Economics

6th edition

Chapter 11

Technology, Production, and Costs

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Technology: An Economic Definition

The basic activity of a firm is to use *inputs* to produce *outputs* of goods and services.

Discuss the examples of inputs.

Technology: The processes a firm uses to turn inputs into outputs of goods and services.

If a firm improves its ability to turn inputs into outputs, we refer to this as a **positive technological change**.

Discussion: UPS uses technology to deal with holiday surge

UPS was late delivering millions of packages leading up to Christmas 2013.

To correct this in following years, the UPS could use the following methods:

Eg, Hire more workers

Practice

Which of the following is an example of positive technological change?

A) A firm offers workers a higher wage to work on weekends and at night. As a result, the firm is able to increase its weekly production of surf boards.

B) A firm buys an additional machine that it uses to make surf boards. As a result, the firm is able to increase its weekly production of surf boards.

C) A firm conducts a new advertising campaign. As a result, the demand for the firm's surf boards increases.

D) A firm's workers participate in a training program designed to increase the number of surf boards they can produce per day.

Practice

When a firm produces more output using the same inputs or the same output using fewer inputs we say that the firm

A) experiences an increase in demand.

B) experiences positive technological change.

C) will hire more workers in order to produce more output.

D) is operating in the short run.

Discussion

Is it possible for technological change to be negative?

If so, give an example.

The Short Run and the Long Run in Economics

Distinguish between the economic short run and the economic long run

Economists refer to the **short run** as a period of time during which at least one of a firm's inputs is fixed.

- **Example:** *A firm might have a long-term lease on a factory that is too costly to get out of.*

In the **long run**, the firm can vary all of its inputs, adopt new technology, and increase or decrease the size of its physical plant.

How long is the long run? It varies from firm to firm.

- Just think of it as "a long enough period of time that anything can be changed".

Fixed, variable, and total costs

The division of time into the short and long run reveals two types of costs:

- **Variable costs** are costs that change as output changes, while
- **Fixed costs** are costs that remain constant as output changes.

In the long run, all of a firm's costs are variable, since the long run is a sufficiently long time to alter the level of any input.

Total cost is the cost of all the inputs a firm uses in production:

$$\text{Total cost} = \text{Fixed cost} + \text{Variable cost}$$

$$TC = FC + VC$$

Making the Connection: Costs in the publishing industry

An academic book publisher turns its inputs (intellectual property, labor, printing machines, paper, factory, electricity, etc.) into its outputs (books).

As it increases the number of books it publishes, some of those inputs stay constant and some rise.

- Can you identify which ones?

True or False

1, A characteristic of the long run that is not available in the short run is that a firm is free to vary its output.

2, Consider a manufacturing operation that uses specialized machinery and labor to produce its output. In this case, the input that is not fixed in the short run is labor.

3, If a firm is producing no output in the short run, then its total costs are zero.

4,In the short run, changes in output can only be brought about by a change in the quantity of variable inputs.

Practice

Jill Johnson's pizza restaurant, explain whether each of the following is a fixed cost or a variable cost:

1, The payment she makes on her fire insurance policy

2, The payment she makes to buy pizza dough

3, The wages she pays her workers

4, The lease payment she makes to the landlord who owns the building where her store is located

5, The $300-per-month payment she makes to her local newspaper for running her weekly advertisement.

Production at Johnson's restaurant

Johnson's restaurant turns its inputs (pizza ovens, ingredients, labor, electricity, etc.) into pizzas for sale.

To make analysis simple, let's consider only two inputs:

- The pizza ovens, and
- Workers

The pizza ovens will be a fixed cost; we will assume Jill cannot change (in the short run) the number of ovens she has.

The workers will be a variable cost; we will assume Jill can easily change the number of workers she hires.

Table 11.2 Short-run production and cost at Jill Johnson's restaurant (1 of 3)

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Quantity of Workers	Quantity of Pizza Ovens	Quantity of Pizzas per Week	Cost of Pizza Ovens (Fixed Cost)	Cost of Workers (Variable Cost)	Total Cost of Pizzas per Week	Cost per Pizza (Average Total Cost)
0	2	0	$800	$0	$800	—
1	2	200	800	650	1,450	$7.25
2	2	450	800	1,300	2,100	4.67
3	2	550	800	1,950	2,750	5.00
4	2	600	800	2,600	3,400	5.67
5	2	625	800	3,250	4,050	6.48
6	2	640	800	3,900	4,700	7.34

Each pizza oven costs $400 per week, and each worker costs $650 per week.

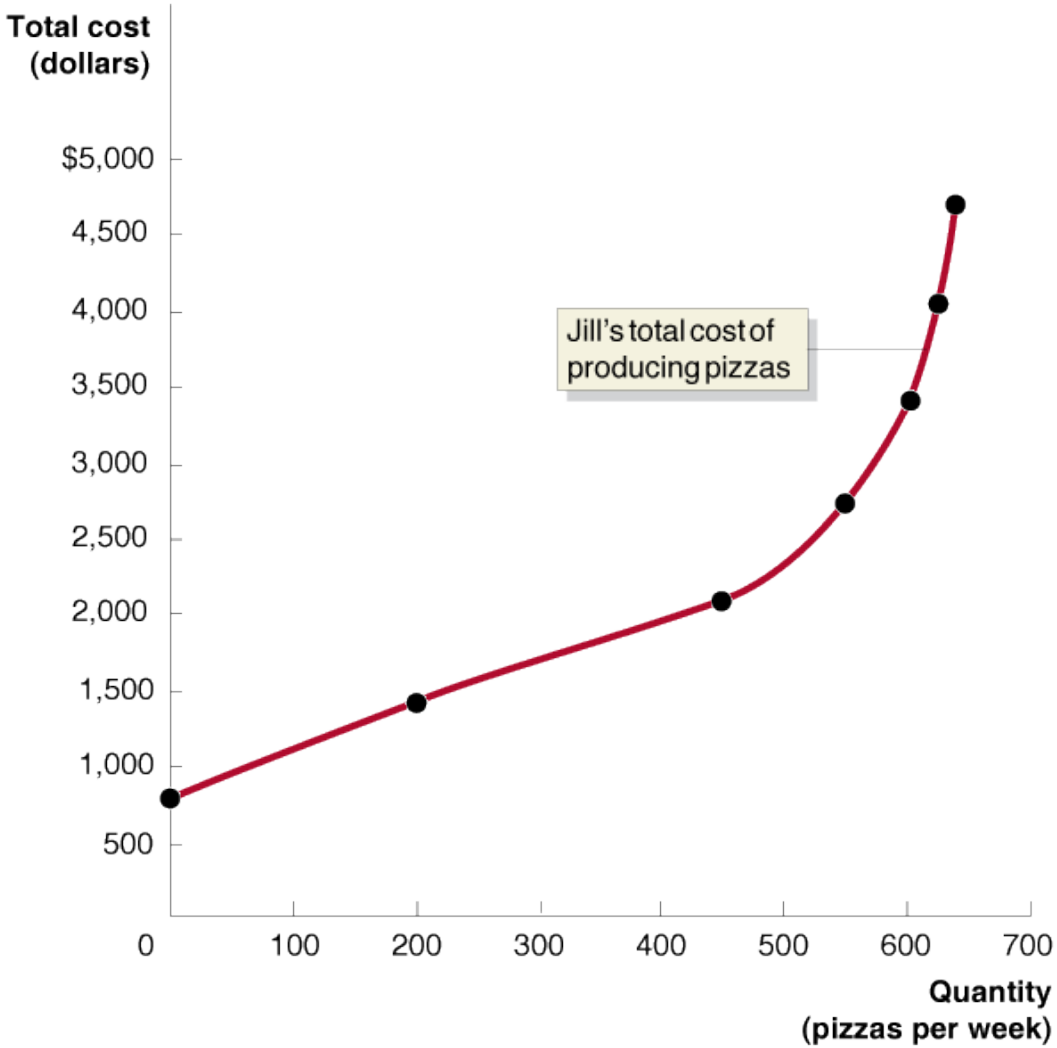
This is the firm's **production function**: the relationship between the inputs employed and the maximum output from those inputs.

Graphing total cost at Jill Johnson's restaurant

Using the information from the table, we can graph the costs for Jill Johnson's restaurant.

Notice that cost is not zero when quantity is zero, because of the fixed cost of the pizza ovens.

Naturally, costs increase as Jill wants to make more pizzas.

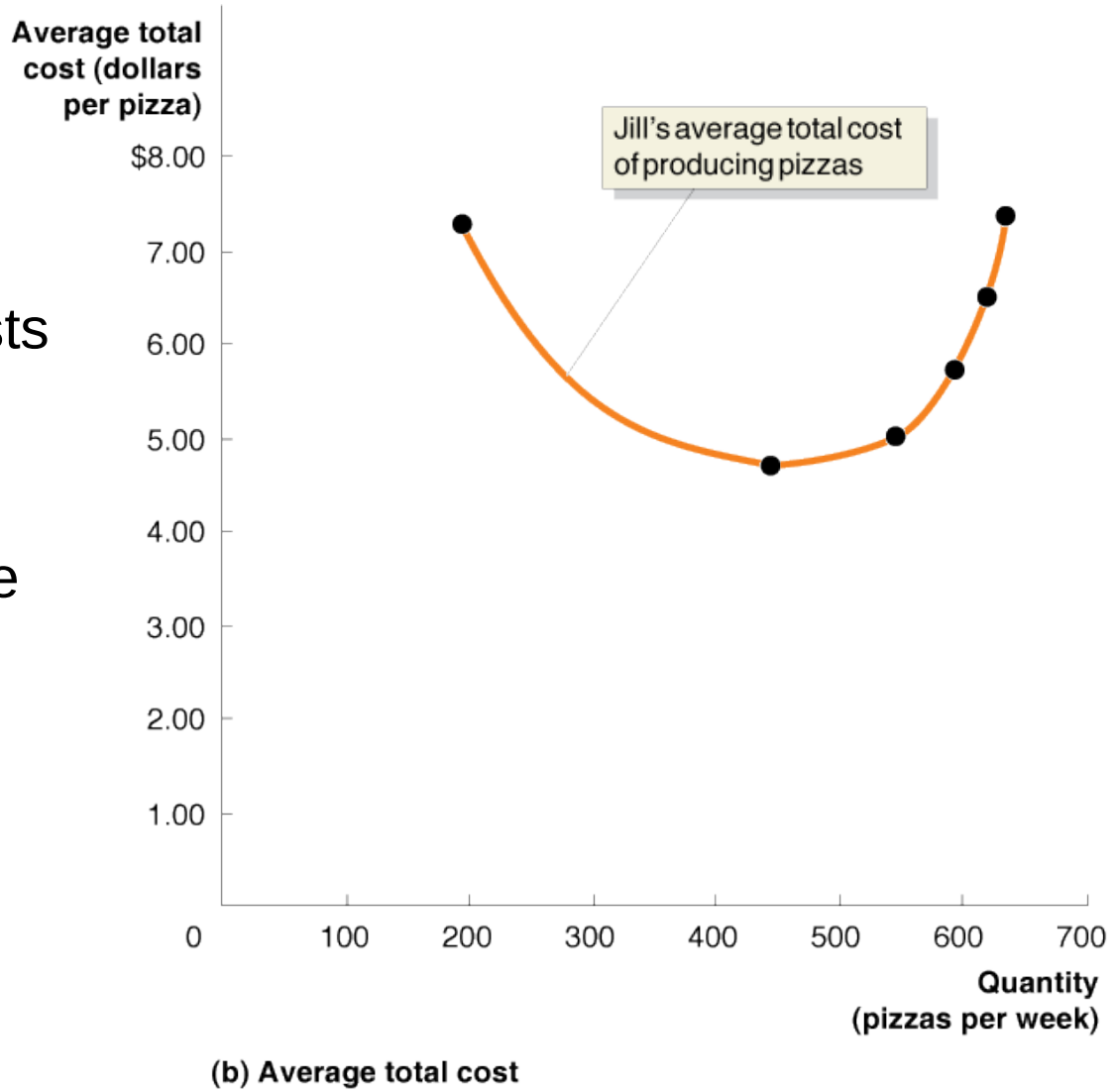


(a) Total cost

Graphing average total cost at Jill Johnson's restaurant

The "falling-then-rising" nature of average total costs results in a U-shaped average total cost curve.

Our next task is to examine *why* we get this shape for average total costs.



(b) Average total cost

The Marginal Product of Labor and the Average Product of Labor

Suppose Jill Johnson hires just one worker; what does that worker have to do?

- Take orders
- Make and cook the pizzas
- Take pizzas to the tables
- Run the cash register, etc.

By hiring another worker, these tasks could be divided up, allowing for some *specialization* to take place, resulting from the *division of labor*.

Two workers can probably produce more output per worker than one worker can alone.

The marginal product of labor at Jill Johnson's restaurant (1 of 2)

Quantity of Workers	Quantity of Pizza Ovens	Quantity of Pizzas	Marginal Product of Labor
0	2	0	—
1	2	200	200
2	2	450	250
3	2	550	100
4	2	600	50
5	2	625	25
6	2	640	15

Let's examine what happens as Jill Johnson hires more workers.

To think about this, consider the **marginal product of labor**: the additional output a firm produces as a result of hiring one more worker.

The marginal product of labor at Jill Johnson's restaurant (2 of 2)

Quantity of Workers	Quantity of Pizza Ovens	Quantity of Pizzas	Marginal Product of Labor
0	2	0	—
1	2	200	200
2	2	450	250
3	2	550	100
4	2	600	50
5	2	625	25
6	2	640	15

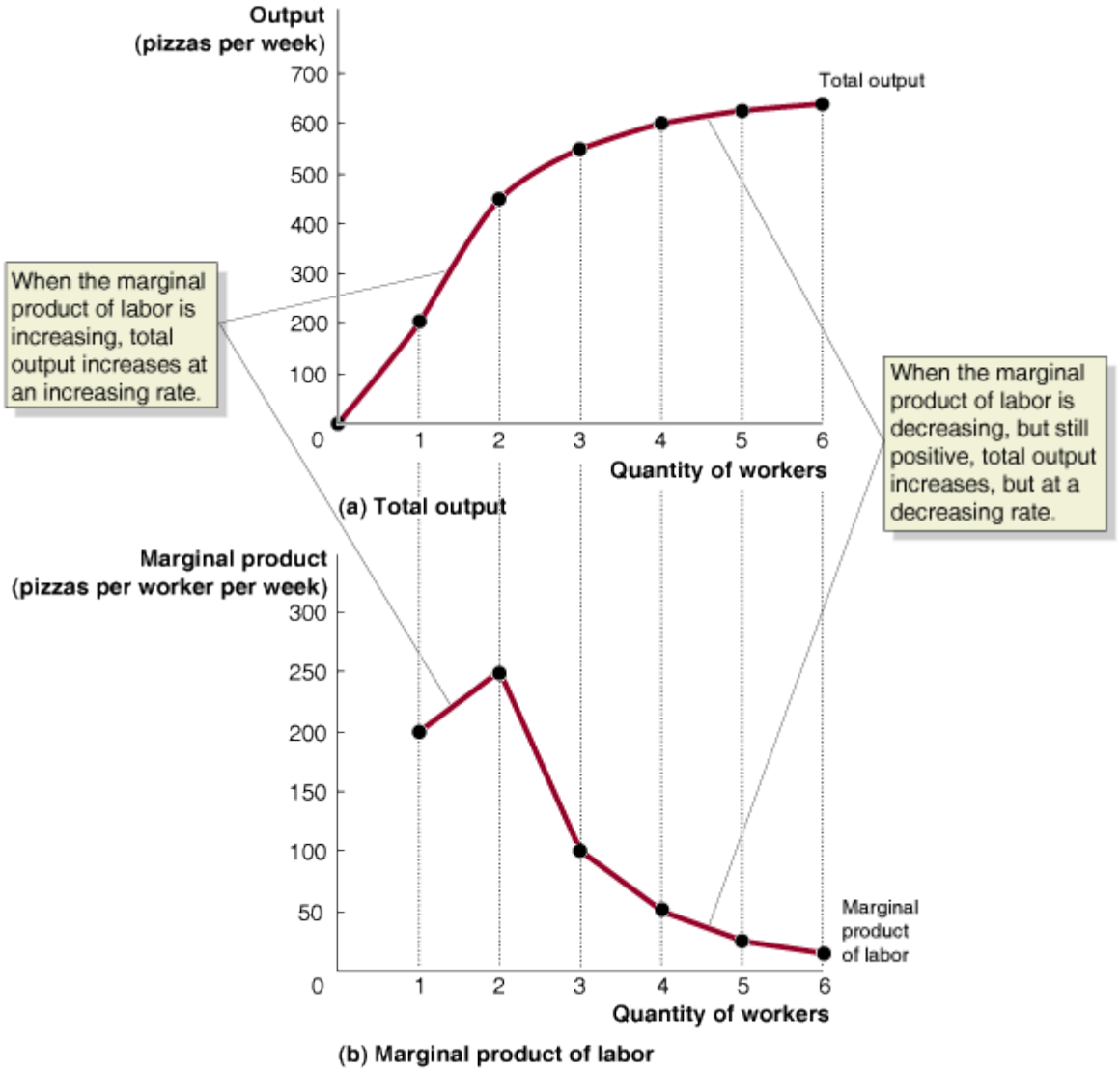
Additional workers add to the potential output, but not by as much. Eventually they start getting in each other's way, etc., because there is only a fixed number of pizza ovens, cash registers, etc.

Law of diminishing returns: At some point, adding more of a variable input, such as labor, to the same amount of a fixed input, such as capital, will cause the marginal product of the variable input to decline.

Total output and the marginal product of labor

Graphing the output and marginal product against the number of workers allows us to see the law of diminishing returns more clearly.

The output curve flattening out, and the decreasing marginal product curve, both illustrate the law of diminishing returns.



Practice

One reason why, in the short run, the marginal product of labor might increase initially as more workers are hired is that

A) the first workers hired get to use the best equipment.

B) specialization allows a worker to focus on one task, thereby increasing her proficiency at that task.

C) the best workers are hired first and later hires are not as skillful.

D) beyond some point, a firm has hired too many workers.

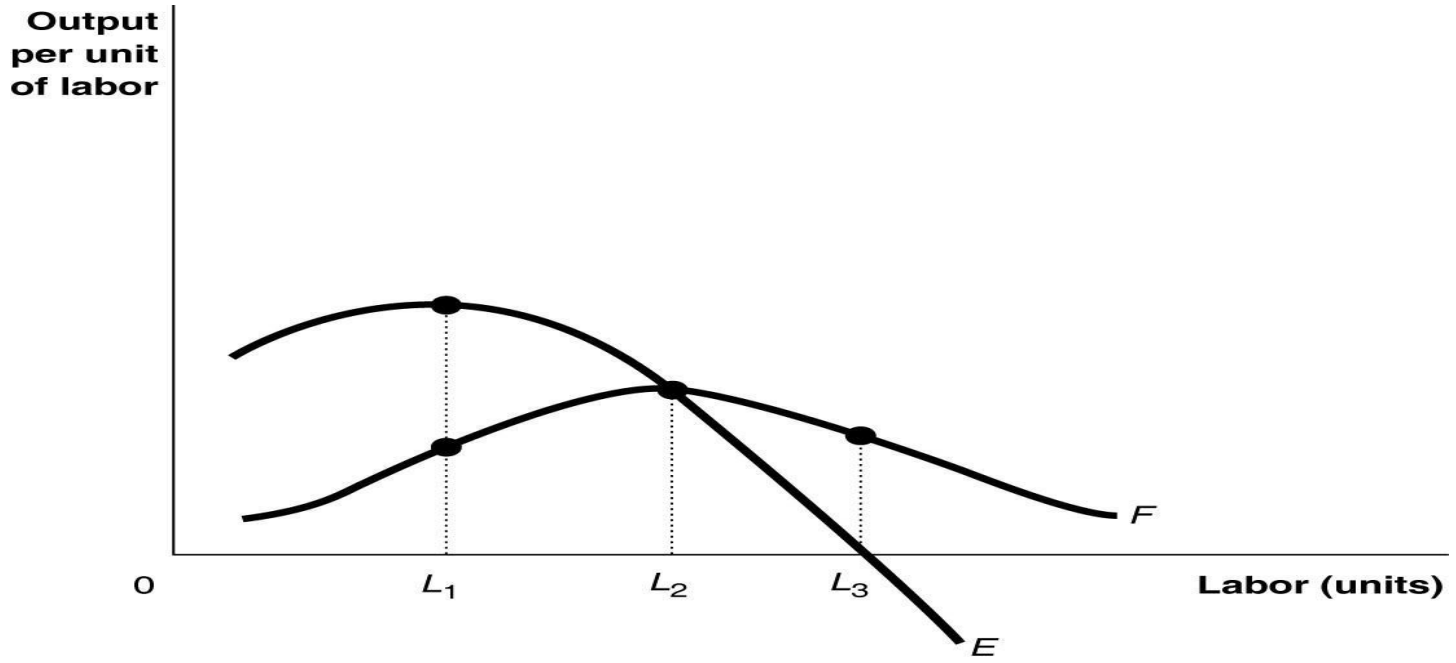
Average product of labor

Another useful indication of output is the **average product of labor**, calculated as the total output produced by a firm divided by the quantity of workers.

Example:

- With 3 workers, the restaurant can produce 550 pizzas, giving an average product of labor of:

$$\frac{550}{3} = 183.3$$



Discussion

1, Which curve shows the marginal product curve?
2, Which curve shows the average product curve?
3, Diminishing returns to labor set in after L1, L2 or L3?
4, Short run output is maximized at L1, L2 or L3?

Graphing Cost Curves

We know that total costs can be divided into fixed and variable costs:

$$TC = FC + VC$$

Dividing both sides by output (Q) gives a useful relationship:

$$TC / Q = FC / Q + VC / Q$$

- The first quantity is **average total cost.**
- The second is **average fixed cost**: fixed cost divided by the quantity of output produced.
- The third is **average variable cost**: variable cost divided by the quantity of output produced.

So, $ATC = AFC + AVC$

Practice

Explain how the events listed in a and b would affect the the marginal cost, average variable cost, average fixed cost and average total cost at Southwest Airlines:

a, The Federal government starts to levy a $20-per-passenger carbon emission tax on all commercial air travel.

b, Southwest decides to double its television advertising budget.

Costs at Jill Johnson's restaurant (1 of 2)

Quantity of Workers	Quantity of Ovens	Quantity of Pizzas	Cost of Ovens (fixed cost)	Cost of Workers (variable cost)	Total Cost of Pizzas	*ATC*	*AFC*	*AVC*	*MC*
0	2	0	$800	$0	$800	—	—	—	—
1	2	200	800	650	1,450	$7.25	$4.00	$3.25	$3.25
2	2	450	800	1,300	2,100	4.67	1.78	2.89	2.60
3	2	550	800	1,950	2,750	5.00	1.45	3.54	6.50
4	2	600	800	2,600	3,400	5.67	1.33	4.33	13.00
5	2	625	800	3,250	4,050	6.48	1.28	5.20	26.00
6	2	640	800	3,900	4,700	7.34	1.25	6.09	43.33

Observe that:

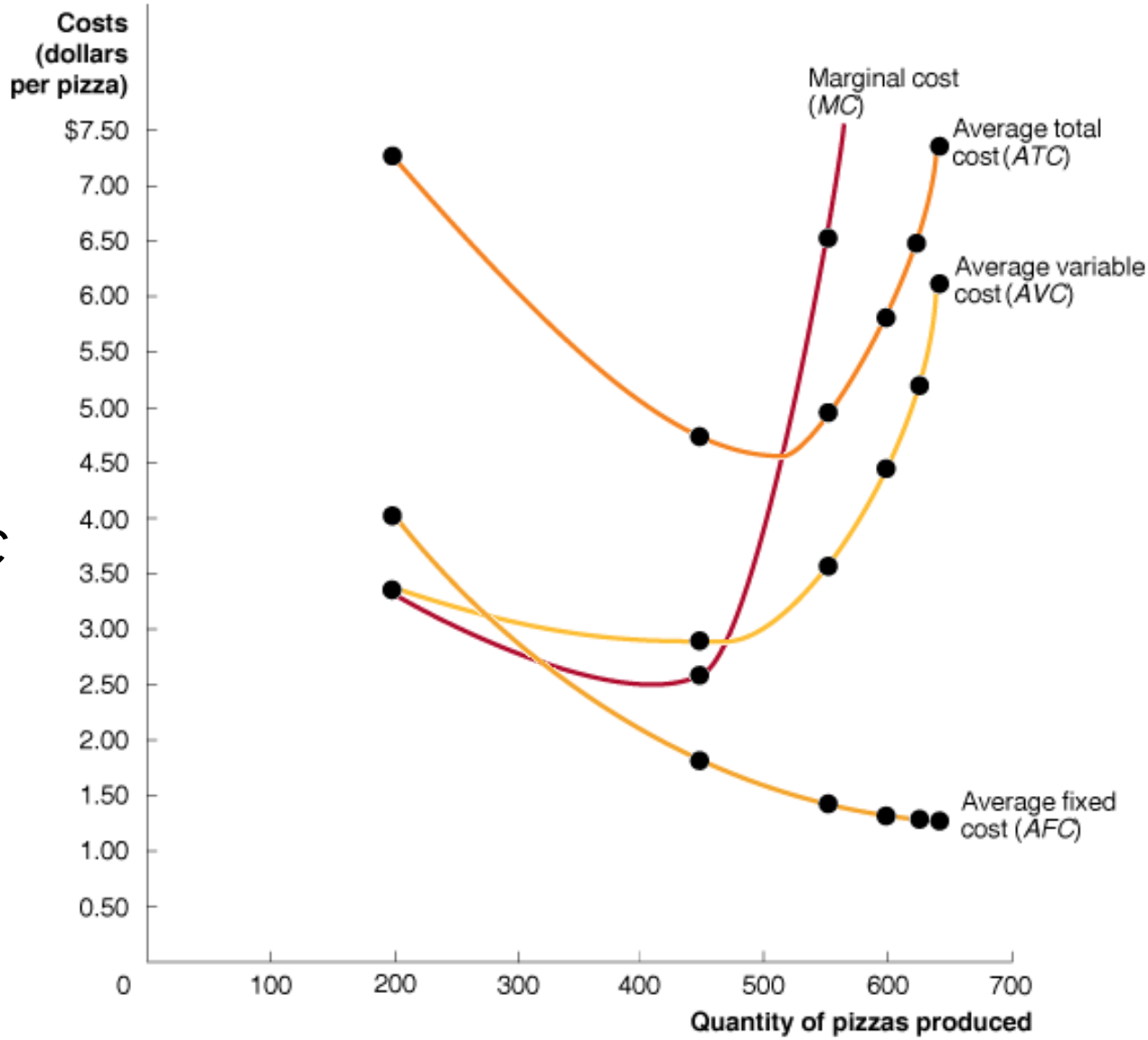
- In each row, *ATC* = *AFC* + *AVC.*
- When *MC* is above *ATC*, *ATC* is falling.
- When *MC* is above *ATC*, *ATC* is rising.
- The same is true for *MC* and *AVC*.

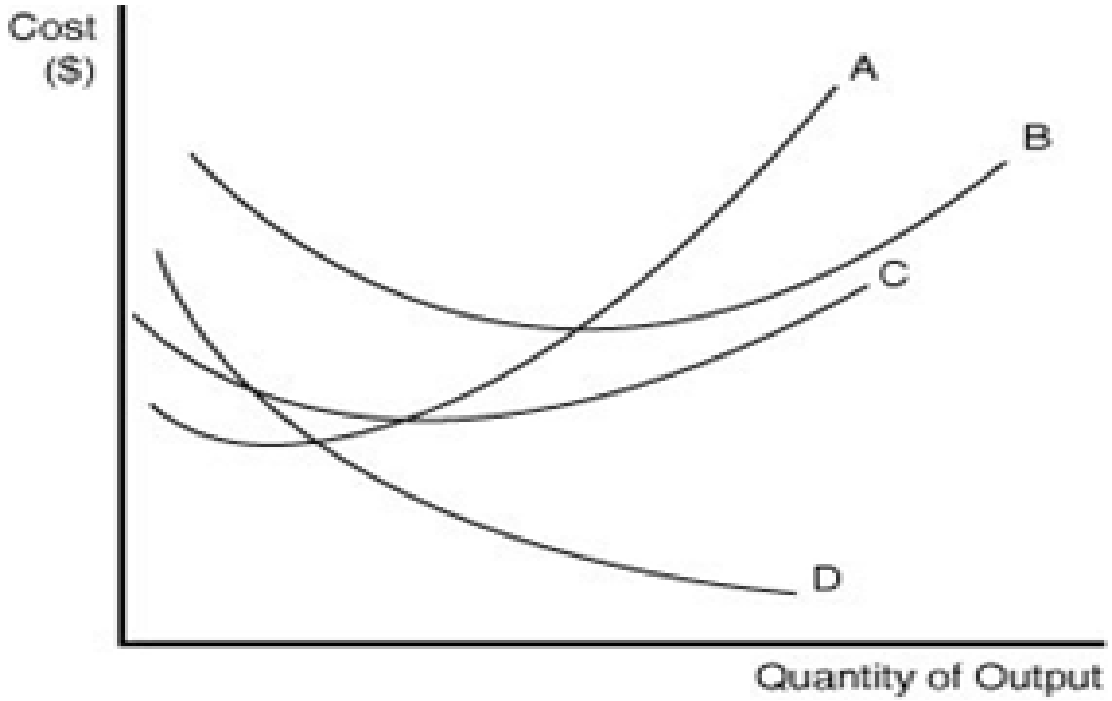
Costs at Jill Johnson's restaurant (2 of 2)

The *MC* curve cuts through each at its minimum point, since both *ATC* and *AVC* "follow" the *MC* curve.

Also notice that the vertical sum of the *AVC* and *AFC* curves is the *ATC* curve.

And because *AFC* gets smaller, the *ATC and AVC* curves converge.





Question:

In the figure above which letter represents

Marginal cost curve?

Average fixed cost curve?

Average variable cost curve?

Average total cost curve?

Question

Which curve is not U-shaped?

A, the marginal cost curve

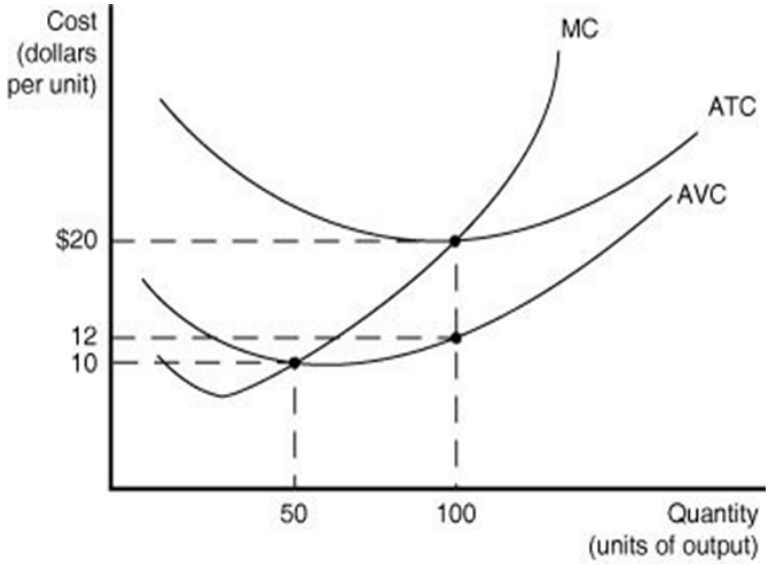
B, the average fixed cost curve

C, the average total cost curve

D, the average variable cost curve

A summary of definitions of cost

Term	Definition	Symbols and Equations
Total cost	The cost of all the inputs used by a firm, or fixed cost plus variable cost	TC
Fixed costs	Costs that remain constant as a firm's level of output changes	FC
Variable costs	Costs that change as a firm's level of output changes	VC
Marginal cost	An increase in total cost resulting from producing another unit of output	$MC = \frac{\Delta TC}{\Delta Q}$
Average total cost	Total cost divided by the quantity of output produced	$ATC = \frac{TC}{Q}$
Average fixed cost	Fixed cost divided by the quantity of output produced	$AFC = \frac{FC}{Q}$
Average variable cost	Variable cost divided by the quantity of output produced	$AVC = \frac{VC}{Q}$
Implicit cost	A nonmonetary opportunity cost	—
Explicit cost	A cost that involves spending money	—



When the output level is 100 units,

1. what is the average fixed cost ?

2. what is the total fixed cost of production ?

3. what is the total cost of production ?

Costs in the Long Run

Recall that the long run is a sufficiently long period of time that all costs are variable.

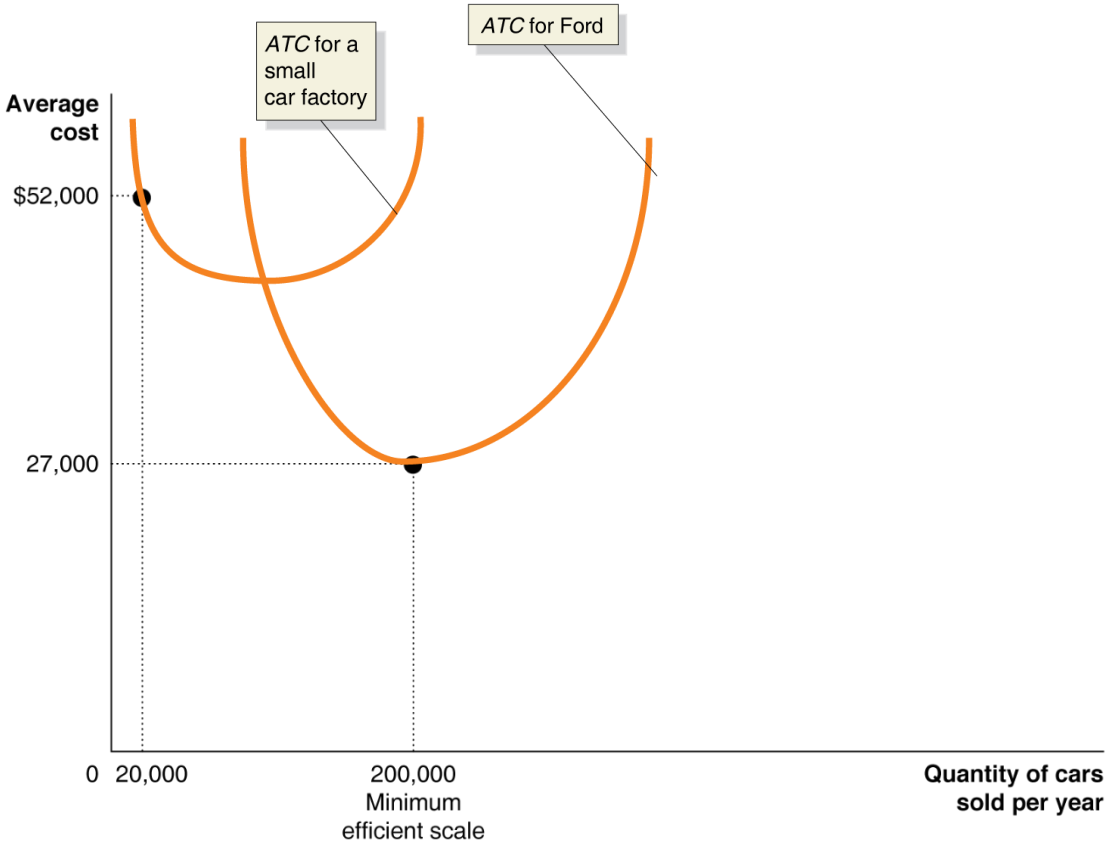
- So In the long run, there is no distinction between fixed and variable costs.

A **long-run average cost curve** shows the lowest cost at which a firm is able to produce a given quantity of output in the long run, when no inputs are fixed.

At low quantities, a firm might experience **economies of scale**: the firm's long-run average costs falling as it increases the quantity of output it produces.

Here, a small car factory can produce at a lower average cost than a large one, for small quantities.

For more output, a larger factory is more efficient.



Why might the firm experience economies of scale?

- The firm's technology may make it possible to increase production with a smaller proportional increase in at least one input.

- Both workers and managers can become more specialized, enable them to be come more productive, as output expands.

- Large firm may be able to purchase inputs at lower costs than smaller competitors. In other words, large firms expanded their bargaining power with their supplier.

- As a firm expands, it may be able to borrow money at a lower interest rate, thereby lowering its costs.

Discussion

From a firm's perspective, expanding production always mean getting better ?

Example

Toyata found that as it expanded production at its Georgetown, Kentucky, plant and its plants in China, its manager had difficulty keeping average cost from rising. According to the president of Toyata's Georgetown plant: "demand for high volumes saps your energy. Over a period of time, it eroded our focus and thinned out the expertise and knowledge we painstakingly build up over the years".

It is the kind of paradox many highly successful companies face: expanding production does not always mean getting better.

Diseconomies of Scale

Diseconomies of scale refer to the situation in which a firm's long-run average costs rise as the firm increases output.

Diseconomies of scale may result when managers have difficulty coordinating the operation of a firm as it grows in scale.

Practice

Over the past twenty years, the number of small family farms has fallen significantly and in their place there are fewer, but larger farms owned by corporation. Which of the following best explains this trend?

A, Diseconomies of scale in farming

B, Economies of scale in farming

C, Diminishing returns to labor in farming

D, Declining productivity