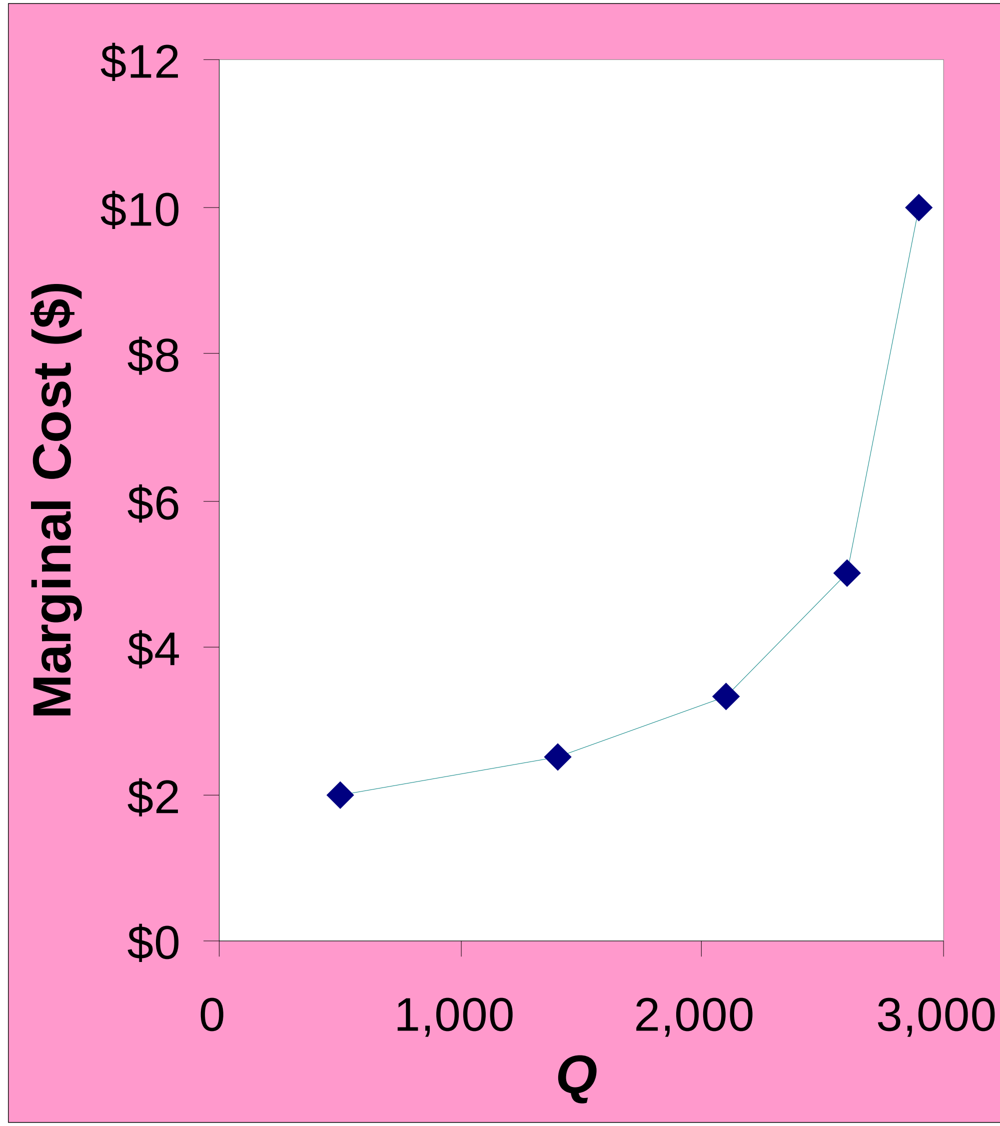
$$MC = \frac{\Delta TC}{\Delta Q}$$

EXAMPLE 1: Total and Marginal Cost

	Q (bushels of wheat)	Total Cost		Marginal Cost (*MC*)
	0	$1,000		
Δ*Q* = 1000			**ΔTC** = $2000	$2.00
	1000	$3,000		
Δ*Q* = 800			**ΔTC** = $2000	$2.50
	1800	$5,000		
Δ*Q* = 600			**ΔTC** = $2000	$3.33
	2400	$7,000		
Δ*Q* = 400			**ΔTC** = $2000	$5.00
	2800	$9,000		
Δ*Q* = 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 Slavko is rational and wants to maximize his profit. To increase profit, should he produce more or less wheat?
- To find the answer, he needs to “think at the margin.”
- If the cost of an additional wheat (*MC*) is less than the revenue he would get from selling it, then Alejandro’s profits rise if he produces more.

Fixed and Variable Costs

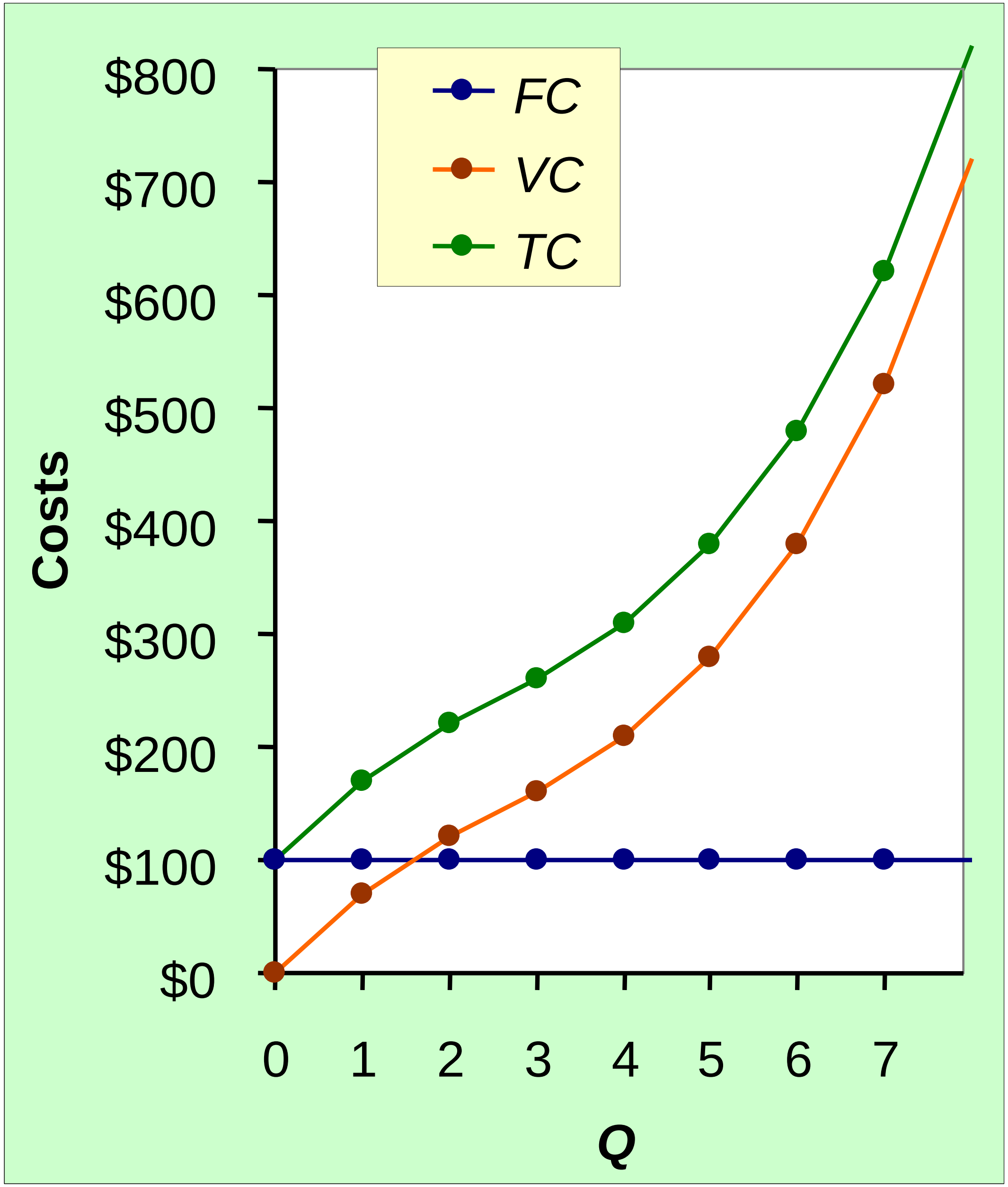
- **Fixed costs (*FC*)** do not vary with the quantity of output produced.
  - For Farmer Slavko, *FC* = \$1000 for his land
  - Other examples:
    cost of equipment, loan payments, rent
- **Variable costs (*VC*)** vary with the quantity produced.
  - For Farmer Slavko, *VC* = wages he pays workers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

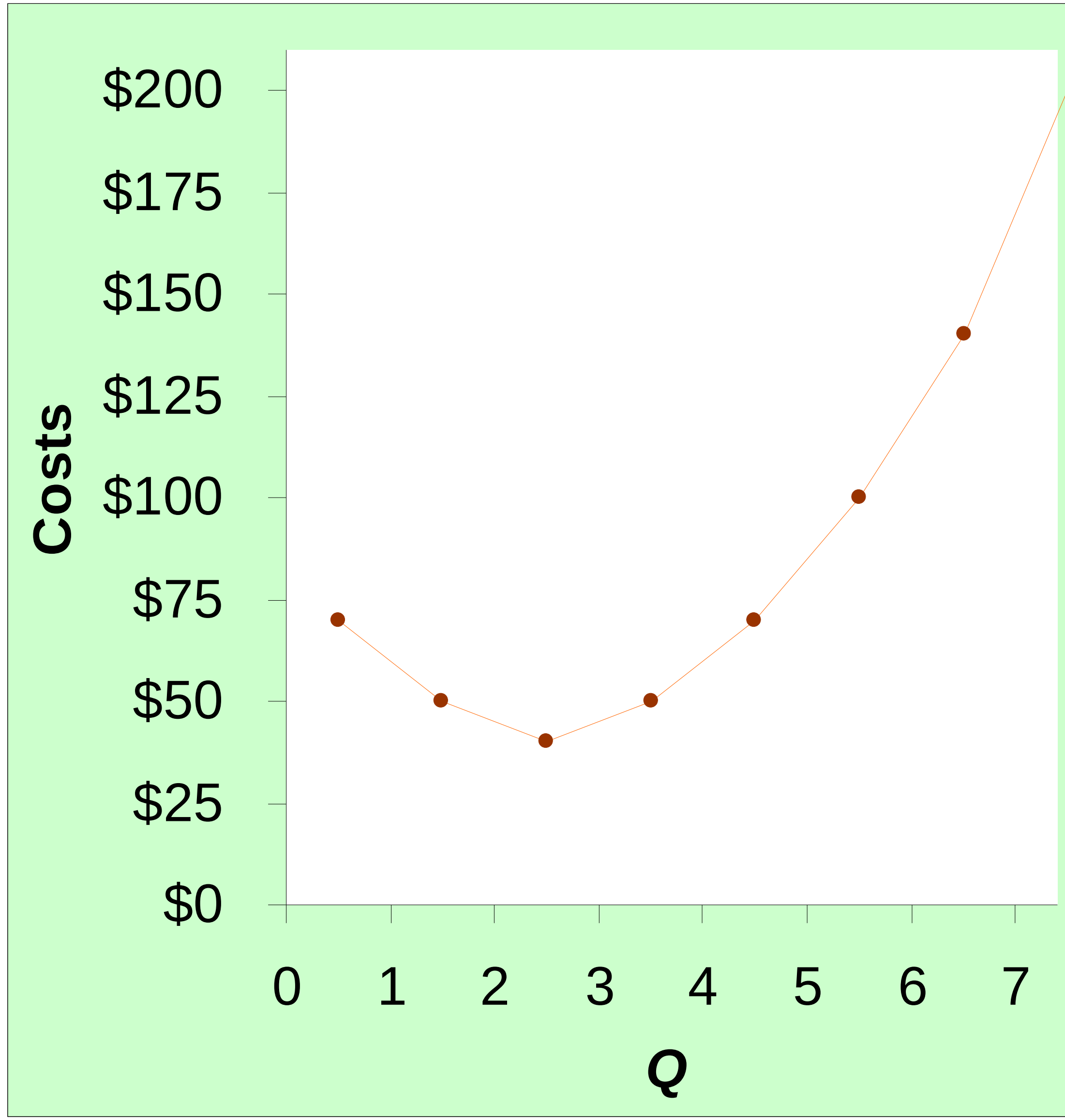
EXAMPLE 2: Costs

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



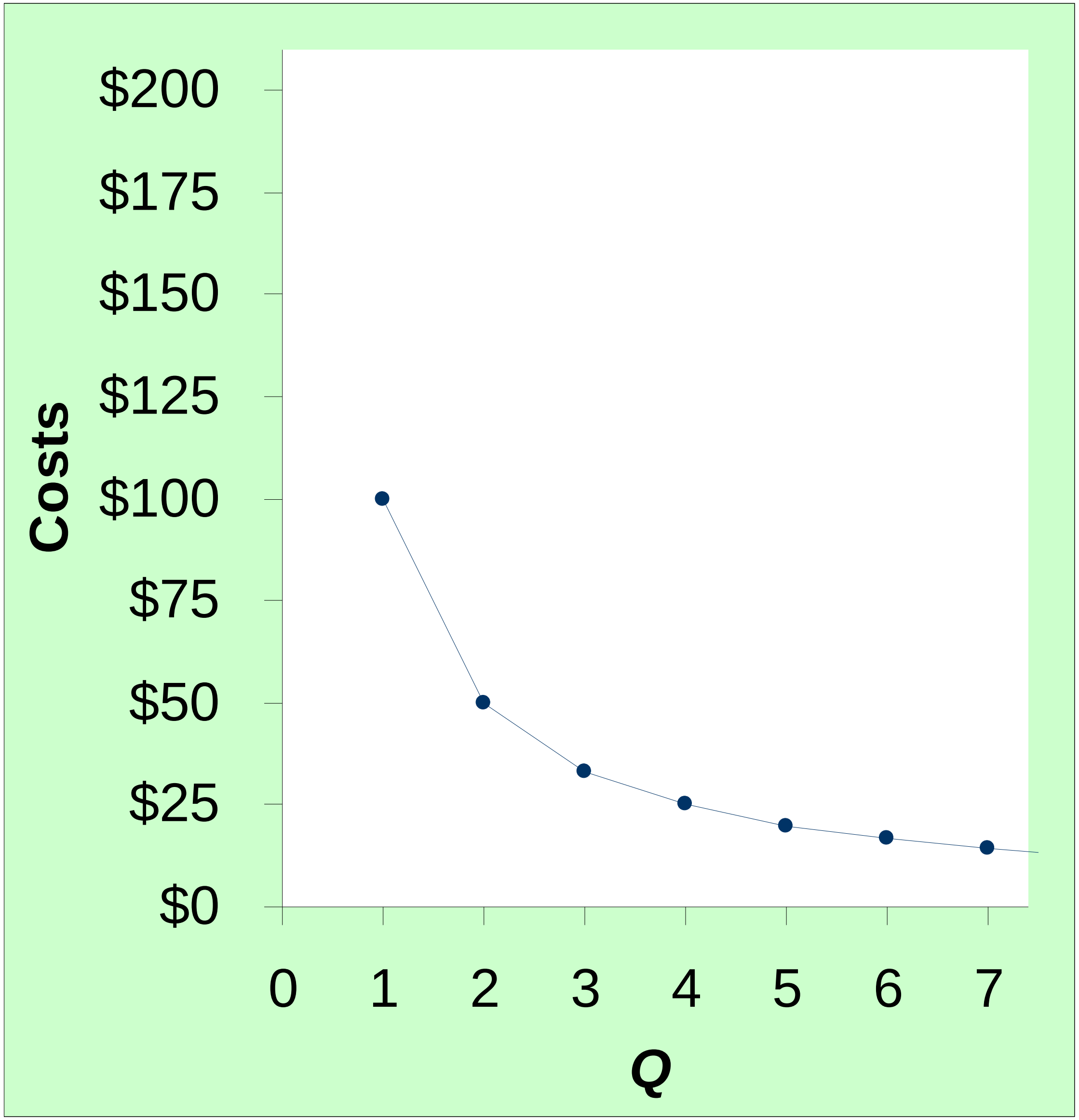
EXAMPLE 2: Marginal Cost

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



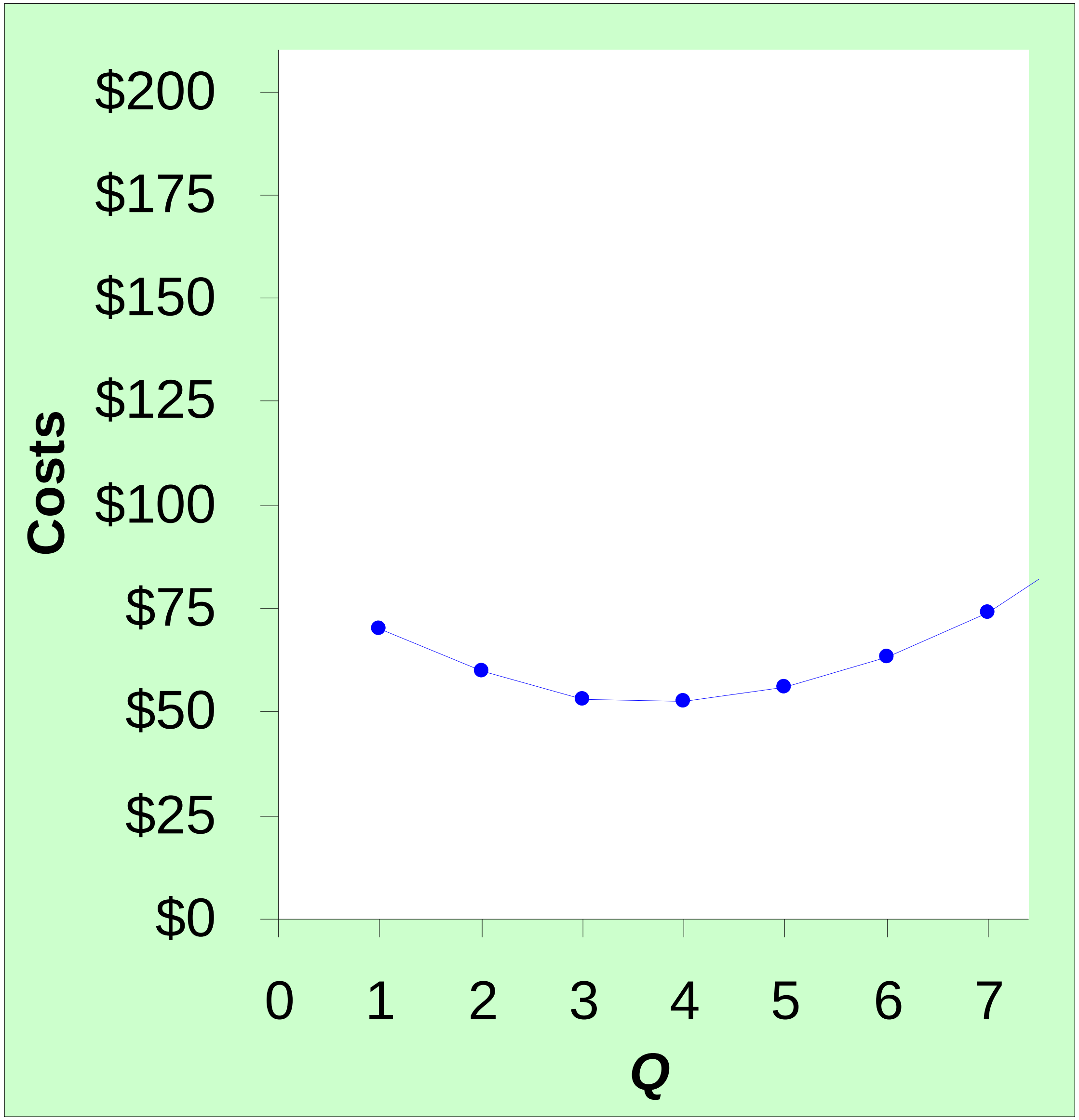
EXAMPLE 2: Average Fixed Cost

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

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*)/cost per unit/unit cost equals total cost divided by the quantity of output:

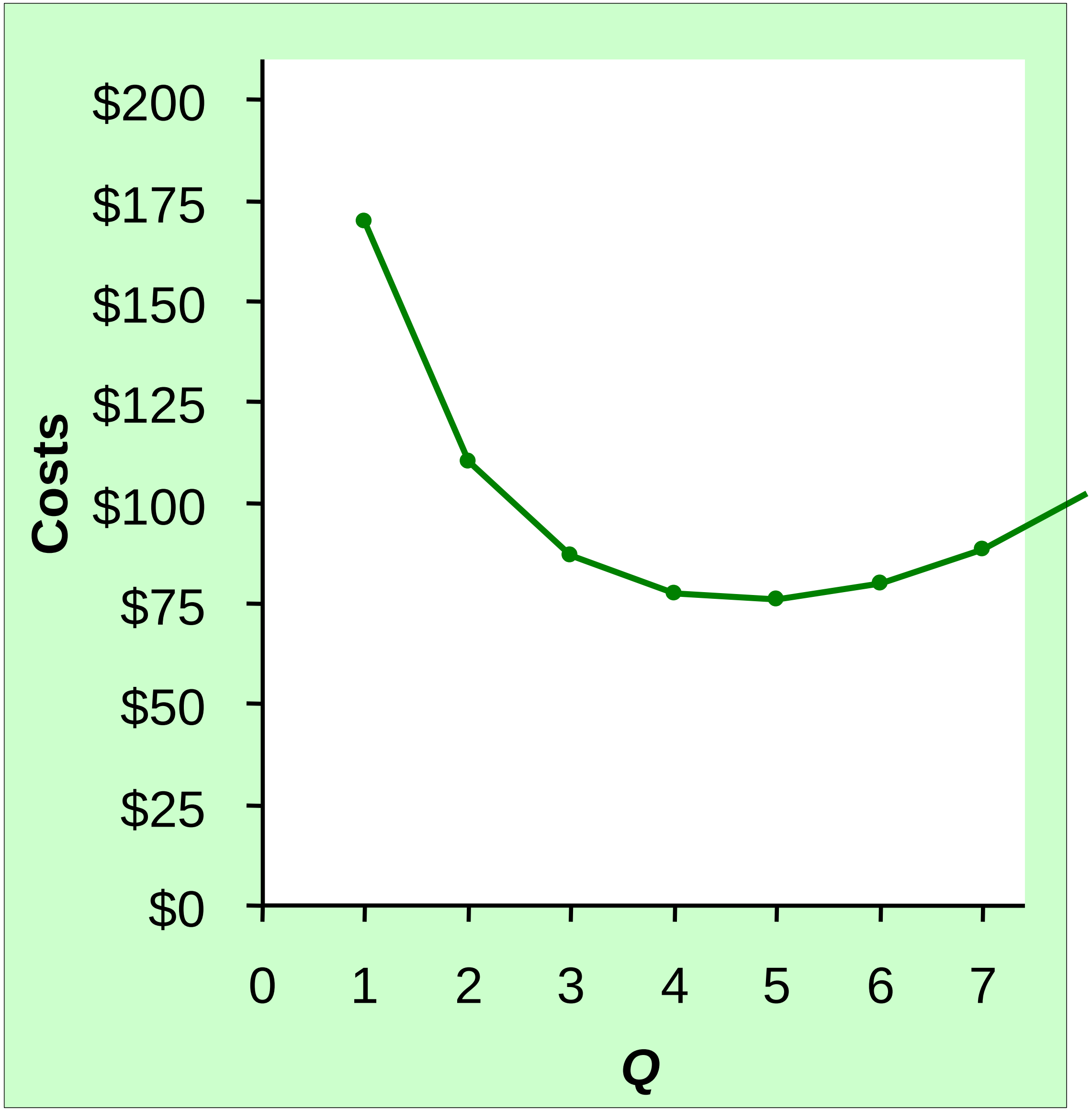
$$ATC = TC/\mathbf{Q}$$

Also,

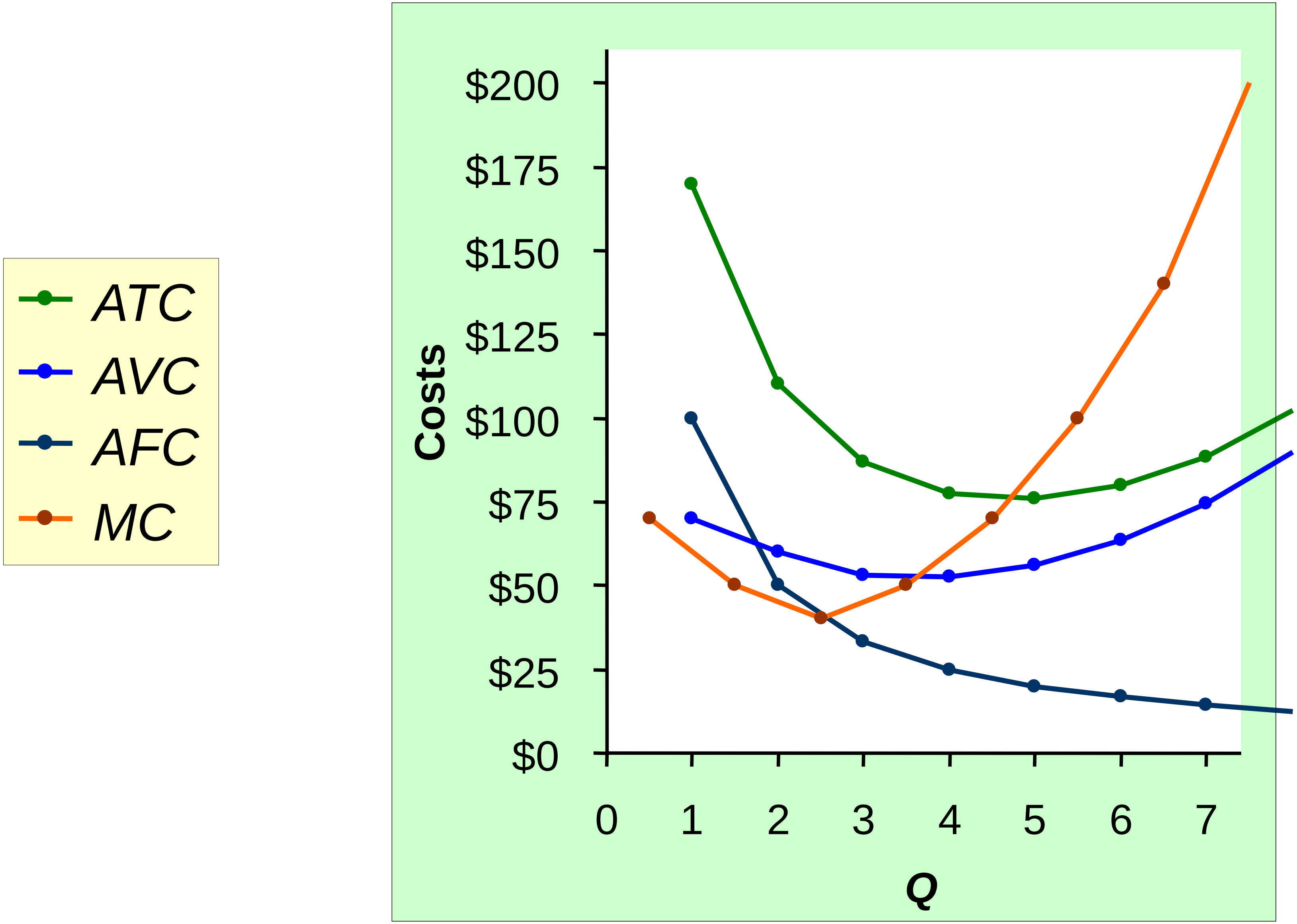
$$ATC = AFC + AVC$$

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



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*	
1	10			$10	$60.00	$10
2	30	80				
3			16.67	20	36.67	30
4	100	150	12.50		37.50	
5	150			30		
6	210	260	8.33	35	43.33	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*	
						$10
1	10	60	$50.00	$10	$60.00	
						20
2	30	80	25.00	15	40.00	
						30
3	60	110	16.67	20	36.67	
						40
4	100	150	12.50	25	37.50	
						50
5	150	200	10.00	30	40.00	
						60
6	210	260	8.33	35	43.33	

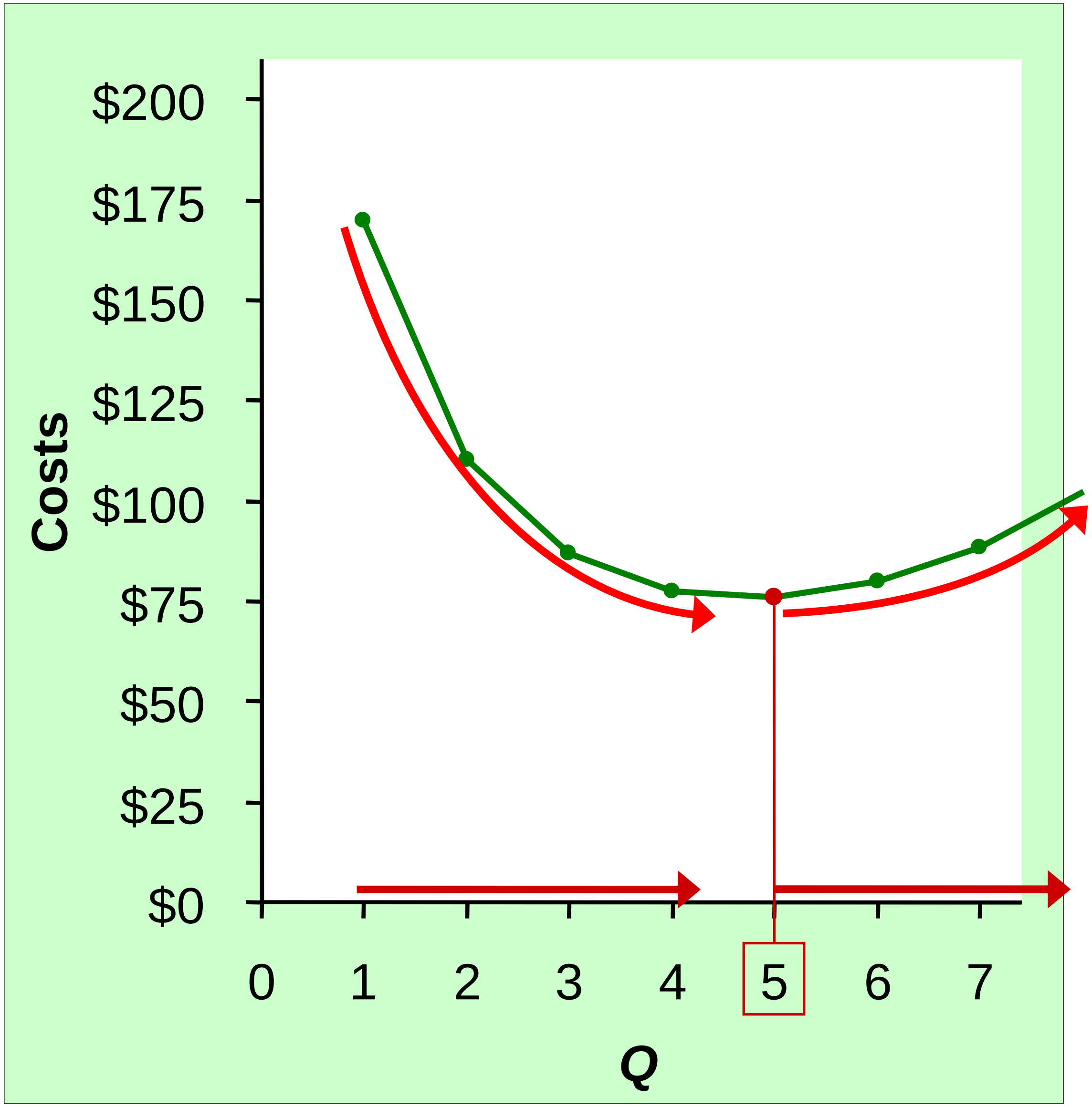
EXAMPLE 2: Why ATC Is Usually U-Shaped

As ***Q*** rises:

Initially,
falling *AFC*
pulls *ATC* down.

Eventually,
rising *AVC*
pulls *ATC* up.

Efficient scale:
The quantity that
minimizes ATC.

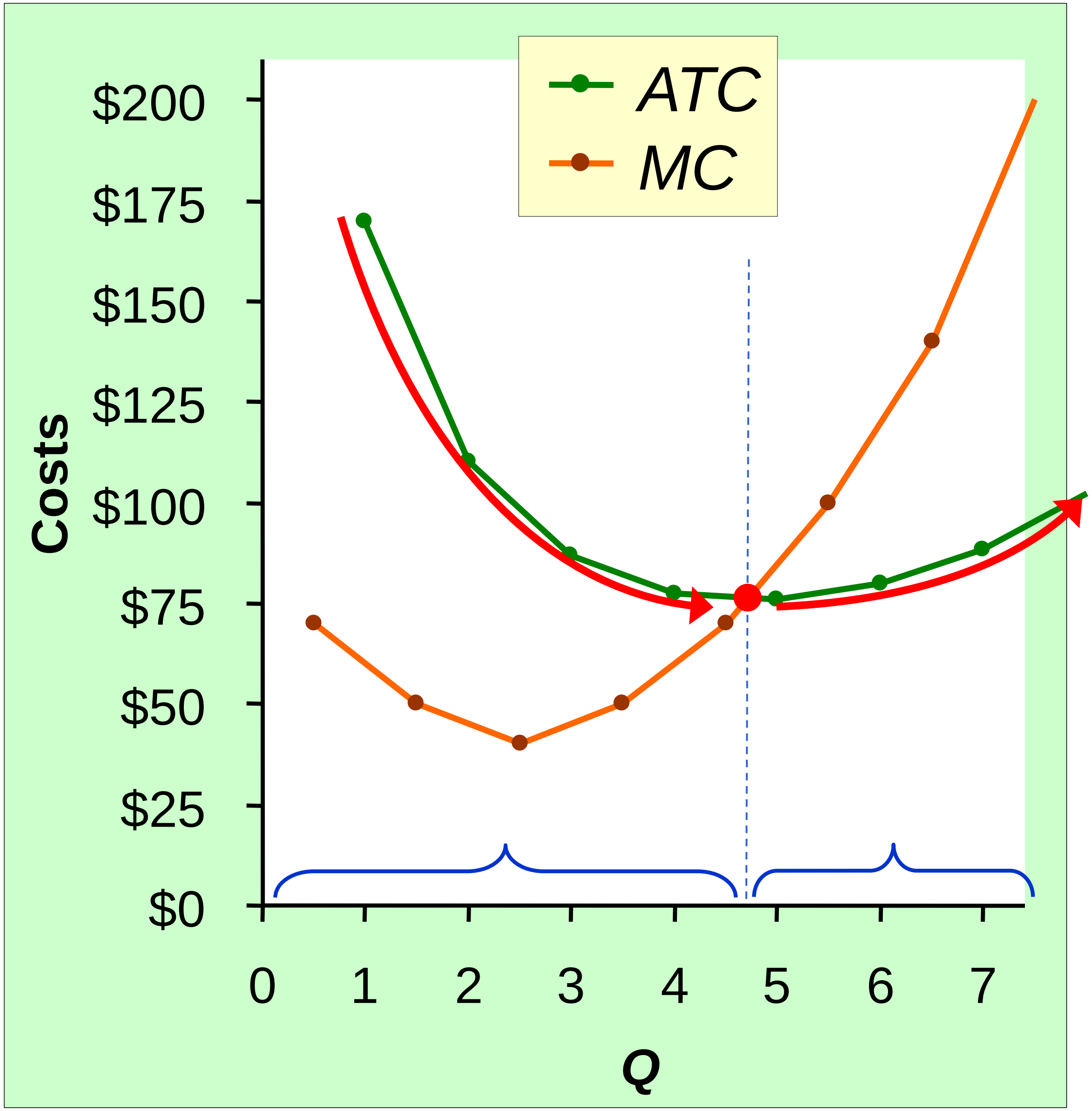


EXAMPLE 2: ATC and MC

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

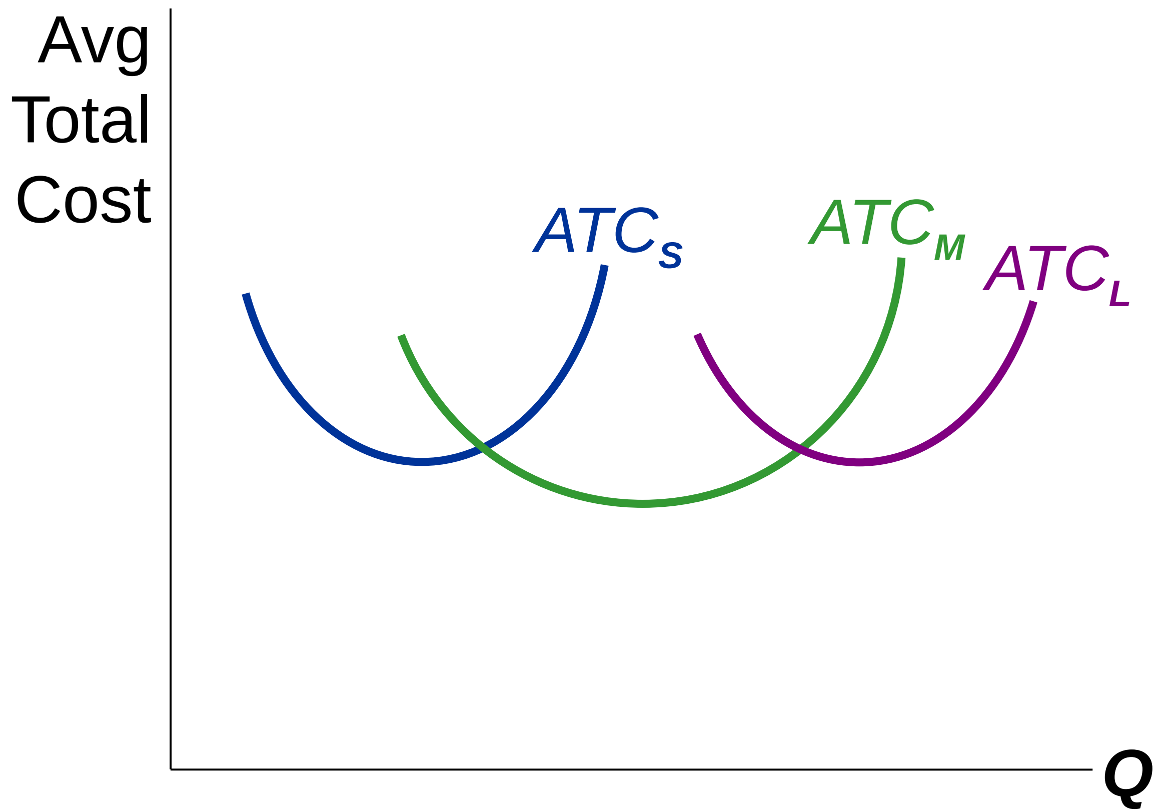
- Short run:
  Some inputs are fixed (e.g., factories, land).
  The costs of these inputs are *FC*.
- Long run:
  All inputs are variable
  (e.g., firms can build more factories
  or sell existing ones).
- In the long run, *ATC* at any ***Q*** is cost per unit using the most efficient mix of inputs for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

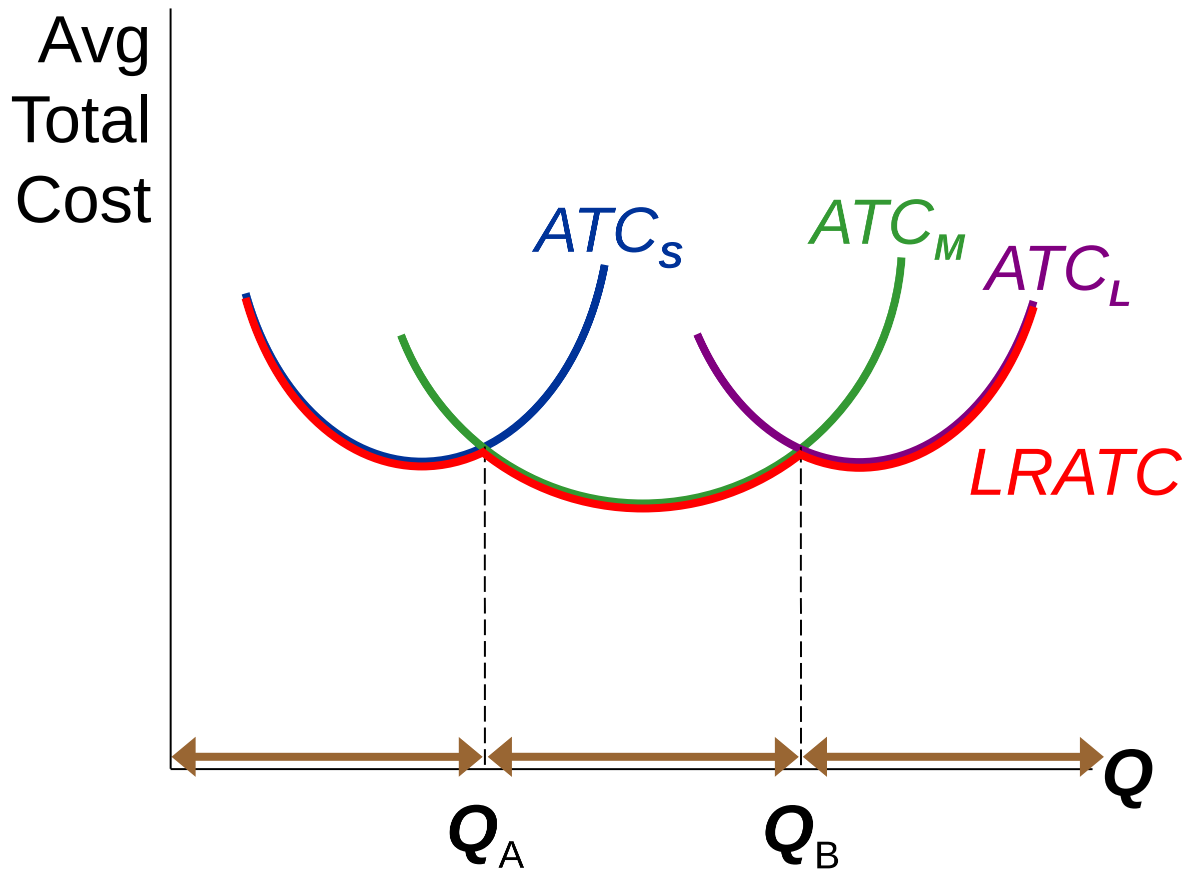


EXAMPLE 3: LRATC with 3 factory sizes

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.

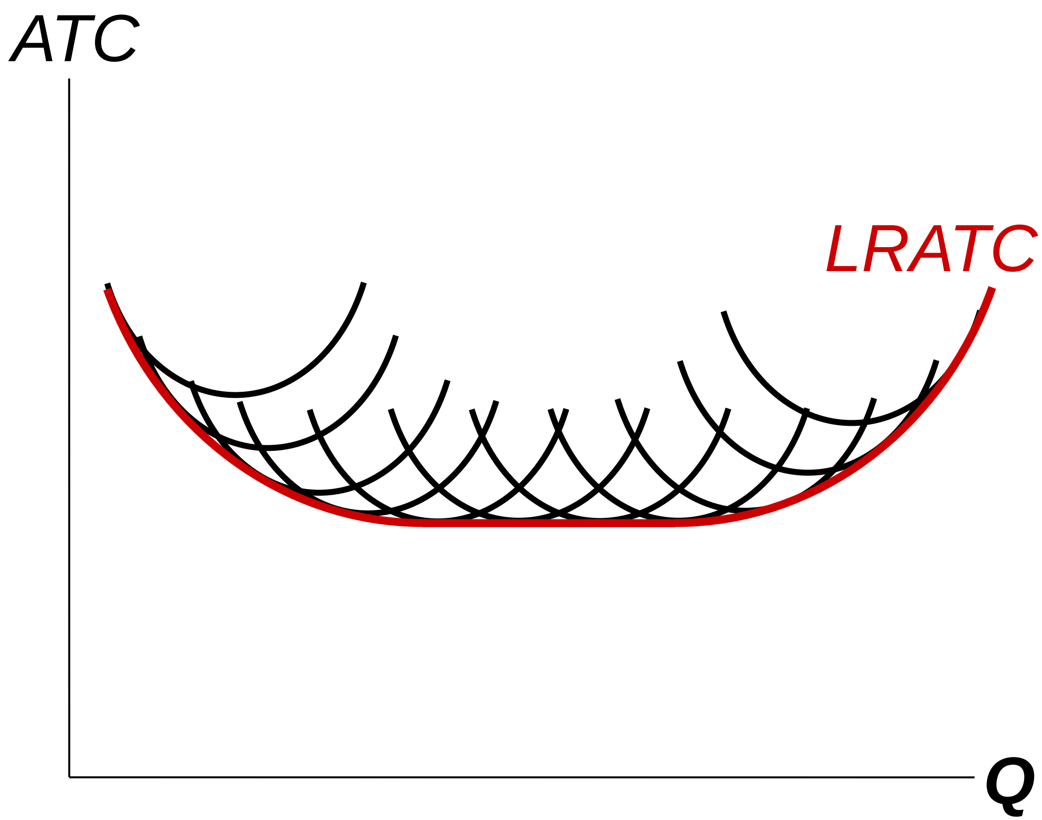
To produce more than Q_B, firm will choose size **L** in the long run.



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:

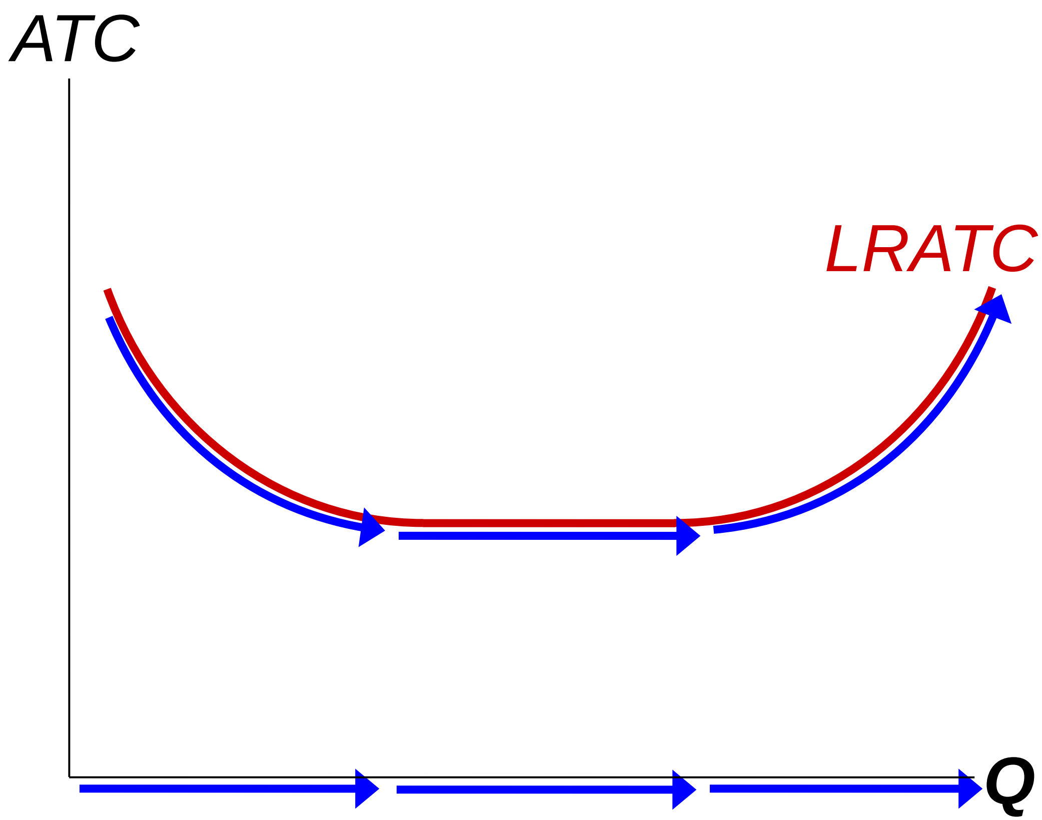


How ATC Changes as the Scale of Production Changes

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 are 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.