The Costs of Production

Chapter 13

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Introduction

Firm Behavior

- So far, we have used the supply curve to interpret firms' production decisions

- According to the *law of supply*, producers are willing to produce more as prices increase (explains the upward slope of the supply curve)

- We will discuss firms' decisions in more detail

- *Industrial organization* is the study of how firms' decisions about prices and quantities depend on the market conditions they face

- To learn about the firms, we need to understand the costs of their production, which are primarily determined by prices

What Are Costs?

Intoduction

- For this chapter, we will use Chloe's Cookie Factory as an example
- Chloe owns the firm
- She needs to buy the ingredients to make cookies (flour, sugar, etc.)
- She also hires workers to make cookies and run the machines
- Chloe sells the cookies to consumers

Total revenue, total cost, and profit

- As economists, we assume that firms start businesses to maximize profit, which works well in most cases
- *Total revenue* is the amount of money a firm receives for the of its output (cookies)
- *Total cost* is the amount that a firm pays to buy inputs (labor, ingredients, ect.)
- *Profit* is the total revenue minus total cost

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

- Chloe aims to maximize her profit

- Measuring total revenue is easy and is equal to the quantity of output produced times the price the output is sold at

- Measuring total cost is not as straightforward

Costs as opportunity costs

- We learned that the *opportunity cost* of an item refers to all the things that must be forgone to acquire that item

- When Chloe pays $1,000 for flour, it is also an *opportunity cost* because she can no longer get it back to buy something else

- The wages Chloe pays are also a part of her costs

- Because these opportunity costs require the firm to pay out some money, they are called *explicit costs*

- Some of the firm's *opportunity cost* is called the *implicit costs* which do not require a cash outlay

Example:

- Say Chloe can code and could earn $100 as a programmer

- For every hour Chloe spends making cookies, she is giving up a $100 in income
- Chloe's total cost is the sum of the *explicit costs* and *implicit costs*

The cost of capital as opportunity cost

- An implicit cost of almost every business is the opportunity cost of the financial capital that has been invested in the business

  Example:

- If Chloe bought the cookies business from a previous owner for $300,000

- Chloe could have put that money away in a savings account that pays 5% interest

- The $15,000---the interest on the money--- is one of Chloe's implicit costs

- The differentiation economists make between implicit and explicit costs highlights how different economists and accountants analyze a business

- An accountant will not show the $15,000 as a cost because no money is flowing out of the business to pay for it

# Example: the difference between economists and accountants

- Say Chloe only has $100,000

- Chloe borrows $200,000 from a bank at a 5% rate

- Chloe's accountant will count the $10,000 interest paid on a bank as a cost

- For an economist, the opportunity cost is still 15,000 = interest on the loan (explicit cost) + forgone interest on savings (implicit cost of 5,000)

Economic vs Accounting Profit

Economic Profit = Total Revenue − Explicit Cost − Implicit Cost
Accounting Profit = Total Revenue − Explicit Cost
Economic Profit < Accounting Profit

Figure 1 **Economists versus Accountants**

Economists include all opportunity costs when analyzing a firm, whereas accountants measure only explicit costs. Therefore, economic profit is smaller than accounting profit.
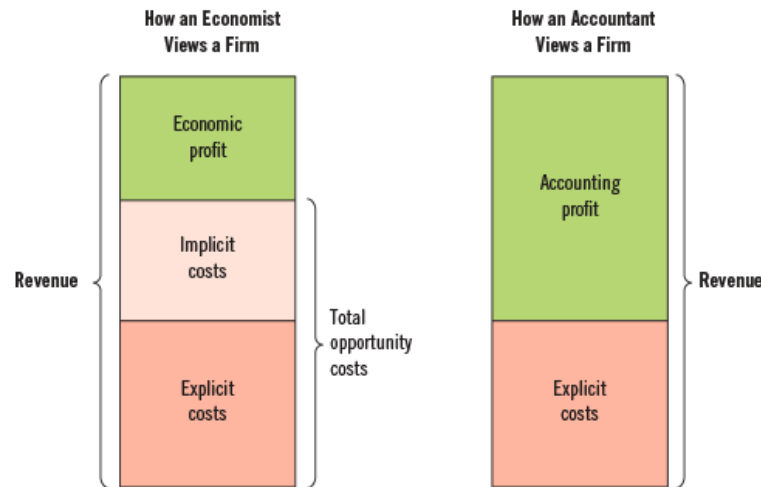
Production and Costs

Introduction

- A firm incurs costs when they produce a good or a service

- Assume that Chloe's factory size is fixed

- Chloe can increase the number of cookies produced by changing the number of workers

- This assumption is realistic in the short run but not in the long run

- Chloe cannot build a bigger store overnight because that takes time

- Our analysis in this section will describe the production decisions that Chloe makes in the short run

The production function

Table 1 A Production Function and Total Cost: Chloe's Cookie Factory

	(1)	(2)	(3)	(4)	(5)	(6)
	Number of Workers	Output (quantity of cookies produced per hour)	Marginal Product of Labor	Cost of Factory	Cost of Workers	Total Cost of Inputs (cost of factory + cost of workers)
	0	0		$30	$0	$30
			50			
	1	50		30	10	40
			40			
	2	90		30	20	50
			30			
	3	120		30	30	60
			20			
	4	140		30	40	70
			10			
	5	150		30	50	80
			5			
	6	155		30	60	90

The production function (cont.)

Figure 2 **Chloe's Production Function and Total-Cost Curve**

The production function in panel (a) shows the relationship between the number of workers hired and the quantity of output produced. Here the number of workers hired (on the horizontal axis) is from column (1) in Table 1, and the quantity of output produced (on the vertical axis) is from column (2). The production function gets flatter as the number of workers increases, reflecting diminishing marginal product. The total-cost curve in panel (b) shows the relationship between the quantity of output produced and total cost of production. Here the quantity of output produced (on the horizontal axis) is from column (2) in Table 1, and the total cost (on the vertical axis) is from column (6). The total-cost curve gets steeper as the quantity of output increases because of diminishing marginal product.
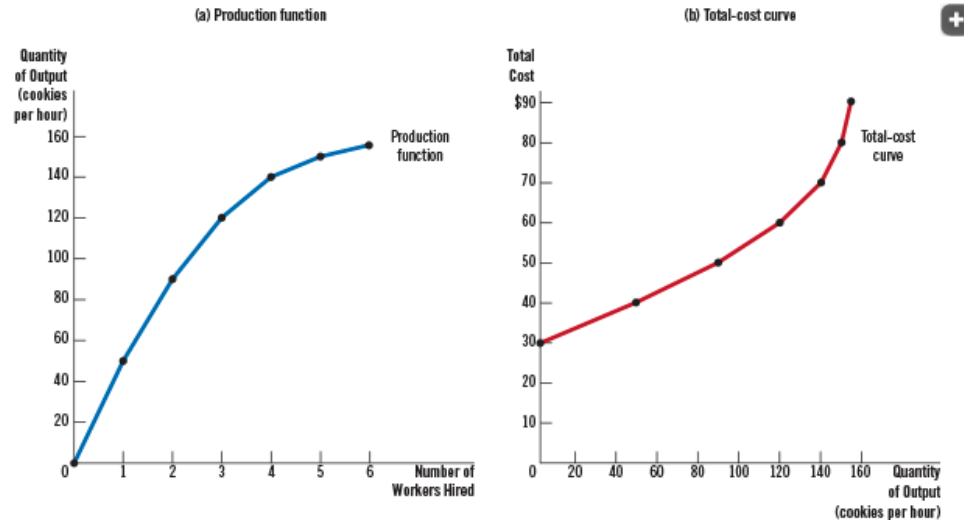
Definitions

The *Marginal product* of any input in the production process is the change in the quantity of output obtained from one additional unit of that input

Diminishing marginal product the property whereby the marginal product of an input declines as the quantity of the input increases

Various Measures of Cost

TABLE 2

The Various Measures of Cost: Conrad's Coffee Shop

| (1) Output (cups of coffee per hour)	(2) Total Cost	(3) Fixed Cost	(4) Variable Cost	(5) Average Fixed Cost	(6) Average Variable Cost	(7) Average Total Cost	(8) Marginal Cost
0	$3.00	$3.00	$0.00	—	—	—	
							$0.30
1	3.30	3.00	0.30	$3.00	$0.30	$3.30	
							0.50
2	3.80	3.00	0.80	1.50	0.40	1.90	
							0.70
3	4.50	3.00	1.50	1.00	0.50	1.50	
							0.90
4	5.40	3.00	2.40	0.75	0.60	1.35	
							1.10
5	6.50	3.00	3.50	0.60	0.70	1.30	
							1.30
6	7.80	3.00	4.80	0.50	0.80	1.30	
							1.50
7	9.30	3.00	6.30	0.43	0.90	1.33	
							1.70
8	11.00	3.00	8.00	0.38	1.00	1.38	
							1.90
9	12.90	3.00	9.90	0.33	1.10	1.43	
							2.10
10	15.00	3.00	12.00	0.30	1.20	1.50	

Various Measures of Cost (cont.)
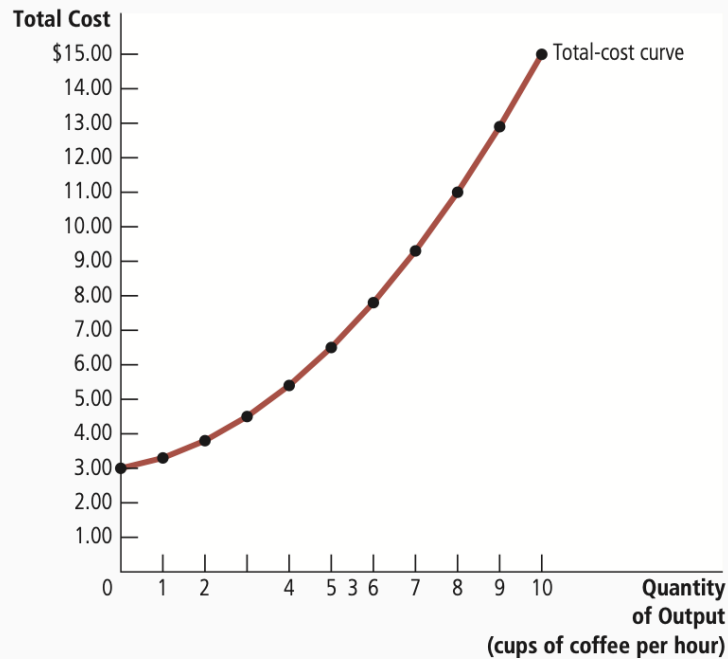
FIGURE 3

Conrad's Total-Cost Curve
Here the quantity of output produced (on the horizontal axis) is from column (1) in Table 2, and the total cost (on the vertical axis) is from column (2). As in Figure 2, the total-cost curve gets steeper as the quantity of output increases because of diminishing marginal product.

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Fixed and Variable Costs

Fixed costs do not vary with the quantity of output produced. A firm will have to pay them even if they produced nothing at all (e.g. rent)

Variable costs changes as the firm changes the quantity of output produced (e.g. inputs to production)

Total costs is the sum of the fixed and variable costs

Average and Marginal costs

How much does it cost to make the typical cup of coffee?

How much does it cost to increase the production of coffee by 1 cup?

Average total cost is the total cost divided by the quantity of output produced

Average fixed cost is the fixed cost divided by the quantity of output produced

Average variable cost is the variable cost divided by the quantity of output produced

Marginal cost is the increase in total cost that arises from an extra unit of production

$$ATC = TC/Q$$
$$MC = \Delta TC/\Delta Q$$

Cost Curves and Their Shapes

Figure 4 **Caleb's Average-Cost and Marginal-Cost Curves**

This figure shows the average total cost (ATC), average fixed cost (AFC), average variable cost (AVC), and marginal cost (MC) for Caleb's Coffee Shop. All of these curves are obtained by graphing the data in Table 2. These cost curves show three common features: (1) Marginal cost rises with the quantity of output. (2) The average-total-cost curve is U-shaped. (3) The marginal-cost curve crosses the average-total-cost curve at the minimum of average total cost.
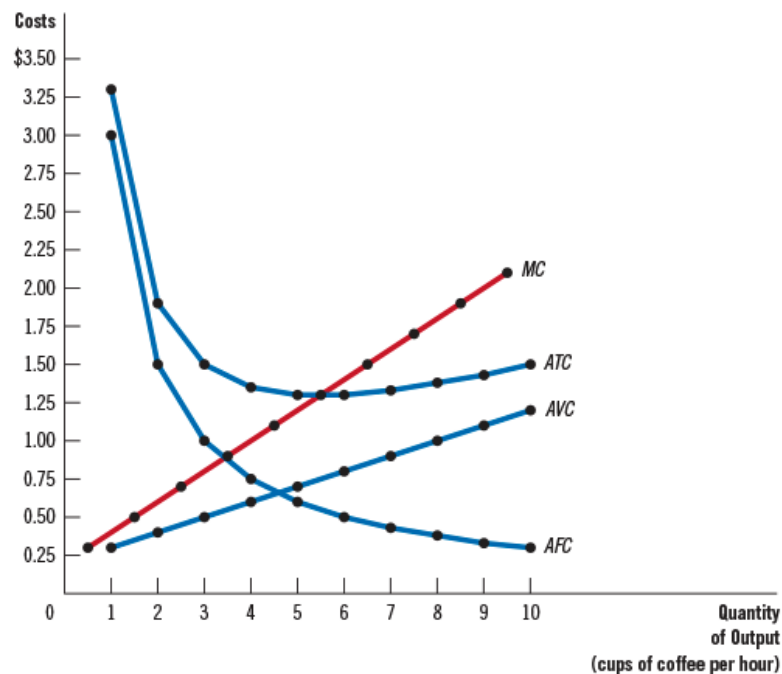
Typical cost curves

Figure 5 **Cost Curves for a Typical Firm**

Many firms experience increasing marginal product before diminishing marginal product. As a result, they have cost curves shaped like those in this figure. Notice that marginal cost and average variable cost fall for a while before starting to rise.
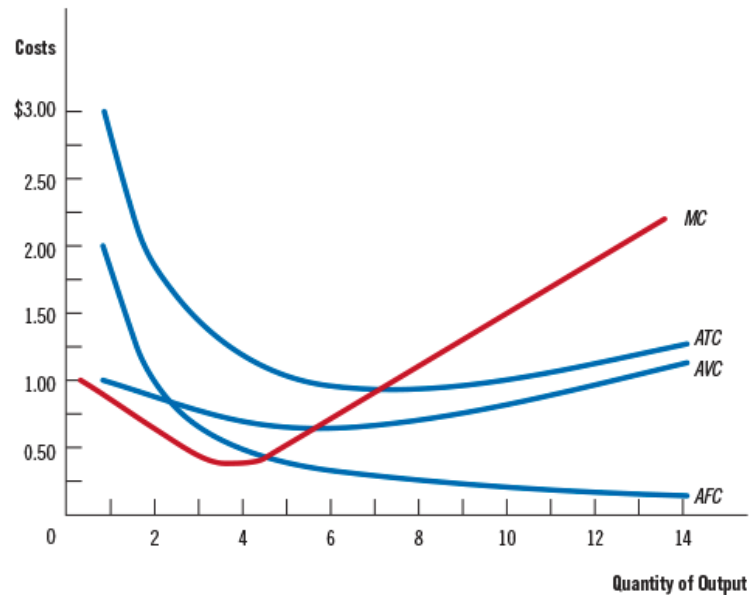
Costs in the Short Run and the Long Run

Relationship between SR and LR ATC

Figure 6 **Average Total Cost in the Short and Long Runs**

Because fixed costs are variable in the long run, the average-total-cost curve in the short run differs from the average-total-cost curve in the long run.
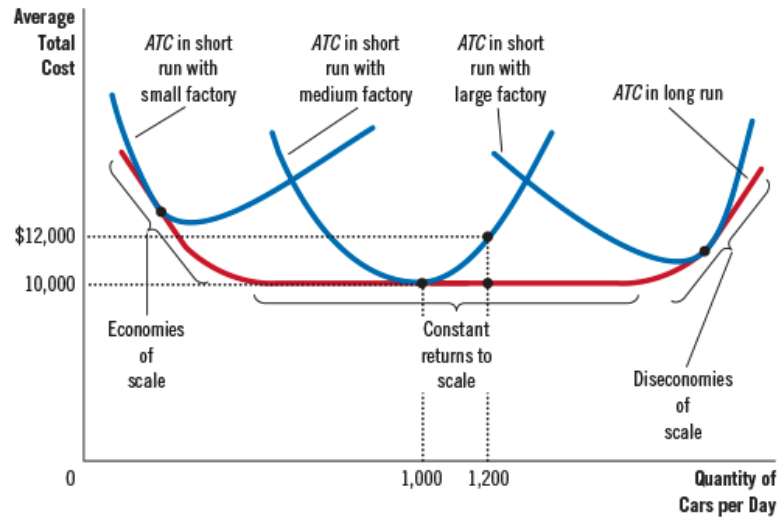
Economies and Diseconomies of Scale

Economies of scale the property whereby long-run average total cost falls as the quantity of output increases

Diseconomies of scale the property whereby long-run average total cost rises as the quantity of output increases

Problems and Applications

Question 1

This chapter discusses many types of costs: opportunity cost, total cost, fixed cost, variable cost, average total cost, and marginal cost. Fill in the type of cost that best completes each sentence:

What you give up in taking some action is called the _

opportunity cost

_ is falling when marginal cost is below it and rising when marginal cost is above it.

average total cost

A cost that does not depend on the quantity produced is a(n) _.

fixed cost

In the ice-cream industry in the short run, _ includes the cost of cream and sugar but not the cost of the factory..

variable cost

Question 1

This chapter discusses many types of costs: opportunity cost, total cost, fixed cost, variable cost, average total cost, and marginal cost. Fill in the type of cost that best completes each sentence:

Profits equal total revenue minus _

total cost

The cost of producing an extra unit of output is the _

marginal cost

Question 2

Your aunt is thinking about opening a hardware store. She estimates that it would cost $500,000 per year to rent the location and buy the stock. In addition, she would have to quit her $50,000 per year job as an accountant

Define opportunity cost

The opportunity cost of something is what must be given up to acquire it

What is your aunt's opportunity cost of running the hardware store for a year? If your aunt thinks she can sell $510,000 worth of merchandise in a year, should she open the store? Explain.

Cost of rent and stocks is $500,000 (explicit cost)

Cost of quitting the job is $50,000 (implicit cost)

The opportunity cost = $550,000—consisting of $500,000 to rent the store and buy the stock and a $50,000 implicit cost

Your aunt should not open the store

$$\text{Ecnomic profit} = 510,000 - 550,000 = -40,000 < 0$$

Question 3

A commercial fisherman notices the following relationship between hours spent fishing and the quantity of fish caught:

Hours	Fish
0	0
1	10
2	18
3	24
4	28
5	30

What is the marginal product of each hour spent fishing?

Question 3

What is the marginal product of each hour spent fishing?

Hours	Fish	Marginal Product of Fishing
0	0	-
1	10	10
2	18	8
3	24	6
4	28	4
5	30	2

Question 3

Use these data to graph the fisherman's production function. Explain its shape.
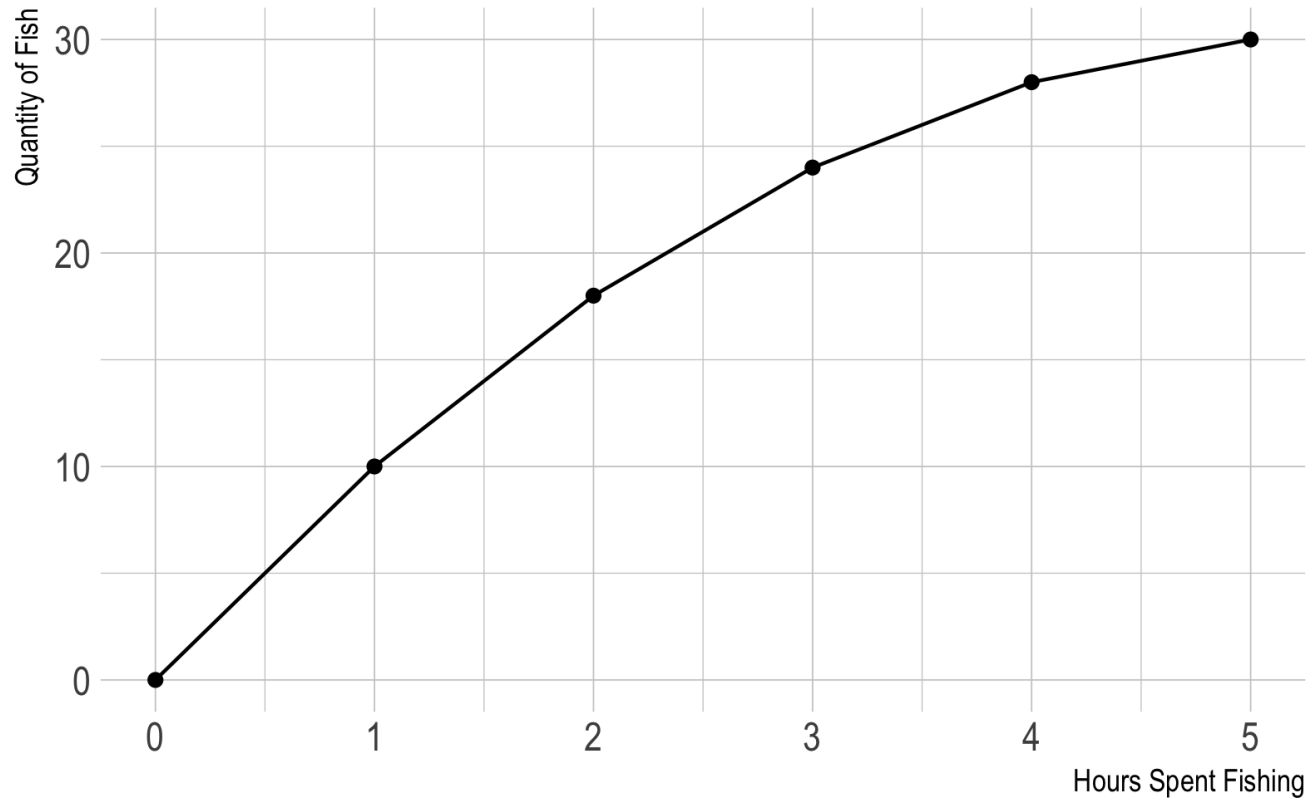
Question 3

The fisherman has a fixed cost of $10 (his pole). The opportunity cost of his time is $5 per hour. Graph the fisherman's total-cost curve. Explain its shape

Hours	Fish	Fixed Cost	Variable Cost	Total Cost	Marginal Product of Fishing
0	0	10	0	10	-
1	10	10	5	15	10
2	18	10	10	20	8
3	24	10	15	25	6
4	28	10	20	30	4
5	30	10	25	35	2

Question 3

The fisherman has a fixed cost of $10 (his pole). The opportunity cost of his time is $5 per hour. Graph the fisherman's total-cost curve. Explain its shape
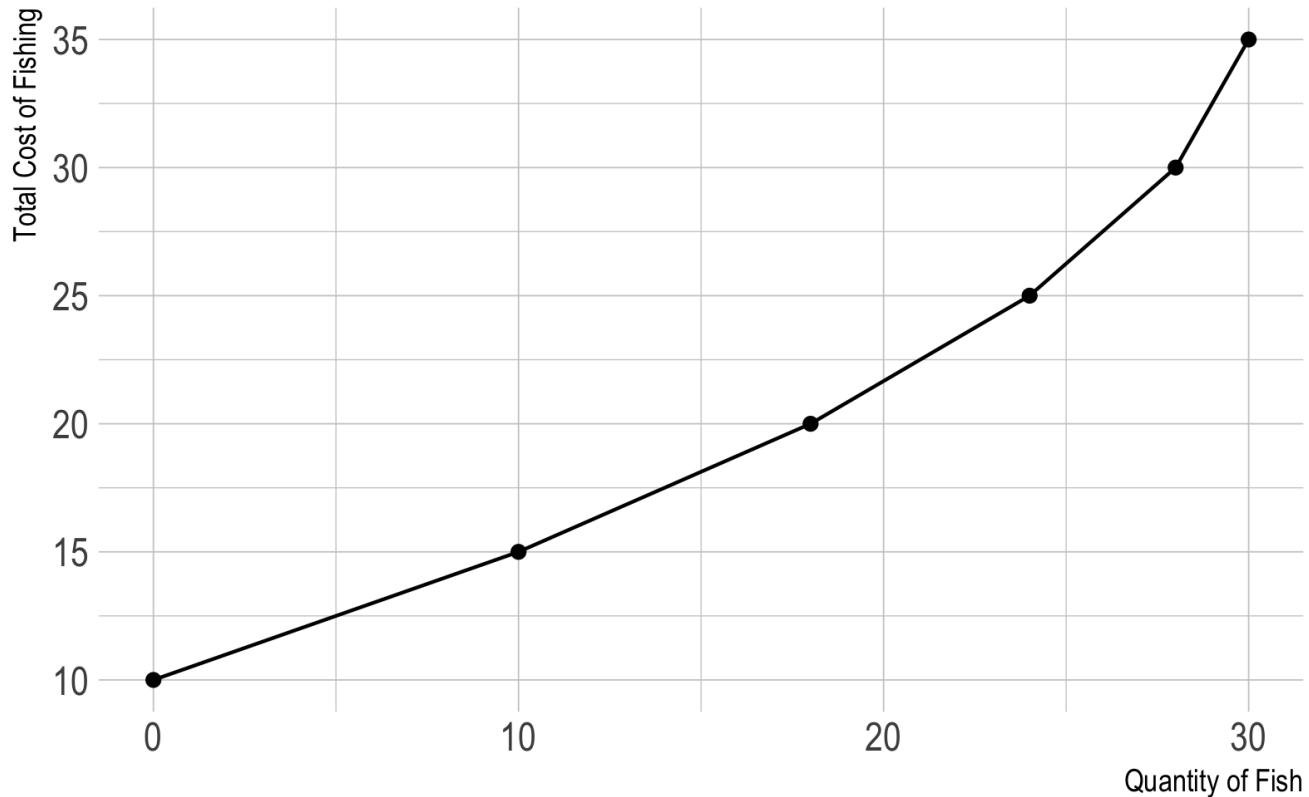
Question 4

Nimbus, Inc., makes brooms and then sells them door-to-door. Here is the relationship between the number of workers and Nimbus's output during a given day:

Workers	Output	Marginal Product	Total Cost	Average total cost	Marginal Cost
0	0				
1	20				
2	50				
3	90				
4	120				
5	140				
6	150				
7	155				

Question 4

Fill in the column of marginal products. What pattern do you see? How might you explain it?

Workers	Output	Marginal Product	Total Cost	Average total cost	Marginal Cost
0	0	-			
1	20	20			
2	50	30			
3	90	40			
4	120	30			
5	140	20			
6	150	10			
7	155	5			

Question 4

A worker costs $100 a day, and the firm has fixed costs of $200. Use this information to fill in the column for total cost.

Workers	Output	Marginal Product	Total Cost	Average total cost	Marginal Cost
0	0	-			
1	20	20			
2	50	30			
3	90	40			
4	120	30			
5	140	20			
6	150	10			
7	155	5			

Question 4

A worker costs $100 a day, and the firm has fixed costs of $200. Use this information to fill in the column for total cost.

Workers	Output	Marginal Product	Fixed Cost	Variable Cost	Total Cost	Average total cost	Marginal Cost
0	0	-	200	0			
1	20	20	200	100			
2	50	30	200	200			
3	90	40	200	300			
4	120	30	200	400			
5	140	20	200	500			
6	150	10	200	600			
7	155	5	200	700			

Question 4

A worker costs $100 a day, and the firm has fixed costs of $200. Use this information to fill in the column for total cost.

Workers	Output	Marginal Product	Fixed Cost	Variable Cost	Total Cost	Average total cost	Marginal Cost
0	0	-	200	0	200		
1	20	20	200	100	300		
2	50	30	200	200	400		
3	90	40	200	300	500		
4	120	30	200	400	600		
5	140	20	200	500	700		
6	150	10	200	600	800		
7	155	5	200	700	900		

Question 4

Fill in the column for average total cost. (Recall that $ATC = TC/Q$) What pattern do you see?

Workers	Output	Marginal Product	Fixed Cost	Variable Cost	Total Cost	Average total cost	Marginal Cost
0	0	-	200	0	200	-	
1	20	20	200	100	300	15	
2	50	30	200	200	400	8	
3	90	40	200	300	500	5.56	
4	120	30	200	400	600	5	
5	140	20	200	500	700	5	
6	150	10	200	600	800	5.33	
7	155	5	200	700	900	5.81	

Question 4

Now fill in the column for marginal cost. (Recall that MC=ΔTC/ΔQ.) What pattern do you see?

Workers	Output	Marginal Product	Fixed Cost	Variable Cost	Total Cost	Average total cost	Marginal Cost
0	0	-	200	0	200	-	-
1	20	20	200	100	300	15	5.00
2	50	30	200	200	400	8	3.33
3	90	40	200	300	500	5.56	2.50
4	120	30	200	400	600	5	3.33
5	140	20	200	500	700	5	5.00
6	150	10	200	600	800	5.33	10.0
7	155	5	200	700	900	5.81	20.0

Question 4

Workers	Output	Marginal Product	Fixed Cost	Variable Cost	Total Cost	Average total cost	Marginal Cost
0	0	-	200	0	200	-	-
1	20	20	200	100	300	15	5.00
2	50	30	200	200	400	8	3.33
3	90	40	200	300	500	5.56	2.50
4	120	30	200	400	600	5	3.33
5	140	20	200	500	700	5	5.00
6	150	10	200	600	800	5.33	10.0
7	155	5	200	700	900	5.81	20.0

- Compare the column for marginal product with the column for marginal cost. Explain the relationship.
- When marginal product is rising, marginal cost is falling, and *vice versa*

Question 4

Workers	Output	Marginal Product	Fixed Cost	Variable Cost	Total Cost	Average total cost	Marginal Cost
0	0	-	200	0	200	-	-
1	20	20	200	100	300	15	5.00
2	50	30	200	200	400	8	3.33
3	90	40	200	300	500	5.56	2.50
4	120	30	200	400	600	5	3.33
5	140	20	200	500	700	5	5.00
6	150	10	200	600	800	5.33	10.0
7	155	5	200	700	900	5.81	20.0

- Compare the column for average total cost with the column for marginal cost. Explain the relationship.
- When marginal cost is less than average total cost, average total cost is falling; the cost of the last unit produced pulls the average down. When marginal cost is greater than

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Question 5

You are the chief financial officer for a firm that sells phones. Your firm has the following average-total-cost schedule:

Quantity	Average Total Cost
600	300
601	301

Your current level of production is 600 devices, all of which have been sold. Someone calls, desperate to buy one of your phones. The caller offers you $550 for it. Should you accept the offer? Why or why not?

At $Q = 600$ **phones,** $TC = 600 \times 300 = 180,000$

At $Q = 601$ **phones,** $TC = 601 \times 301 = 180,901$

Marginal cost of one extra phone is 901

Should not accept offer because $MC_{601} = 901 > 550$

Question 6

Consider the following cost information for a pizzeria:

Quantity	Variable Cost	Total Cost
0	0	300
1	50	350
2	90	390
3	120	420
4	150	450
5	190	490
6	240	540

What is the pizzeria's fixed cost?

$TC = VC + FC$**, we know VC and we have the TC** $\rightarrow FC = TC - VC$

At $Q = 0, FC = 300 - 0 = 300$

Question 6

Construct a table in which you calculate the marginal cost per dozen pizzas using the information on total cost. Also, calculate the marginal cost per dozen pizzas using the information on variable cost. What is the relationship between these sets of numbers? Explain.

Quantity	Variable Cost	Total Cost	Marginal Cost (using total cost)	Marginal Cost (using variable cost)
0	0	300	-	-
1	50	350	50	50
2	90	390	40	40
3	120	420	30	30
4	150	450	30	30
5	190	490	40	40
6	240	540	50	50

- Marginal cost equals the change in total cost for each additional unit of output. It is also equal to the change in variable cost for each additional unit of output. This

Question 6

Construct a table in which you calculate the marginal cost per dozen pizzas using the information on total cost. Also, calculate the marginal cost per dozen pizzas using the information on variable cost. What is the relationship between these sets of numbers? Explain.

Quantity	Variable Cost	Total Cost	Marginal Cost (using total cost)	Marginal Cost (using variable cost)
0	0	300	-	-
1	50	350	50	50
2	90	390	40	40
3	120	420	30	30
4	150	450	30	30
5	190	490	40	40
6	240	540	50	50

- $MC = \Delta TC/\Delta Q = \Delta(FC + VC)/\Delta Q = (\Delta FC + \Delta VC)/\Delta Q = \Delta VC/\Delta Q$
- $MC = \delta TC/\delta Q = \delta(FC + VC)/\delta Q = (\delta FC + \delta VC)/\delta Q$ where $\delta FC/\delta Q = 0$

Question 7

Your cousin Vinnie owns a painting company with fixed costs of $200 and the following schedule for variable costs:

Quantity	VC	FC	TC	AFC	AVC	ATC
0	0					
1	10					
2	20					
3	40					
4	80					
5	160					
6	320					
7	640					

Calculate average fixed cost, average variable cost, and average total cost for each quantity. What is the efficient scale of the painting company?

Question 7

Calculate average fixed cost, average variable cost, and average total cost for each quantity. What is the efficient scale of the painting company?

| Quantity	VC	FC	TC	AFC	AVC	ATC
0	0	200	200			
1	10	200	210	200	10	210
2	20	200	220	100	10	110
3	40	200	240	66.67	13.33	80
4	80	200	280	50	20	70
5	160	200	360	40	32	72
6	320	200	520	33.33	53.33	86.67
7	640	200	840	28.57	91.43	120

Question 8

The city government is considering two tax proposals:

1. A lump-sum tax of $300 on each producer of hamburgers.

2. A tax of $1 per burger, paid by producers of hamburgers.

   Which of the following curves—average fixed cost, average variable cost, average total cost, and marginal cost—would shift as a result of the lump-sum tax? Why? Show this in a graph. Label the graph as precisely as possible.

- The lump-sum tax causes an increase in fixed cost. Therefore, as Figure 10 shows, only average fixed cost and average total cost will be affected.
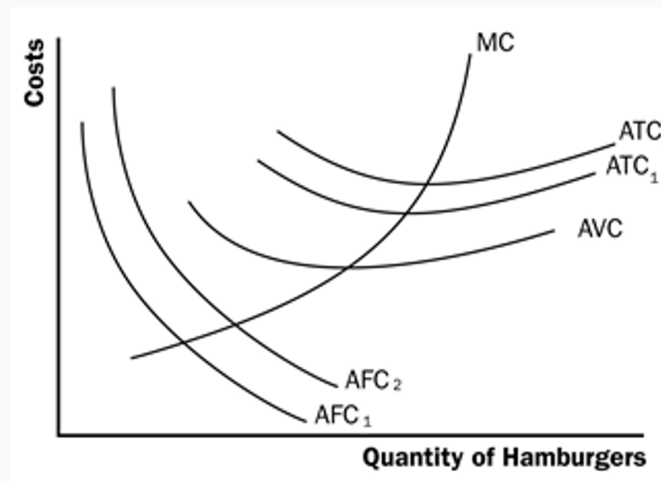

Quantity of Hamburgers

Question 8

The city government is considering two tax proposals:

1. A lump-sum tax of $300 on each producer of hamburgers.

2. A tax of $1 per burger, paid by producers of hamburgers.

Which of these same four curves would shift as a result of the per-burger tax? Why? Show this in a new graph. Label the graph as precisely as possible.

- Average variable cost, average total cost, and marginal cost will all be greater. Average fixed cost will be unaffected.
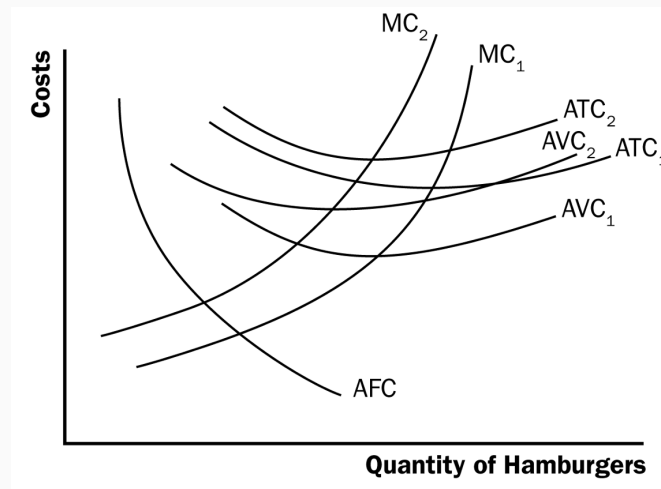
Question 9

Jane's Juice Bar has the following cost schedules:

- Calculate average variable cost, average total cost, and marginal cost for each quantity.

Quantity	Variable Cost	Total Cost	Average Variable Cost	Average Total Cost	Marginal Cost
0	0.00	30.00			
1	10.00	40.00	10.00	40.0	10.00
2	25.00	55.00	12.50	27.50	15.00
3	45.00	75.00	15.00	25.00	20.00
4	70.00	100.00	17.50	25.00	25.00
5	100.00	130.00	20.00	26.00	30.00
6	135.00	165.00	22.50	27.50	35.00

Jane's Juice Bar has the following cost schedules:

- Graph all three curves. What is the relationship between the marginal-cost curve and the average-total-cost curve? Between the marginal-cost curve and the average-variable-cost curve? Explain.
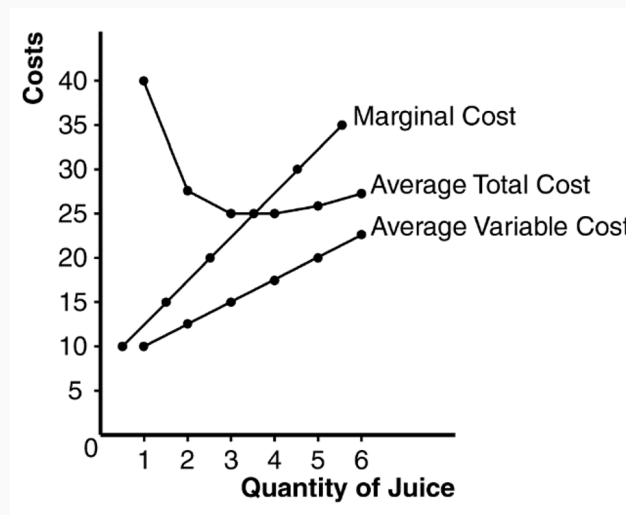
- The marginal-cost curve is below the average-total-cost curve when output is less than four and average total cost is declining

- The marginal-cost curve is above the average-total-cost curve when output is above four and average total cost is rising
- The marginal-cost curve lies above the average-variable-cost curve.

Question 10

Consider the following table of long-run total costs for three different firms:

Quantity	1	2	3	4	5	6	7
Firm A	$60	$70	$80	$90	$100	$110	$120
Firm B	11	24	39	56	75	96	119
Firm C	21	34	49	66	85	106	129

Does each of these firms experience economies of scale or diseconomies of scale?

Quantity	Firm A		Firm B		Firm C	
	TC	ATC	TC	ATC	TC	ATC
1	$60.00	$60.00	$11.00	$11.00	$21.00	$21.00
2	70.00	35.00	24.00	12.00	34.00	17.00
3	80.00	26.67	39.00	13.00	49.00	16.33
4	90.00	22.50	56.00	14.00	66.00	16.50
5	100.00	20.00	75.00	15.00	85.00	17.00
6	110.00	18.33	96.00	16.00	106.00	17.67
7	120.00	17.14	119.00	17.00	129.00	18.43