

13 The Costs of Production

PRINCIPLES OF ECONOMICS FOURTH EDITION

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Premium PowerPoint® Slides
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ACTIVE LEARNING 1: Brainstorming

You run Foxconn Electronics Inc. (鴻海).

- 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?



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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”?

CHAPTER 13 THE COSTS OF PRODUCTION

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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

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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.



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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.

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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.

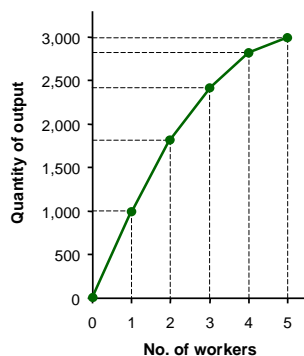
Implicit costs increase \$5000/month (opp. cost of using your space instead of renting it), so economic profit falls by \$5000/month.

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

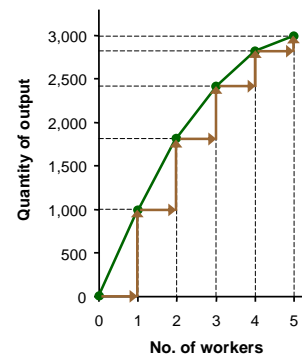
- If Jack hires one more worker, his output rises by the *marginal product of labor*.
- The **marginal product** of any input is the increase in output arising from an additional unit of that input, holding all other inputs constant.
- Notation:
 Δ (delta) = "change in..."
 Examples:
 ΔQ = change in output, ΔL = 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	1000
$\Delta L = 1$	2	1800	800
$\Delta L = 1$	3	2400	600
$\Delta L = 1$	4	2800	400
$\Delta L = 1$	5	3000	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

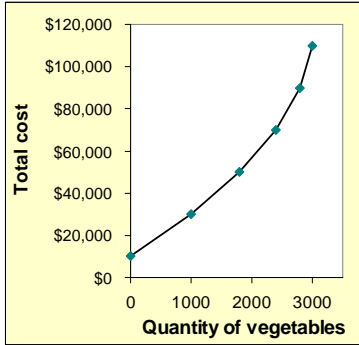
- Farmer Jack must pay \$10,000 per month for the land, regardless of how much wheat he grows.
- The market wage for a farm worker is \$20,000 per month.
- So Farmer Jack's costs are related to how much wheat he produces....

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:

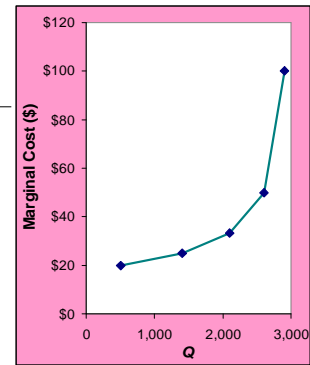
$$MC = \frac{\Delta TC}{\Delta Q}$$

EXAMPLE 1: Total and Marginal Cost

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

EXAMPLE 1: The Marginal Cost Curve

Q (bushels of wheat)	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 wheat, or less?
- 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

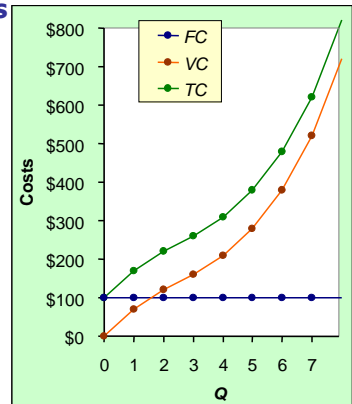
- Fixed costs (FC)** – do not vary with the quantity of output produced.
 - For Farmer Jack, $FC = \$10,000$ for his land
 - Other examples: cost of equipment, loan payments, rent
- Variable costs (VC)** – vary with the quantity produced.
 - For Farmer Jack, $VC =$ wages he pays workers
 - Other example: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

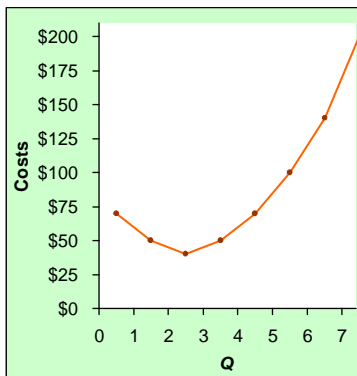
EXAMPLE 2: Costs

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



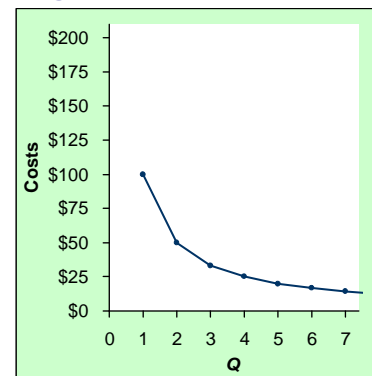
EXAMPLE 2: Marginal Cost

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



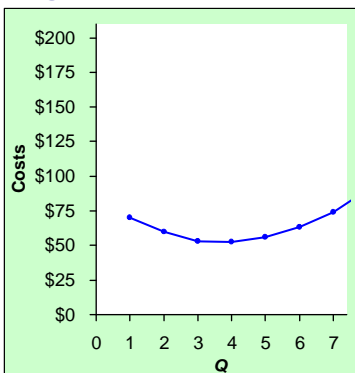
EXAMPLE 2: Average Fixed Cost

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:

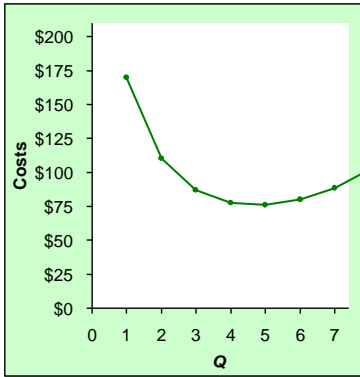
$$ATC = TC/Q$$

Also,

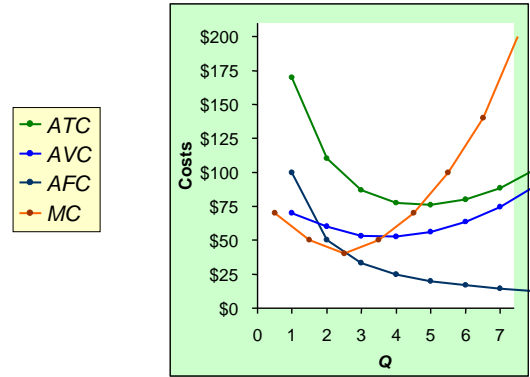
$$ATC = AFC + AVC$$

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: 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				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 $FC + VC = TC$.

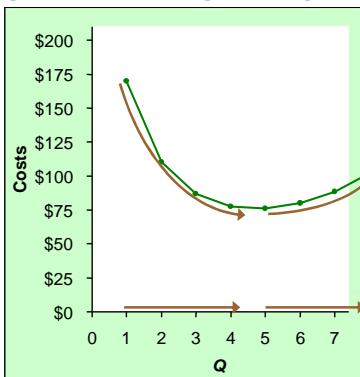
Q	VC	TC	AFC	AVC	ATC	MC
0	\$0	\$50	n.a.	n.a.	n.a.	
1	10	60	\$50.00	\$10	\$60.00	\$10
2	30	80	25.00	15	40.00	20
3	60	110	16.67	20	36.67	30
4	100	150	12.50	25	37.50	40
5	150	200	10.00	30	40.00	50
6	210	260	8.33	35	43.33	60

EXAMPLE 2: Why ATC Is Usually U-Shaped

As Q rises:

Initially, falling AFC pulls ATC down.

Eventually, rising AVC pulls ATC up.

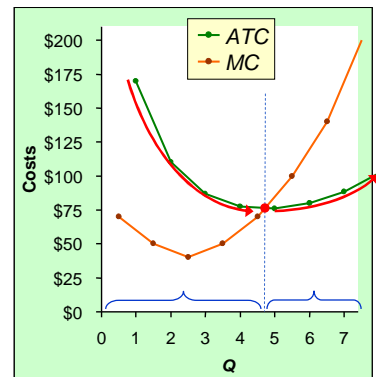


EXAMPLE 2: ATC and MC

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

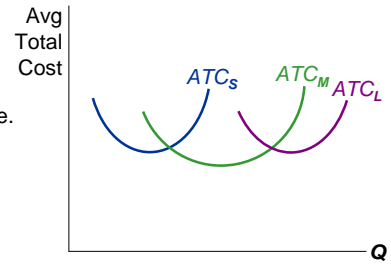
- Short run:
 - Some inputs are fixed (e.g., factories, land).
 - The costs of these inputs are *FC*.
- Long run:
 - All inputs are variable (e.g., firms can build more factories, or sell existing ones)
- In the long run, *ATC* at any *Q* is cost per unit using the most efficient mix of inputs for that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

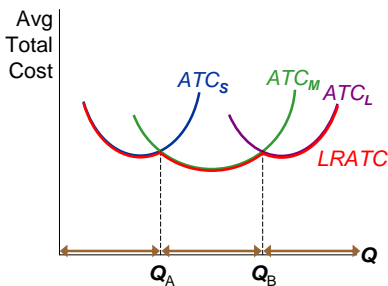


EXAMPLE 3: LRATC with 3 factory Sizes

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.

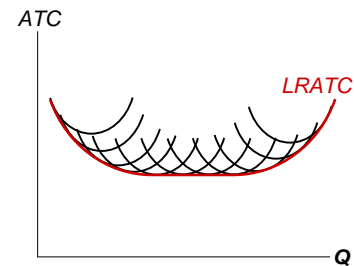
To produce more than Q_B , firm will choose size **L** in the long run.



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:

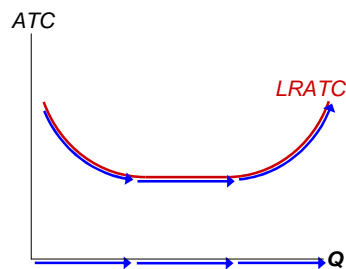


How ATC Changes As the Scale of Production Changes

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 3, 5, 9, 10, 11.