chapter: 11

>> Behind the Supply Curve: Inputs and Costs

Krugman/Wells Economics

1

WHAT YOU WILL LEARN IN THIS CHAPTER

- The importance of the firm's **production function**, the relationship between quantity of inputs and quantity of output
- Why production is often subject to **diminishing returns to inputs**
- The various types of costs a firm faces and how they generate the firm's **marginal** and **average cost curves**
- Why a firm's costs may differ in the **short run** versus the **long run**
- How the firm's technology of production can generate **increasing returns to scale**

2

The Production Function

- A **production function** is the relationship between the quantity of inputs a firm uses and the quantity of output it produces.
- A **fixed input** is an input whose quantity is fixed for a period of time and cannot be varied.
- A **variable input** is an input whose quantity the firm can vary at any time.

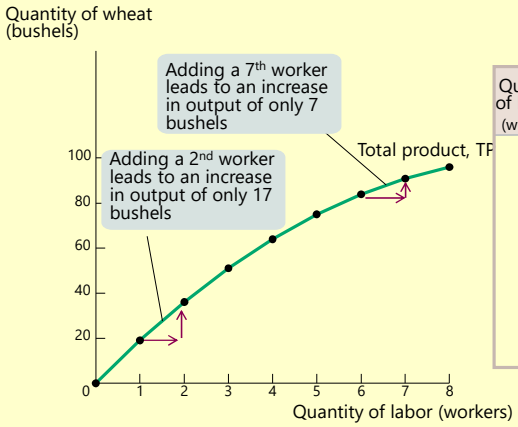
3

Inputs and Output

- The **long run** is the time period in which all inputs can be varied.
- The **short run** is the time period in which at least one input is fixed.
- The **total product curve** shows how the quantity of output depends on the quantity of the variable input, for a given quantity of the fixed input.

4

Production Function and TP Curve for George and Martha's Farm



Quantity of labor L (worker)	Quantity of wheat Q (bushels)	MP of labor MPL = ΔQ/ΔL (bushels per worker)
0	0	
		19
1	19	
		17
2	36	
		15
3	51	
		13
4	64	
		11
5	75	
		9
6	84	
		7
7	91	
		5
8	96	

Although the total product curve in the figure slopes upward along its entire length, the slope isn't constant: as you move up the curve to the right, it flattens out due to changing marginal product of labor.

5 of 41

5

Marginal Product of an Input

- The **marginal product** of an input is the additional quantity of output that is produced by using one more unit of that input.

Marginal Product of Labor = $\frac{\textbf{Change in quantity of Output}}{\textbf{Change in quantity of Labor}}$

MPL = $\frac{\Delta Q}{\Delta L}$ (discrete analysis)

TP = Q = f(K, L); **MPL** = $\frac{\partial Q}{\partial L}$ (continuous analysis)

MPK = $\frac{\Delta Q}{\Delta K}$ (discrete analysis)

MPK = $\frac{\partial Q}{\partial K}$ (continuous analysis)

6 of 41

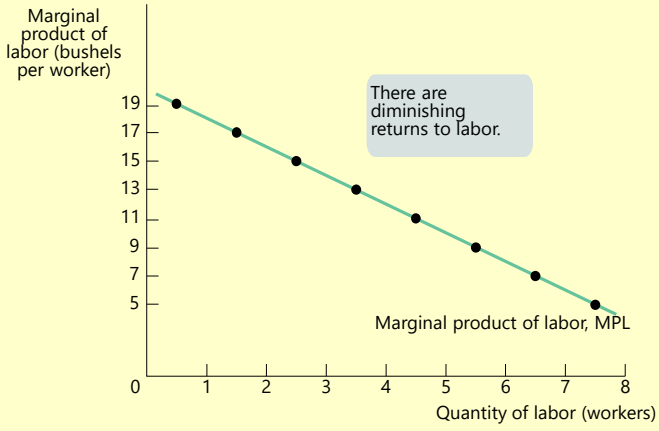
6

Diminishing Returns to an Input

- There are **diminishing returns to an input** when an increase in the quantity of that input, holding the levels of all other inputs fixed, leads to a decline in the marginal product of that input.
- The following marginal product of labor curve illustrates this concept clearly…

7

Marginal Product of Labor Curve



Here, the first worker employed generates an **increase in output** of 19 bushels, the second worker generates an increase of 17 bushels, and so on…

8

From the Production Function to Cost Curves

- A **fixed cost** is a cost that does not depend on the quantity of output produced. It is the cost of the fixed input.
- A **variable cost** is a cost that depends on the quantity of output produced. It is the cost of the variable input.

9

Total Cost Curve

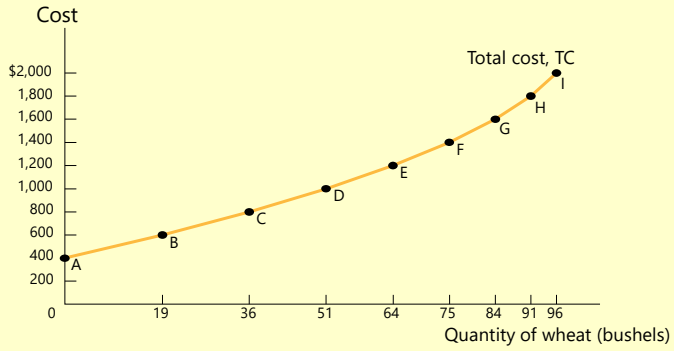
- The **total cost** of producing a given quantity of output is the sum of the fixed cost and the variable cost of producing that quantity of output.

$$TC = FC + VC$$

- The *total cost curve* becomes steeper as more output is produced due to diminishing returns.

10

Total Cost Curve for George and Martha's Farm



Point on graph	Quantity of labor L (worker)	Quantity of wheat Q (bushels)	Variable cost (VC)	Fixed Cost (FC)	Total cost (TC = FC + VC)
A	0	0	$O	$400	$400
B	1	19	200	400	600
C	2	36	400	400	800
D	3	51	600	400	1,000
E	4	64	800	400	1,200
F	5	75	1,000	400	1,400
G	6	84	1,200	400	1,600
H	7	91	1,400	400	1,800
I	8	96	1,600	400	2,000

11

Two Key Concepts: Marginal Cost and Average Cost

$$\text{Marginal cost} = \frac{\text{Change in total cost}}{\text{Change in quantity of output}} = \text{Change in total cost generated by one additional unit of output}$$

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

Marginal Cost (in continuous terms) = $\frac{dTC}{dQ}$

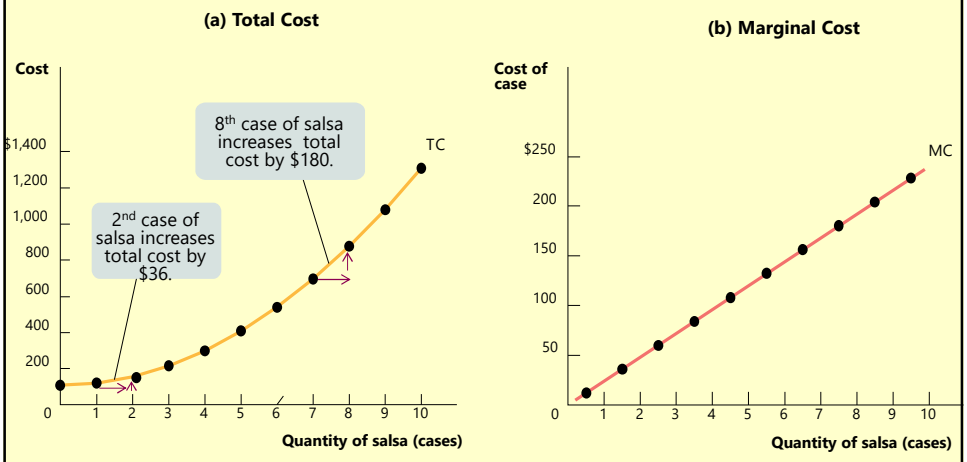
12

Costs at Selena's Gourmet Salsas

Quantity of salsa *Q* (cases)	Fixed cost *FC*	Variable cost *VC*	Total cost *TC = FC + VC*	Marginal cost of case *MC = ΔTC/ΔQ*
0	$108	$0	$108	
				$12
1	108	12	120	
				36
2	108	48	156	
				60
3	108	108	216	
				84
4	108	192	300	
				108
5	108	300	408	
				132
6	108	432	540	
				156
7	108	588	696	
				180
8	108	768	876	
				204
9	108	972	1,080	
				228
10	108	1,200	1,308	

13

Total Cost and Marginal Cost Curves for Selena's Gourmet Salsas



14

Average Cost

- **Average total cost**, often referred to simply as **average cost**, is total cost divided by quantity of output produced.

  ATC = TC/Q = (Total Cost) / (Quantity of Output)

- A **U-shaped average** total cost curve falls at low levels of output, then rises at higher levels.

- **Average fixed cost** is the fixed cost per unit of output.

  AFC = FC/Q = (Fixed Cost) / (Quantity of Output)

15

Average Cost

- **Average variable cost** is the variable cost per unit of output.

  AVC = VC/Q= (Variable Cost) / (Quantity of Output)

16

Average Total Cost Curve

- Increasing output, therefore, has two opposing effects on average total cost—the "***spreading effect***" and the "***diminishing returns effect***":
  - ***The spreading effect***: the larger the output, the greater the quantity of output over which fixed cost is spread, leading to lower the average fixed cost.
  - ***The diminishing returns effect***: the larger the output, the greater the amount of variable input required to produce additional units leading to higher average variable cost.

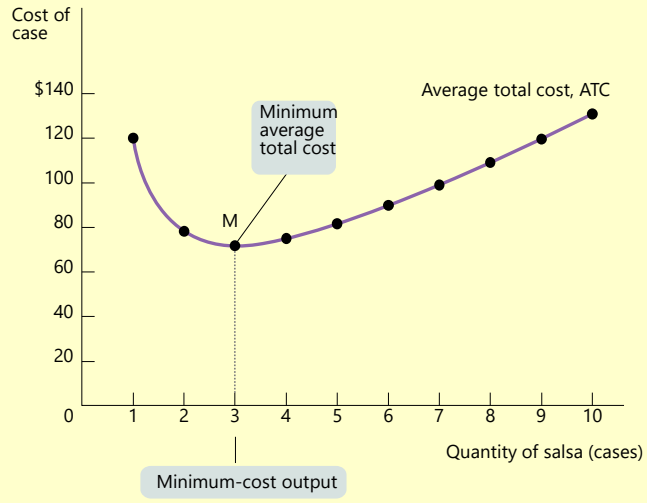
17

Average Costs for Selena's Gourmet Salsas

Quantity of salsa *Q* (cases)	Total cost *TC*	Average total cost of case *ATC = TC/Q*	Average fixed cost of case *AFC = FC/Q*	Average variable cost of case *AVC = VC/Q*
1	$120	$120.00	$108.00	$12.00
2	156	78.00	54.00	24.00
3	216	72.00	36.00	36.00
4	300	75.00	27.00	48.00
5	408	81.60	21.60	60.00
6	540	90.00	18.00	72.00
7	696	99.43	15.43	84.00
8	876	109.50	13.50	96.00
9	1,080	120.00	12.00	108.00
10	1,308	130.80	10.80	120.00

18

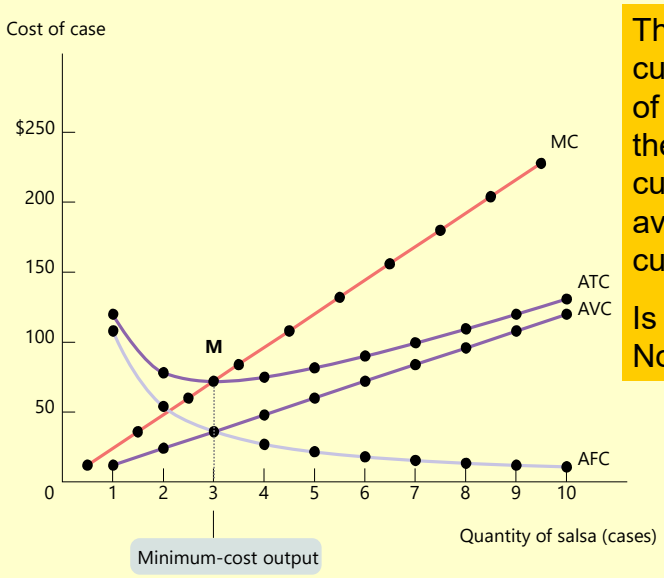
Average Total Cost Curve for Selena's Gourmet Salsas



19 of 41

19

Marginal Cost and Average Cost Curves for Selena's Gourmet Salsas



The bottom of the U curve is at the level of output at which the marginal cost curve crosses the average total cost curve from below.

Is this an accident? No!

20 of 41

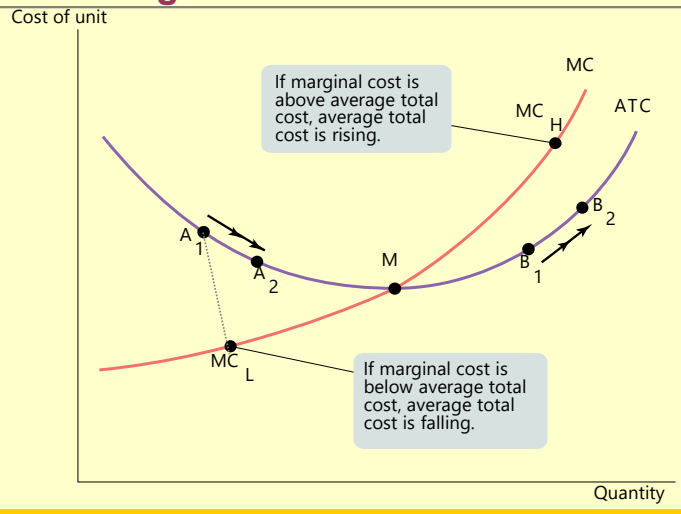
20

General Principles That Are Always True About a Firm's Marginal and Average Total Cost Curves

- The minimum-cost output is the quantity of output at which average total cost is lowest—the bottom of the U-shaped average total cost curve.
  - At the minimum-cost output, average total cost is ***equal to*** marginal cost.
  - At output less than the minimum-cost output, marginal cost is ***less than*** average total cost and average total cost is falling.
  - And at output greater than the minimum-cost output, marginal cost is ***greater than*** average total cost and average total cost is rising.

21

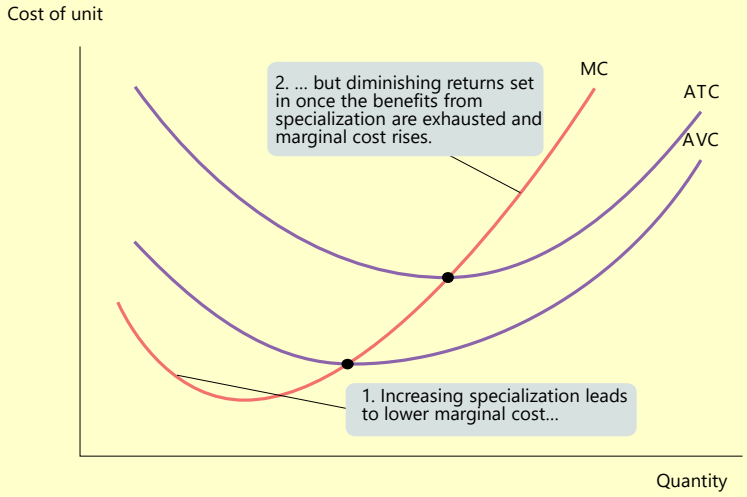
The Relationship Between the Average Total Cost and the Marginal Cost Curves



When marginal cost equals average total cost, we must be at the bottom of the U, because only at that point is average total cost neither falling nor rising.

22

More Realistic Cost Curves



23 of 41

23

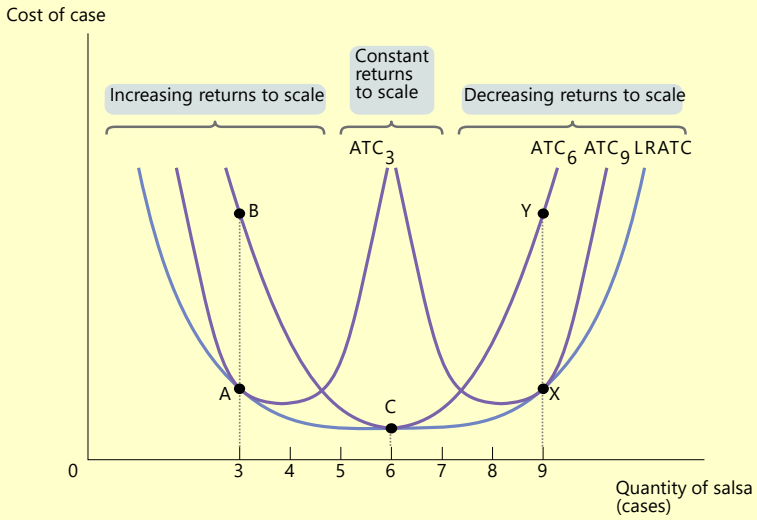
Short-Run versus Long-Run Costs

- In the short run, fixed cost is completely outside the control of a firm. But all inputs are variable in the long run: This means that in the long run fixed cost may also be varied. In the long run, in other words, a firm's fixed cost becomes a variable it can choose.
- The firm will choose its fixed cost in the long run based on the level of output it expects to produce.
- The **long-run average total cost curve** shows the relationship between output and average total cost when fixed cost has been chosen to minimize average total cost for each level of output.

24 of 41

24

Short-Run and Long-Run Average Total Cost Curves



25 of 41

25

Returns to Scale

- There are **increasing returns to scale (economies of scale)** when long-run average total cost declines as output increases.
- There are decreasing returns to scale (**diseconomies of scale)** when long-run average total cost increases as output increases.
- There are **constant returns to scale** when long-run average total cost is constant as output increases.

26 of 41

26

The End of Chapter 11

Coming attraction:

Chapter 12:
Perfect Competition and the Supply Curve