CHAPTER 13

The Costs of Production

PRINCIPLES OF Economics

N. Gregory Mankiw

Premium PowerPoint Slides
by Ron Cronovich
Modified by Joseph Tao-yi Wang

ACTIVE LEARNING 1

Brainstorming costs

You run Foxconn Electronics Inc. (鴻海/富士康).

- List 3 different costs you have.
- List 3 different business decisions that are affected by your costs.
- How would your answers change if you run 台北農產運銷公司 instead?

1

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"?

2

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 $1,000,000 to start your business.
The interest rate is 5%.

- Case 1: borrow $1,000,000
  - explicit cost = $50,000 interest on loan
- Case 2: use $400,000 of your savings, borrow the other $600,000
  - explicit cost = $30,000 (5%) interest on the loan
  - implicit cost = $20,000 (5%) *foregone* interest you could have earned on your $400,000.

In both cases, total (exp + imp) costs are $50,000.

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 $5000/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 $5000/month.

a. You rent your office space.
Explicit costs increase $5000/month.
Accounting profit & economic profit each fall $5000/month.

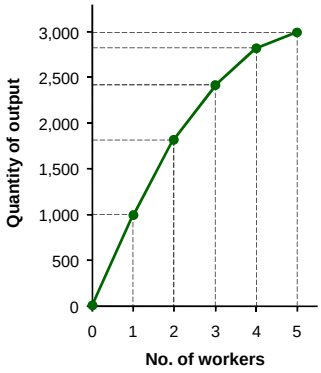
b. You own your office space.
Explicit costs do not change, so accounting profit does not change.
Implicit costs increase $5000/month (opp. cost of using your space instead of renting it), so economic profit falls by $5000/month.

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 Jack grows vegetables.
  - 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 veggie)
0	0
1	1000
2	1800
3	2400
4	2800
5	3000



Marginal Product

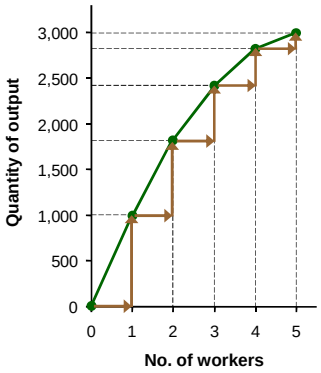
- If Jack hires one more worker, his output rises by the *marginal product of labor*.
- The **marginal product** of any input is the increase in output arising from an additional unit of that input, holding all other inputs constant.
- Notation:
  Δ (delta) = "change in…"
  Examples:
  Δ***Q*** = change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

EXAMPLE 1: Total & Marginal Product

	L (no. of workers)	*Q* (bushels of veggie)		*MPL*
	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 = Slope of Prod Function

L (no. of workers)	*Q* (bushels of veggie)	*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 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

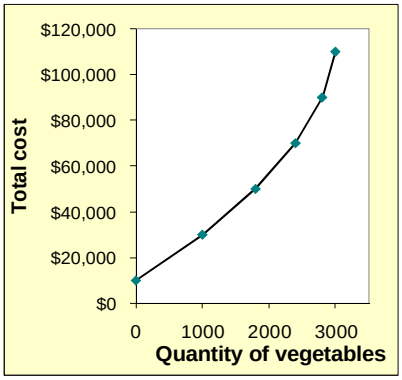
- Farmer Jack must pay $10,000 per month for the land, regardless of how much wheat he grows.
- The market wage for a farm worker is $20,000 per month.
- So Farmer Jack's costs are related to how much wheat he produces….

EXAMPLE 1: Farmer Jack's Costs

L (no. of workers)	*Q* (bushels of veggie)	Cost of land	Cost of labor	Total Cost
0	0	$10,000	$0	$10,000
1	1000	$10,000	$20,000	$30,000
2	1800	$10,000	$40,000	$50,000
3	2400	$10,000	$60,000	$70,000
4	2800	$10,000	$80,000	$90,000
5	3000	$10,000	$100,000	$110,000

EXAMPLE 1: Farmer Jack's Total Cost Curve

Q (bushels of veggie)	Total Cost
0	$10,000
1000	$30,000
1800	$50,000
2400	$70,000
2800	$90,000
3000	$110,000



Marginal Cost

- **Marginal Cost** (*MC*) is the increase in Total Cost from producing one more unit:

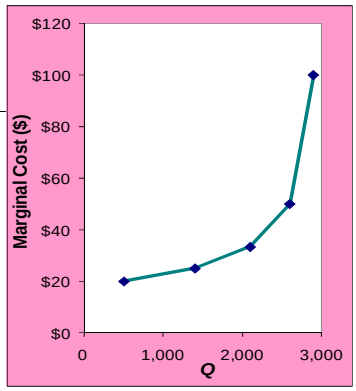
$$MC = \frac{\Delta TC}{\Delta Q}$$

EXAMPLE 1: Total and Marginal Cost

	Q (bushels of veggie)	Total Cost		Marginal Cost (*MC*)
	0	$10,000		
ΔQ = 1000	1000	$30,000	ΔTC = $20,000	$20.0
ΔQ = 800	1800	$50,000	ΔTC = $20,000	$25.0
ΔQ = 600	2400	$70,000	ΔTC = $20,000	$33.3
ΔQ = 400	2800	$90,000	ΔTC = $20,000	$50.0
ΔQ = 200	3000	$110,000	ΔTC = $20,000	$100.0

EXAMPLE 1: The Marginal Cost Curve

Q (bushels of veggie)	*TC*	*MC*
0	$10,000	
1000	$30,000	$20.0
1800	$50,000	$25.0
2400	$70,000	$33.3
2800	$90,000	$50.0
3000	$110,000	$100.0



Why MC Is Important

- Farmer Jack is rational and wants to maximize his profit. To increase profit, should he produce more or less veggie?
- To find the answer, Farmer Jack needs to "think at the margin."
- If the cost of additional veggie (*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

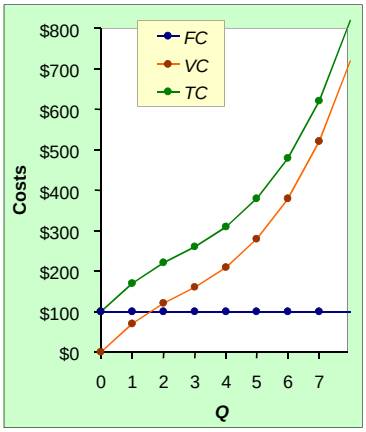
- **Fixed costs (*FC*)** do not vary with the quantity of output produced.
  - For Farmer Jack, *FC* = $10,000 for his land
  - Other examples: cost of equipment, loan payments, rent
- **Variable costs (*VC*)** vary with the quantity produced.
  - For Farmer Jack, *VC* = wages he pays workers
  - Other 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.

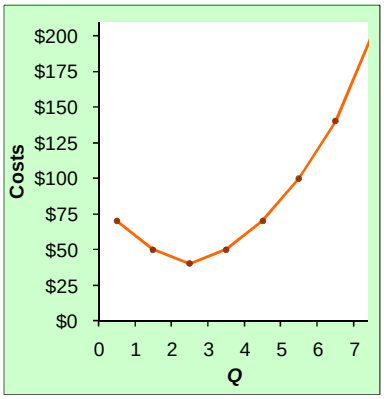
EXAMPLE 2: Costs

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



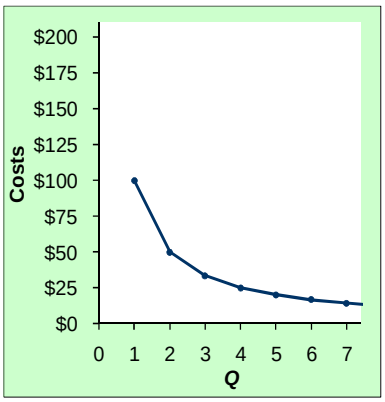
EXAMPLE 2: Marginal Cost

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



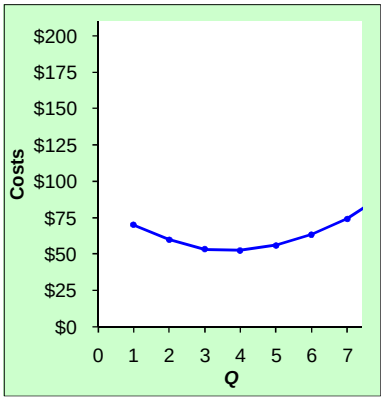
EXAMPLE 2: Average Fixed Cost

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

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:

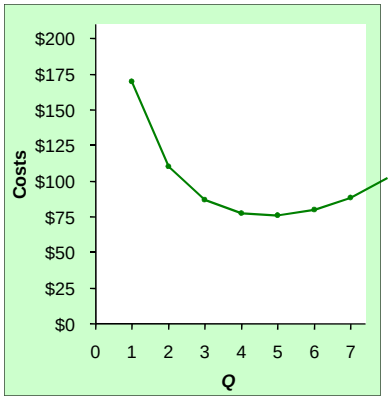
$ATC = TC/Q$

Also,

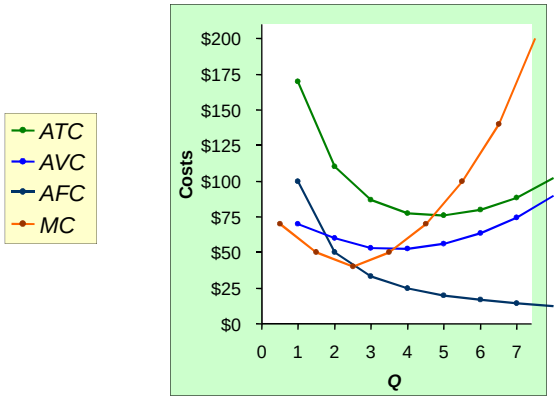
$ATC = AFC + AVC$

EXAMPLE 2: Average Total Cost

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*	$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	

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	

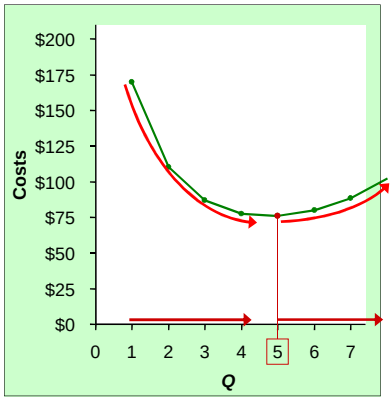
EXAMPLE 2: Why ATC Is Usually U-Shaped

As ***Q*** rises:

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

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

Efficient scale: The quantity that minimizes ATC.

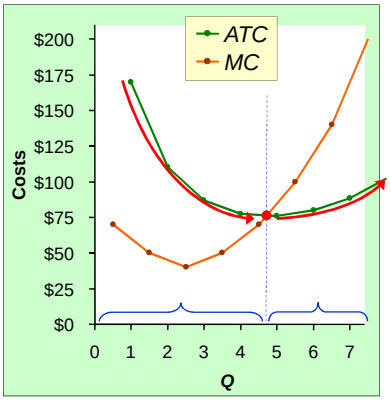


EXAMPLE 2: ATC and MC

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

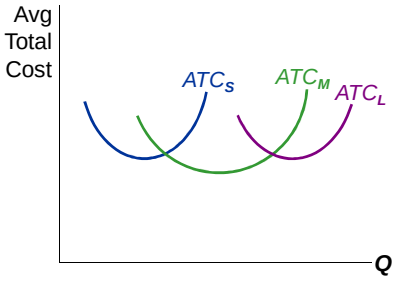
- Short run:
  Some inputs are fixed (*e.g.,* factories, land).
  The costs of these inputs are *FC*.
- Long run:
  All inputs are variable
  (*e.g.,* firms can build more factories,
  or sell existing ones).
- In the long run, *ATC* at any ***Q*** is cost per unit using the most efficient mix of inputs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

EXAMPLE 3: LRATC with 3 factory Sizes

Firm can choose from 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.

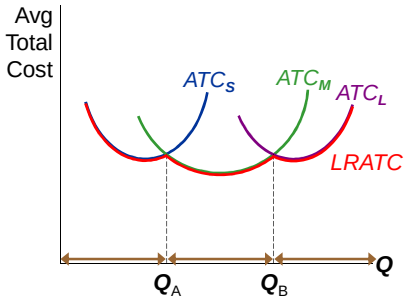


EXAMPLE 3: LRATC with 3 factory Sizes

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.

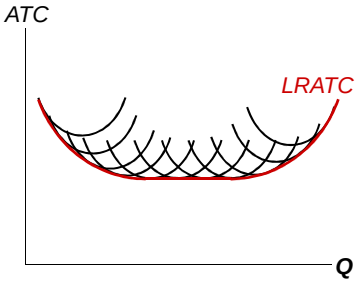
To produce more than Q_B, firm will choose size **L** in the long run.



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:

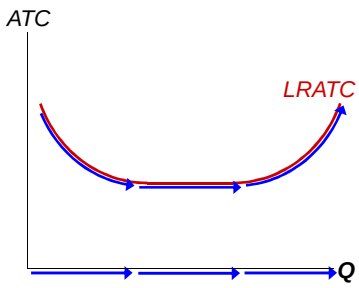


How ATC Changes as the Scale of Production Changes

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.

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.

CHAPTER 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.

CHAPTER 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.

CHAPTER 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.

CHAPTER 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.

The Cost of Production

- Opportunity Cost (Explicit / Implicit)
- Accounting Profit vs. Economic Profit
- Marginal Product
- MC, TC = FC + VC, ATC = AFC+AVC
- Economies of Scale (for LR)
- Homework: Mankiw, Chp. 13,pp. 285-287, Problem 2, 6, 7, 9, 10, 12.