N. GREGORY MANKIW NINTH EDITION

PRINCIPLES OF

ECONOMICS

CHAPTER 13

The Costs of Production

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IN THIS CHAPTER

- 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"?

Active Learning 1: Brainstorming Costs

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

A. List three different costs they have.

B. List three different business decisions that are affected by these costs.

C. How would your answers change if you instead run 台北農產運銷公司?

Total Revenue, Total Cost, and Profit

- Assumption:
  - The goal of a firm is to maximize profit
- Total Revenue, $TR = P \times Q$
  - The amount a firm receives for the sale of its output
- Total Cost, TC
  - The market value of the inputs a firm uses in production
- Profit = $TR - TC$

EXAMPLE 1A: Jelani's Gelato Shop

Jelani owns a small gelato shop on campus.

She can make 15,000 pints of gelato a year, and sell them at NT$50 each.

If Jelani's total costs are NT$650,000 a year, how much profit the shop brings in one year?

- Total Revenue: $TR = P \times Q$
  = NT$50 × 15,000 = NT$750,000
- Profit = $TR - TC$
  = NT$750,000 – NT$650,000
  = NT$100,000

Explicit and Implicit Costs

- "The cost of something is what you give up to get it."
- Explicit Costs
  - Input costs that require an outlay of money by the firm (paying wages to workers)
- Implicit Costs
  - Input costs that do not require an outlay of money by the firm (opportunity cost of the owner's time)
- Total Cost = Explicit + Implicit Costs

EXAMPLE 1B: Costs for Jelani's Gelato Shop

Jelani owns a small gelato shop on campus.

Jelani pays NT$200,000 for raw materials and NT$120,000 in rent per year. Jelani can work at a local coffee shop for NT$250,000 a year.

Identify/calculate explicit and implicit costs.

- Explicit Costs: Raw Materials and Rent
  = NT$200,000 + NT$120,000 = NT$320,000
- Implicit Costs: Opportunity Cost of Owner's Time
  = NT$250,000
- Total Costs = NT$320,000 + NT$250,000
  = NT$570,000

EXAMPLE 1C: The Cost of Capital for Jelani

Jelani invested NT$800,000 in factory and equipment to start the business last year:

NT$300,000 from savings and borrowed NT$500,000 (interest 10% for saving and borrowing).

Identify and calculate the explicit and implicit costs.

- Explicit Cost: Interest Jelani has to pay every year: the 10% interest on the borrowed money
  = 0.10 × 500,000 = NT$50,000
- Implicit Cost: Interest Jelani could have earned if savings were not spent: 10% on NT$300,000
  = 0.10 × 300,000 = NT$30,000

Opportunity Cost of Capital = NT$80,000 per year

Economic Profit vs. Accounting Profit

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

EXAMPLE 1D: Profit for Jelani's Gelato Shop

Jelani owns a small gelato shop on campus.

She makes 15,000 pints of gelato a year, and sell them at NT$50 each. Jelani pays NT$200,000 a year for raw materials, and NT$120,000 in rent.

Jelani can work at a local coffee shop for NT$250,000 a year. Jelani invested NT$800,000 in factory and equipment to start the business last year: NT$300,000 from savings and borrowed NT$500,000 (interest rate is 10% for saving and borrowing).

Calculate accounting and economic profit.

EXAMPLE 1D: Solutions

- Total Revenue ***TR*** = $50 × 15,000 = NT$750,000
- Explicit Costs = Raw Materials + Rent + Interest
  = $200,000 + $120,000 + $50,000 = NT$370,000
- Implicit Costs = Alternative Job + Forgone Interest = $250,000 + $30,000 = NT$280,000
- Accounting Profit = ***TR*** – Explicit Costs
  = $750,000 – $370,000 = NT$380,000
- Economic Profit = ***TR*** – (Explicit + Implicit Costs)
  = $750,000 – ($370,000 + $280,000)
  = NT$100,000
  = Accounting Profit – Implicit Cost

Active Learning 2: Economic vs. Accounting Profit

The equilibrium rent on office space has just increased by NT$5,000/month.

Determine the effects on accounting profit and economic profit if:

A. You rent your office space (you pay NT$5,000/month more)

B. You own your office space

Active Learning 2: Answers

The rent on office space increases by NT$5,000/mo.

A. You rent your office space.
- Explicit costs increase NT$5,000/month.
- Accounting and economic profit each fall NT$5,000/month.

B. You own your office space.
- Explicit costs do not change, so accounting profit does not change.
- Implicit costs increase NT$5,000/month, so economic profit falls by NT$5,000/month.

Production and Costs

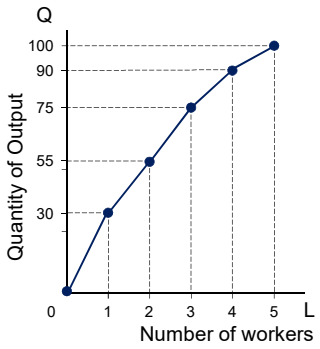
- Assumption:
  - Production in the short run
  - Factory size is fixed
  - To increase production: hire more workers
- Production function
  - Relationship between
    - Quantity of inputs used to make a good
    - And the quantity of output of that good
  - Gets flatter as production rises

EXAMPLE 2A: Xavier's Popcorn Truck

- Xavier has a popcorn truck (fixed resource) that he takes to fairs and sporting events.
- He can hire as many workers as he wants
  - The quantity of output produced varies with the number of workers
  - If Xavier hires only 1 worker, his truck will produce 30 buckets of popcorn per hour
  - If Xavier hires 5 workers, his truck will produce 100 buckets of popcorn per hour

EXAMPLE 2A: Xavier's Popcorn Production Function

L workers	Q buckets
0	0
1	30
2	55
3	75
4	90
5	100



Marginal Product

- Marginal Product
  - Increase in output that arises from an additional unit of input
  - Other inputs constant
  - Slope of the production function
- Marginal Product of Labor, MPL = ΔQ / ΔL
  - If Xavier hires one more worker, his output rises by the marginal product of labor.

EXAMPLE 2B: Xavier's Total and Marginal Product

	L workers	Q buckets		*MPL* buckets
	0	0		
ΔL = 1	1	30	ΔQ = 30	30
ΔL = 1	2	55	ΔQ = 25	25
ΔL = 1	3	75	ΔQ = 20	20
ΔL = 1	4	90	ΔQ = 15	15
ΔL = 1	5	100	ΔQ = 10	10

Diminishing MPL

- Diminishing Marginal Product
  - Marginal product of an input declines as the quantity of the input increases
  - Production function gets flatter as more inputs are being used
  - The slope of the production function decreases

"Rational people think at the margin"

- Hiring one extra worker
  - Increases output by MPL
  - Increases costs by the wage paid

EXAMPLE 2C: Xavier's Popcorn Truck Costs

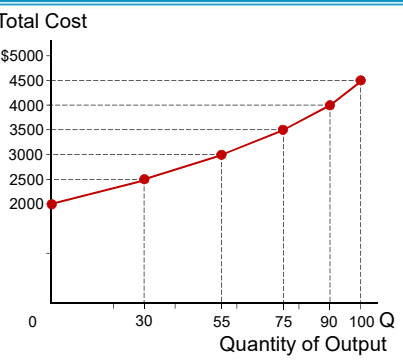
- Xavier must pay NT$2,000 per hour for the truck, regardless of how much popcorn he produces
- The market wage for popcorn makers is NT$500 per hour
- So, Xavier's costs are related to how much popcorn the truck produces

EXAMPLE 2C: Solutions

L workers	**Q** buckets	Cost of the truck	Cost of labor	Total Cost
0	0	$2,000	$0	$2,000
1	30	$2,000	$500	$2,500
2	55	$2,000	$1,000	$3,000
3	75	$2,000	$1,500	$3,500
4	90	$2,000	$2,000	$4,000
5	100	$2,000	$2,500	$4,500

EXAMPLE 2D: Xavier's Total Cost Curve

Q buckets	Total Cost
0	$2,000
30	$2,500
55	$3,000
75	$3,500
90	$4,000
100	$4,500



Active Learning 2: Diminishing MPL

Number of workers	Output	***MPL***
0	0	
1	45	45
2	85	40
3	115	30
4	135	20
5	145	10

A. What is the marginal product of the second worker?
40

B. What is the marginal product of the fourth worker?
20

C. Does this production function exhibits diminishing marginal returns?
Yes

The Various Measures of Cost

- Total cost, ***TC*** = ***FC*** + ***VC***
  - Total cost of producing a given amount of output
- Fixed costs, ***FC***
  - Do not vary with the quantity of output produced
  - Incur even if production is zero
- Variable costs, ***VC***
  - Vary with the quantity of output produced

EXAMPLE 3: Angel's Knitted Scarves Business

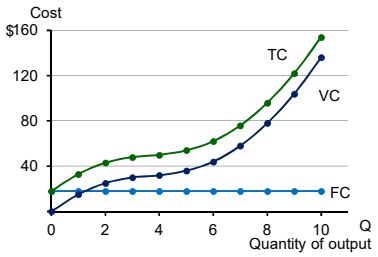
Q	FC	VC	TC
0	18	0	18
1	18	15	33
2	18	25	43
3	18	30	48
4	18	32	50
5	18	36	54
6	18	44	62
7	18	58	76
8	18	78	96
9	18	104	122
10	18	136	154

Angel loves to knit scarves:

- Angel paid $18 for two pairs of knitting needles
- To produce more scarves, Angel needs more yarn and more workers

EXAMPLE 3A: Angel's *FC*, *VC*, and *TC* Curves

Q	FC	VC	TC
0	18	0	18
1	18	15	33
2	18	25	43
3	18	30	48
4	18	32	50
5	18	36	54
6	18	44	62
7	18	58	76
8	18	78	96
9	18	104	122
10	18	136	154



The ***TC*** and ***VC*** curves are parallel
The ***FC*** curve is a horizontal line

Average and Marginal Cost

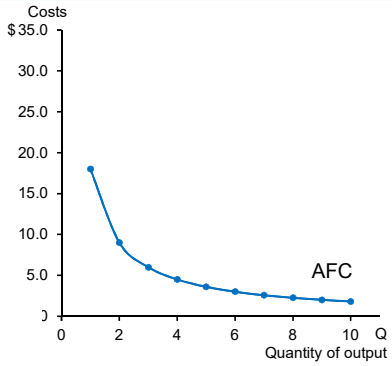
- Average Fixed Cost, ***AFC*** = ***FC*** / ***Q***
- Average Variable Cost, ***AVC*** = ***VC*** / ***Q***
- Average Total Cost,
  ATC = ***TC*** / ***Q*** = ***AFC*** + ***AVC***
  - The cost of the typical unit produced
  - Total cost divided by the quantity of output
- Marginal Cost, ***MC*** = ***ΔTC*** / ***ΔQ***
  - The increase in total cost that arises from an extra unit of production

EXAMPLE 3B: Angel's Average and Marginal Cost

Q	FC	VC	TC	AFC	AVC	ATC	MC
0	$18	$0	$18	-	-	-	
1	18	15	33	$18.0	$15.0	$33.0	$15.0
2	18	25	43	9.0	12.5	21.5	10.0
3	18	30	48	6.0	10.0	16.0	5.0
4	18	32	50	4.5	8.0	12.5	2.0
5	18	36	54	3.6	7.2	10.8	4.0
6	18	44	62	3.0	7.3	10.3	8.0
7	18	58	76	2.6	8.3	10.9	14.0
8	18	78	96	2.3	9.8	12.0	20.0
9	18	104	122	2.0	11.6	13.6	26.0
10	18	136	154	1.8	13.6	15.4	32.0

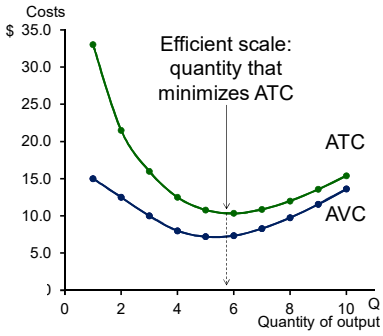
EXAMPLE 3C: Angel's *AFC* Curve

Q	FC	AFC
0	18	-
1	18	18.0
2	18	9.0
3	18	6.0
4	18	4.5
5	18	3.6
6	18	3.0
7	18	2.6
8	18	2.3
9	18	2.0
10	18	1.8



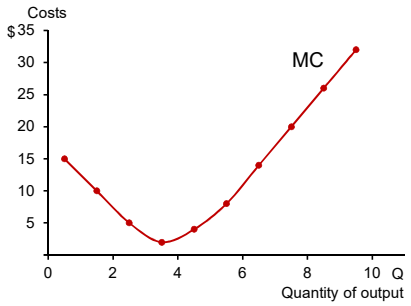
EXAMPLE 3C: Angel's *AVC* and *ATC* Curves

Q	VC	TC	AVC	ATC
0	$0	$18	-	-
1	15	33	15.0	33.0
2	25	43	12.5	21.5
3	30	48	10.0	16.0
4	32	50	8.0	12.5
5	36	54	7.2	10.8
6	44	62	7.3	10.3
7	58	76	8.3	10.9
8	78	96	9.8	12.0
9	104	122	11.6	13.6
10	136	154	13.6	15.4

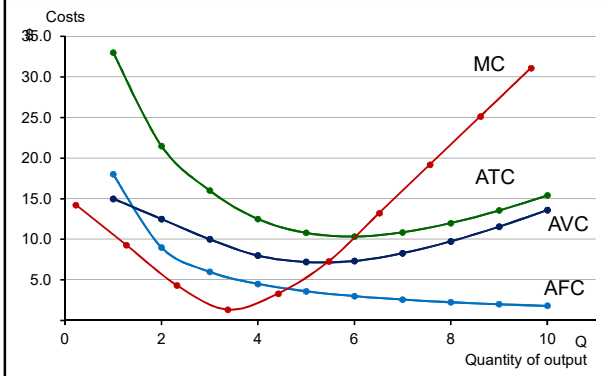


EXAMPLE 3C: Angel's Marginal Cost Curve

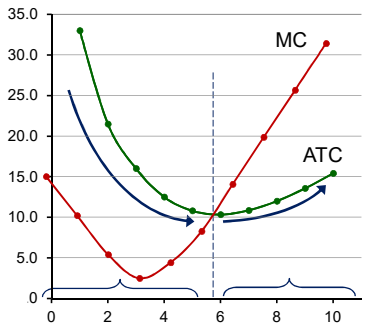
Q	TC	MC
0	$18	
1	33	$15.0
2	43	10.0
3	48	5.0
4	50	2.0
5	54	4.0
6	62	8.0
7	76	14.0
8	96	20.0
9	122	26.0
10	154	32.0



EXAMPLE 3C: Angel's Knitting Cost Curves



EXAMPLE 3D: Angel's *ATC* and *MC* Curves



- 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.

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

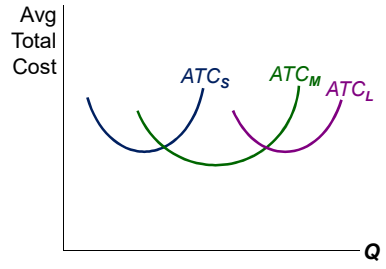
First, deduce *FC* = $50 and use *FC* + *VC* = *TC*.

Q	*VC*	*TC*	*AFC*	*AVC*	*ATC*	*MC*
0	$0	$50	*n/a*	*n/a*	*n/a*	
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

Costs in the Short Run and Long Run

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

LRATC with 3 Factory Sizes

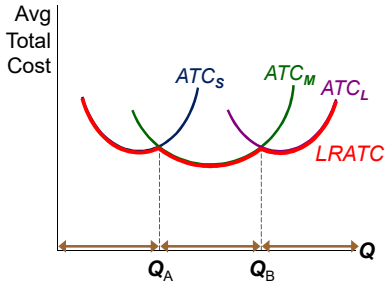


- Firm can choose from three factory sizes: S, M, L.

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.

LRATC with 3 Factory Sizes



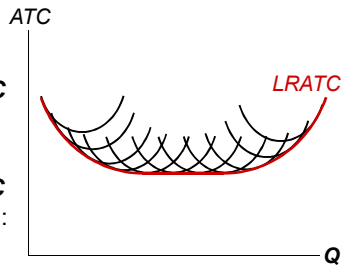
To produce less than Q_A, firm will choose size S in the long run.

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:



Costs in Short and Long Run – 1

- Economies of scale
  - Long-run average total cost falls as the quantity of output increases
    - Increasing specialization among workers
    - More common when Q is low
- Constant returns to scale
  - Long-run average total cost stays the same as the quantity of output changes

Costs in Short and Long Run – 2

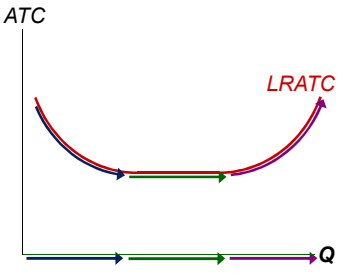
- Diseconomies of scale
  - Long-run average total cost rises as the quantity of output increases
  - Increasing coordination problems in large organizations.
    - E.g., management becomes stretched, can't control costs.
    - More common when ***Q*** is high.

Economies and Diseconomies of Scale

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.



THINK-PAIR-SHARE

Your neighbor has a back-yard garden and grows fresh fruit and vegetables to be sold at a local "farmer's market."

He comments, "I hired a college student who was on summer vacation to help me this summer and my production more than doubled.

Next summer, I think I'll hire three helpers and my output should go up more than three- or fourfold."

A. What can explain why the production more than doubled when your neighbor hired a helper?

B. Will production increase three- or fourfold if your neighbor hires 3 helpers next summer?

CHAPTER IN A NUTSHELL

- The goal of firms is to maximize profit, which equals total revenue minus total cost.
- When analyzing a firm's behavior, it is important to include all the opportunity costs of production.
  - Explicit: wages a firm pays its workers
  - Implicit: wages the firm owner gives up by working at the firm rather than taking another job
- Economic profit takes both explicit and implicit costs into account, whereas accounting profit considers only explicit costs.

CHAPTER IN A NUTSHELL

- A firm's costs reflect its production process.
  - Diminishing marginal product: production function gets flatter as Q of an input increases
  - Total-cost curve gets steeper as the quantity produced rises.
- Firm's total costs = fixed costs + variable costs.
  - Fixed costs: do not change when the firm alters the quantity of output produced.
  - Variable costs: change when the firm alters the quantity of output produced.

CHAPTER IN A NUTSHELL

- Average total cost is total cost divided by the quantity of output.
- Marginal cost is the amount by which total cost rises if output increases by 1 unit.
- Graph average total cost and marginal cost.
  - Marginal cost rises with the quantity of output.
  - Average total cost first falls as output increases and then rises as output increases further.
  - The MC curve always crosses the ATC curve at the minimum of ATC

CHAPTER IN A NUTSHELL

- A firm's costs often depend on the time horizon considered.
  - In particular, many costs are fixed in the short run but variable in the long run.
  - As a result, when the firm changes its level of production, average total cost may rise more in the short run than in the long run.

Chapter 13: 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, Ch.13, Problem 2, 4, 5, 7-9

Chapter 13: The Cost of Production

- Challenge Questions (Past Finals)
  - 2007 - Part 1
  - 2008 - Essay C
  - 2012 - Part I
  - 2013 - Part I (both A and B)
  - 2014 - Essay A1-A4
  - 2015 - Essay B1-B6
  - 2017 - Essay D5-D6

The Big Picture

- Chapter 13: The Cost of Production
- Then, we will look at firm's revenue
  - But revenue depends on market structure
1. Competitive market (chapter 14)
2. Monopoly (chapter 15)
3. Monopolistic Competition (chapter 16)
4. Oligopoly (chapter 17)
   - Are there other types of markets? Yes, see more advance courses in IO and firm competition