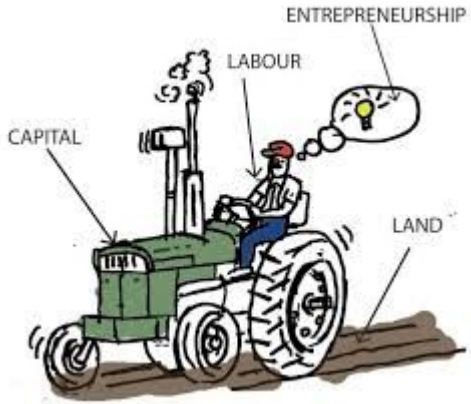
Principles of Economics

Chapter 4

Production
Theory of Cost

You would be able to learn…

1. Understand and differentiate accounting and economic costs
2. Assess the concept of profit and short-run and long-run in production
3. Analyze production using the production function
4. Calculate and interpret cost concepts
5. Understand cost curves and their shapes
6. Examine long-run costs and economies of scale



Basic motivation of a firm

The motivation for business decisions is **profit maximization**.

What is a firm's profit? The amount that the firm receives for the sale of its output (cookies) is called total revenue. The amount that the firm pays to buy inputs (flour, sugar, workers, ovens, and so forth) is called total cost. The firm gets to keep any revenue that is not needed to cover costs. **Profit is a firm's total revenue minus its total cost:**

Profit = Total revenue - Total cost

Total revenue equals the quantity of output the firm produces multiplied by the price at which it sells its output.

Costs

Economic cost that a firm incurs in the production of a good refers to the payments it must make to all the resources (factors of production) employed by it in the production of that good.

The total cost (economic cost) of a business is the sum of **explicit** and **implicit costs**.

Explicit cost: Payments to nonowners of a firm for their resources (input costs that require an outlay of money by the firm).

Implicit cost: The opportunity costs of using resources owned by the firm (input costs that do not require an outlay of money by the firm).

Total opportunity cost= Explicit cost + Implicit cost

When economists speak of a firm's cost of production, they include all the opportunity costs of making its output of goods and services.

Costs

Consider a firm which produces 10 tonnes of wheat by employing the following resources, costing the amounts as indicated against them. Explicit cost of wheat production is Rs. 70,000 and its implicit cost is Rs. 85,000.

Factors hired from outside	*Cost (actual)*
	(Rs.)
Seed	7,500
Labour	19,000
Tractor for ploughing	20,000
Fertilizer	11,000
Tubewell for irrigation	12,500
Sub-total	70,000
Self-owned Factors Employed	*Cost (imputed)*
	(Rs.)
Family labour	35,000
Land	50,000
Sub-total	85,000
Total	155,000

Think like an economist or accountant

Economist

interested in studying how firms make production and pricing decisions

include both explicit and implicit types when measuring a firm's costs

Economic profit: Total revenue - Total Opportunity Cost (Total Explicit Cost + Total Implicit Cost)

Accountant

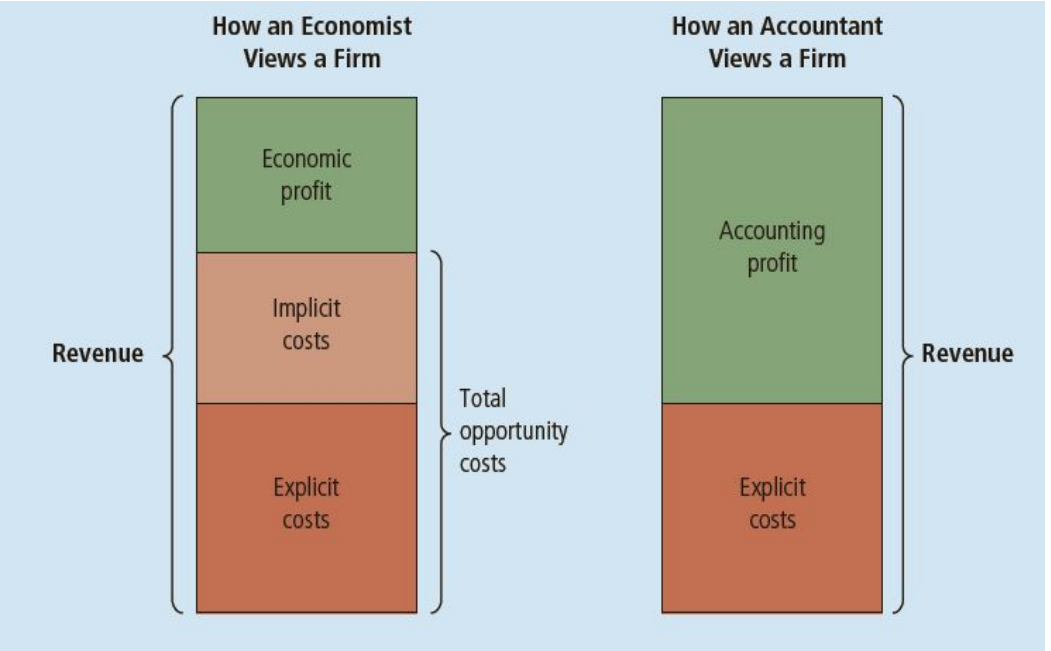
keep track of the money that flows into and out of firms

measure the explicit costs but usually ignore the implicit costs

Accounting profit: Total revenue - Total Explicit Cost

Think like an economist or accountant

Economic profit is smaller than accounting profit.



Think like an economist or accountant: Class task

Farmer McDonald gives banjo lessons for $20 an hour. One day, he spends 10 hours planting $100 worth of seeds on his farm. What opportunity cost has he incurred? What cost would his accountant measure? If these seeds yield $200 worth of crops, does McDonald earn an accounting profit? Does he earn an economic profit?

Short-run and long-run in Economics

Short run The period of time during which at least one of a firm's inputs is fixed.

Long run The period of time in which a firm can vary all its inputs, adopt new technology, and increase or decrease the size of its physical plant.

Total cost The cost of all the inputs a firm uses in production.

Variable costs Costs that change as output changes.

Fixed costs Costs that remain constant as output changes.

Total Cost = Fixed Cost + Variable Cost

If capital is the fixed factor, capital rental is the fixed cost and if labour is the variable factor, wage bill is the variable cost.

Production function

A production function expresses the technological or engineering relationship between output of a good and inputs used in the production, namely land, labour, capital and management (organization); besides raw-materials and intermediate goods.

Traditionally, production functions are defined in terms of quantities of output and inputs.

The quality of inputs is accounted for by introducing a variable called, technology. This is a separate input variable in the production function.

The technology variable consists of all improvements in technology, including introduction of computer which permits a firm to produce a given output with fewer raw-materials, energy or/and labour, and training programmes which increase the productivity of labour.

Thus, a production function could be written as

$$Q = f(Ld, L, K, M, T)$$

$$f_1, f_2, f_3, f_4, f_5 > 0$$

Q = output in physical units of good X

Ld = land units employed in the production of Q

L = labour units employed in the production of Q

K = capital units employed in the production of Q

M = managerial units employed in the production of Q

T = technology employed in the production of Q

f = unspecified function

f_i = partial derivative of Q with respect to ith input

Cost function

Costs which a firm incurs in the production of a good or service depends basically on two functions:

(a) Firm's production function
(b) Market's inputs' supply functions
Production function specifies the technical relationship between combinations of inputs and the level of output.
The following cost function: $C = f(Q, E_1, P_1, L, S, Z)$

$$f_1, f_3 > 0 > f_2, f_4, f_5$$

$$f_6 = ?$$

where
C = Total (production) cost
Q = Total output
EI = Efficiencies of inputs

PI = Prices of inputs
L = Learning/experience curve effect
S = Scope economies effect
Z = Other (including government policy-taxes and subsidies) determinants

Production function

Marginal product
the increase in output that arises from an additional unit of input

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

The number of workers increases, the marginal product declines. The second worker has a marginal product of 40 cookies, the third worker has a marginal product of 30 cookies, and the fourth worker has a marginal product of 20 cookies.

A Production Function and Total Cost: Caroline's Cookie Factory

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

Production function

At first, when only a few workers are hired, they have easy access to Caroline's kitchen equipment. As the number of workers increases, additional workers have to share equipment and work in more crowded conditions. Eventually, the kitchen becomes so overcrowded that workers often get in each other's way. Hence, as more workers are hired, each additional worker contributes fewer additional cookies to total production.

Production and cost functions

The production function in panel (a) shows the relationship between the number of workers hired and the quantity of output produced.

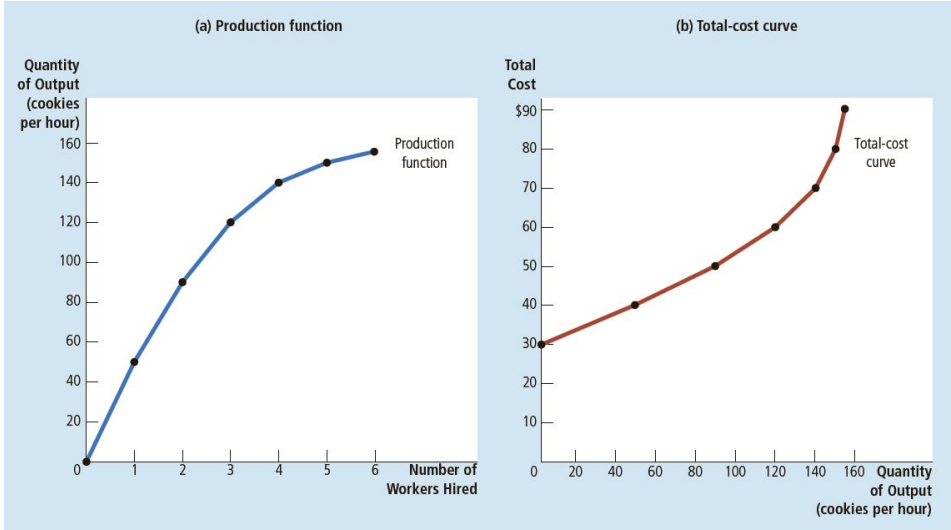
The number of workers hired (on the horizontal axis) is from column (1) in Table 1, and the quantity of output produced (on the vertical axis) is from column (2).

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.

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.



Various measures of cost

The Various Measures of Cost: Conrad's Coffee Shop

Output (cups of coffee per hour)	Total Cost	Fixed Cost	Variable Cost
0	$3.00	$3.00	$0.00
1	3.30	3.00	0.30
2	3.80	3.00	0.80
3	4.50	3.00	1.50
4	5.40	3.00	2.40
5	6.50	3.00	3.50
6	7.80	3.00	4.80
7	9.30	3.00	6.30
8	11.00	3.00	8.00
9	12.90	3.00	9.90
10	15.00	3.00	12.00

Total cost (TC) is the sum total of explicit and implicit costs.

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

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

Various measures of cost

Average cost (AC) is the per unit cost and can be computed simply by dividing total cost by the quantities of output produced (TC/Q).

Average total cost is the total cost divided by the quantity of output
(Average total cost = Total cost/Quantity)

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

Average variable cost variable cost divided by the quantity of output

Marginal cost is the increase in total cost that arises from an extra unit of production
(Marginal cost = Change in total cost/Change in quantity) $MC = \Delta TC / \Delta Q$

Various measures of cost

Seller must keep in mind the concepts of average total cost and marginal cost when deciding how much of their product to supply to the market.

The Various Measures of Cost: Conrad's Coffee Shop

Output (cups of coffee per hour)	Total Cost	Fixed Cost	Variable Cost	Average Fixed Cost	Average Variable Cost	Average Total Cost	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

These cost curves show three common features:

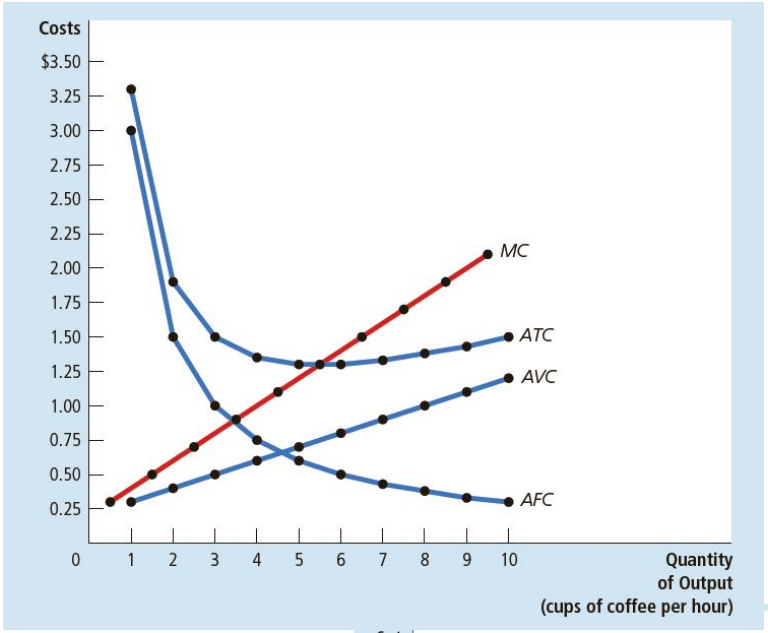
(1) Marginal cost rises with the quantity of output.

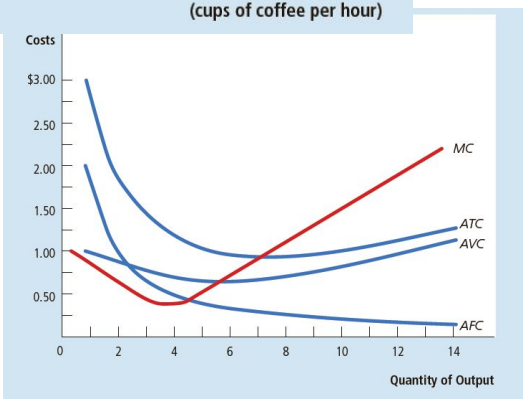
(2) The average-total-cost curve is U-shaped.

(3) The marginal-cost curve crosses the average-total-cost curve at the minimum of average total cost.

At low levels of output, the firm experiences increasing marginal product, and the marginal-cost curve falls. Eventually, the firm starts to experience diminishing marginal product, and the marginal-cost curve starts to rise.

These are short run cost curves.





Various measures of cost

Marginal cost rises with the quantity of output. Why?

This upward slope reflects the property of diminishing marginal product.

When firm produces a small quantity of coffee, it has few workers, and much of its equipment is not used.

Because firm can easily put these idle resources to use, the marginal product of an extra worker is large, and the marginal cost of an extra cup of coffee is small.

By contrast, when firm produces a large quantity of coffee, shop is crowded with workers, and most of its equipment is fully utilized. It can produce more coffee by adding workers, but these new workers have to work in crowded conditions and may have to wait to use the equipment. Therefore, when the quantity of coffee produced is already high, the marginal product of an extra worker is low, and the marginal cost of an extra cup of coffee is large.

Various measures of cost

The average-total-cost curve is U-shaped. Why?

Average total cost is the sum of average fixed cost and average variable cost. Average total cost reflects the shapes of both average fixed cost and average variable cost.

Average fixed cost always declines as output rises because the fixed cost is getting spread over a larger number of units. Average variable cost usually rises as output increases because of diminishing marginal product.

At very low levels of output, average total cost is very high. Even though average variable cost is low, average fixed cost is high because the fixed cost is spread over only a few units.

As output increases, the fixed cost is spread over more units. Average fixed cost declines, rapidly at first and then more slowly. When the firm produces more, the increase in average variable cost becomes the dominant force, and average total cost starts rising. The tug of war between average fixed cost and average variable cost generates the U-shape in average total cost.

Various measures of cost

The marginal-cost curve crosses the average-total-cost curve at the minimum of average total cost. Why?

Whenever marginal cost is less than average total cost, average total cost is falling.
Whenever marginal cost is greater than average total cost, average total cost is rising.

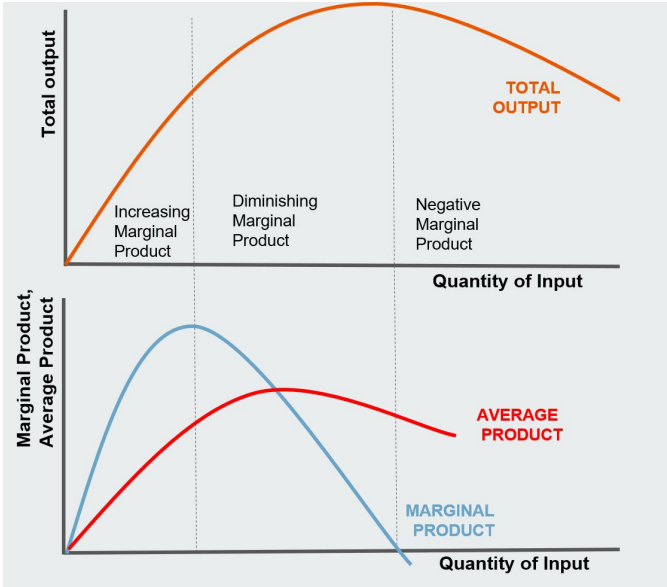
At low levels of output, marginal cost is below average total cost, so average total cost is falling. But after the two curves cross, marginal cost rises above average total cost. As a result, average total cost must start to rise at this level of output. Hence, this point of intersection is the minimum of average total cost.

Theory of production and returns to scale

(a) in the beginning as more labour is used, fixed capital is utilized better and more efficiently than before, thereby output increases at all increasing rate, and this continues until optimal utilization of fixed capital is achieved;
Stage I: The total production increases at an increasing rate. We refer to this as increasing stage where the total product, marginal product and average production are increasing.

(b) after this point, new (additional) labour finds the fixed capital inadequate and hence increment in output is at a diminishing rate. **Stage II:** The total production continues to increase but at a diminishing rate until it reaches the next stage. Marginal product, average product are declining but are positive. The total production is at the maximum level at the end of the second stage with a zero marginal product.

(c) eventually labour input becomes so much that there is no work for new labour and so they disturb the earlier labour from carrying out their work, thereby leading to a decrease in total output. **Stage III:** In this third stage total production declines and marginal product becomes negative. And the average production also started decline. Which implies that the change in input factors there is a decline in the over all production along with the average and marginal.



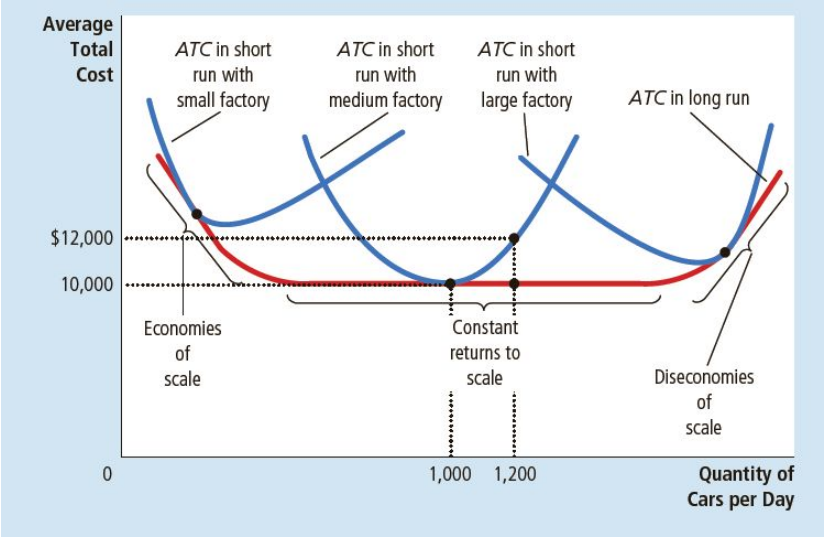
Long run cost curves

Because many decisions are fixed in the short run but variable in the long run, a firm's long-run cost curves differ from its short-run cost curves.

The figure presents three short-run ATC curves—for a small, medium, and large factory. It also presents the long-run ATC curve. As the firm moves along the long-run curve, it is adjusting the size of the factory to the quantity of production.

This graph shows how short-run and long-run costs are related. The long-run ATC curve has a much flatter U-shape than the short-run ATC curve.

All the short-run curves lie on or above the long-run curve. These properties arise because firms have greater flexibility in the long run. In the long run, the firm gets to choose which short-run curve it wants to use. But in the short run, it has to use whatever short-run curve it has, based on decisions it has made in the past.



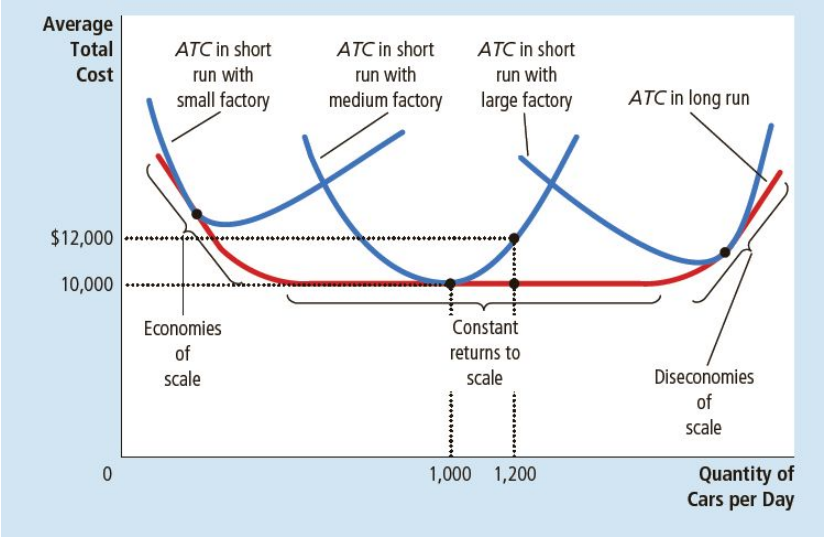
Long run cost curves

Why is the long run ATC curve U-shaped?

At low levels of production, the firm benefits from increased size because it can take advantage of greater specialization. Coordination problems, meanwhile, are not yet acute.

By contrast, at high levels of production, the benefits of specialization have already been realized, and coordination problems become more severe as the firm grows larger.

Thus, long-run average total cost is falling at low levels of production because of increasing specialization and rising at high levels of production because of growing coordination problems.



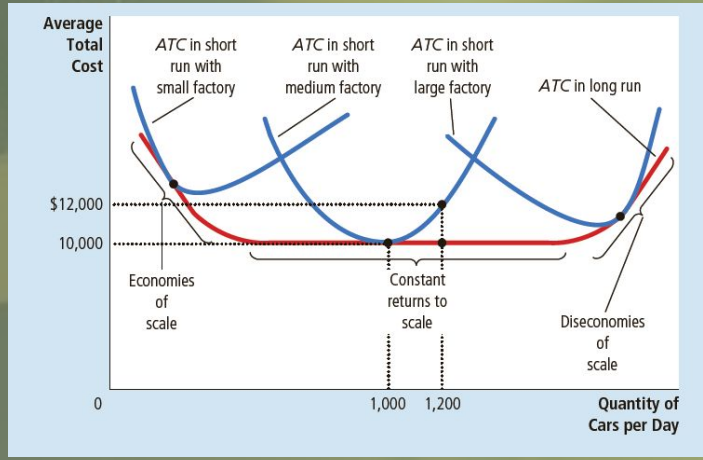
Economies of Scale

The shape of the long-run average-total-cost curve conveys important information about the production processes that a firm has available for manufacturing a good. It tells us how costs vary with the scale—that is, the size—of a firm's operations.

When long-run average total cost declines as output increases, there are said to be **economies of scale**. This often arise because higher production levels allow specialization among workers, which permits each worker to become better at a specific task.

When long-run average total cost rises as output increases, there are said to be **diseconomies of scale**. This can arise because of coordination problems that are inherent in any large organization.

When long-run average total cost does not vary with the level of output, there are said to be **constant returns to scale**.



Economies of Scale: examples

Economies of scale McDonald's buys massive quantities of beef, potatoes, packaging, etc., at lower prices than smaller chains can get. Their highly efficient kitchens and training systems allow consistent, fast service with minimal waste. Spreads operational and expansion costs while benefiting from brand consistency and scale.
Effect: McDonald's can offer meals at lower prices while still making strong profits, due to lower per-unit costs across its huge global system.

Diseconomies of scale In the 1980s, General Motors became so large that it suffered from: Complex management hierarchies, Poor communication between divisions and Inefficiencies in adapting to market changes.
Effect: Higher costs per car, compared to leaner automakers like Toyota at the time.

Constant returns to scale A cloud-based company might scale user access without needing significantly more infrastructure or cost. E.g., the cost to serve 10,000 users might not be much higher than 5,000.
Effect: Output doubles, and costs roughly double too – no gain or loss in efficiency.