

Chapter 7

The Cost of Production

Topics to be Discussed

- Measuring Cost: Which Costs Matter?
- Cost in the Short Run
- Cost in the Long Run
- Long-Run Versus Short-Run Cost Curves
- Production with Two Outputs--Economies of Scope

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Introduction

- The production technology measures the relationship between input and output.
- Given the production technology, managers must choose *how* to produce.

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Introduction

- To determine the optimal level of output and the input combinations, we must convert from the unit measurements of the production technology to dollar measurements or costs.

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Measuring Cost: Which Costs Matter?

Economic Cost vs. Accounting Cost

- Accounting Cost
 - Actual expenses plus depreciation charges for capital equipment
- Economic Cost
 - Cost to a firm of utilizing economic resources in production, including opportunity cost

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Measuring Cost: Which Costs Matter?

- Opportunity cost.
 - Cost associated with opportunities that are foregone when a firm's resources are not put to their highest-value use.

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Measuring Cost: Which Costs Matter?

- Sunk Cost
 - Expenditure that has been made and cannot be recovered
 - Should not influence a firm's decisions.

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Measuring Cost: Which Costs Matter?

- An Example
 - A firm pays \$500,000 for an option to buy a building.
 - The cost of the building is \$5 million or a total of \$5.5 million.
 - The firm finds another building for \$5.25 million.
 - Which building should the firm buy?

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Measuring Cost: Which Costs Matter?

Fixed and Variable Costs

- Total output is a function of variable inputs and fixed inputs.
- Therefore, the total cost of production equals the fixed cost (the cost of the fixed inputs) plus the variable cost (the cost of the variable inputs), or...

$$TC = FC + VC$$

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Measuring Cost: Which Costs Matter?

Fixed and Variable Costs

- Fixed Cost
 - Does not vary with the level of output
- Variable Cost
 - Cost that varies as output varies

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Measuring Cost: Which Costs Matter?

- Fixed Cost
 - Cost paid by a firm that is in business regardless of the level of output
- Sunk Cost
 - Cost that has been incurred and cannot be recovered

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A Firm's Short-Run Costs (\$)

Rate of Output	Fixed Cost (FC)	Variable Cost (VC)	Total Cost (TC)	Marginal Cost (MC)	Average Fixed Cost (AFC)	Average Variable Cost (AVC)	Average Total Cost (ATC)
0	50	0	50	---	---	---	---
1	50	50	100	50	50	50	100
2	50	78	128	28	25	39	64
3	50	98	148	20	16.7	32.7	49.3
4	50	112	162	14	12.5	28	40.5
5	50	130	180	18	10	26	36
6	50	150	200	20	8.3	25	33.3
7	50	175	225	25	7.1	25	32.1
8	50	204	254	29	6.3	25.5	31.8
9	50	242	292	38	5.6	26.9	32.4
10	50	300	350	58	5	30	35
11	50	385	435	85	4.5	35	39.5

Cost in the Short Run

- Marginal Cost (MC) is the cost of expanding output by one unit. Since fixed cost has no impact on marginal cost, it can be written as:

$$MC = \frac{\Delta VC}{\Delta Q} = \frac{\Delta TC}{\Delta Q}$$

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Cost in the Short Run

- Average Total Cost (ATC) is the cost per unit of output, or average fixed cost (AFC) plus average variable cost (AVC). This can be written:

$$ATC = \frac{TFC}{Q} + \frac{TVC}{Q}$$

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Cost in the Short Run

- Average Total Cost (ATC) is the cost per unit of output, or average fixed cost (AFC) plus average variable cost (AVC). This can be written:

$$ATC = AFC + AVC = \frac{TC}{Q}$$

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Cost in the Short Run

- The Determinants of Short-Run Cost
 - *Diminishing marginal returns to labor*

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Cost in the Short Run

- The Determinants of Short-Run Cost
 - Increasing marginal returns (at the beginning)
 - ◆ With increasing returns, output is increasing relative to input and variable cost and total cost will fall relative to output.
 - Decreasing returns
 - ◆ With decreasing returns, output is decreasing relative to input and variable cost and total cost will rise relative to output.

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Cost in the Short Run

- For Example: Assume the wage rate (w) is fixed relative to the number of workers hired. Then:

$$MC = \frac{\Delta VC}{\Delta Q}$$

$$VC = wL$$

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Cost in the Short Run

- Continuing:

$$\Delta VC = w\Delta L$$

$$MC = \frac{w\Delta L}{\Delta Q}$$

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Cost in the Short Run

- Continuing:

$$\Delta MP_L = \frac{\Delta Q}{\Delta L}$$

$$\Delta L \text{ for a 1 unit } \Delta Q = \frac{\Delta L}{\Delta Q} = \frac{1}{\Delta MP_L}$$

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Cost in the Short Run

- In conclusion:

$$MC = \frac{w}{MP_L}$$

- ...and a low marginal product (MP) leads to a high marginal cost (MC) and vice versa.

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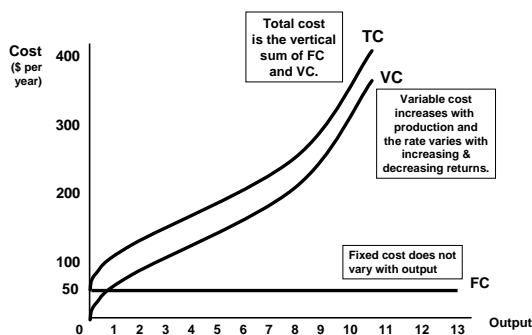
Cost in the Short Run

- Consequently (from the table):

- MC decreases initially with increasing returns
 - 0 through 4 units of output
- MC increases with decreasing returns
 - 5 through 11 units of output

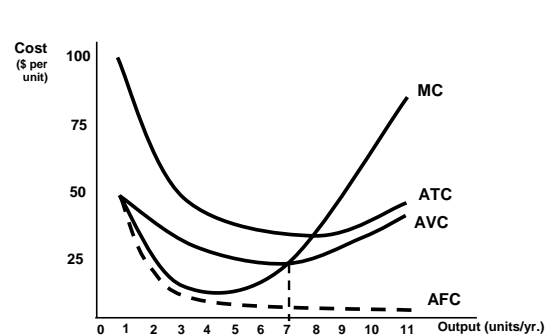
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Cost Curves for a Firm



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Cost Curves for a Firm

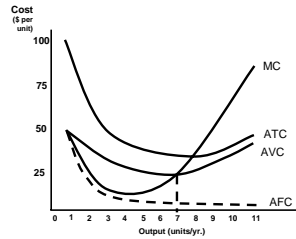


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Cost Curves for a Firm

Unit Costs

- AFC falls continuously
- When $MC < AVC$ or $MC < ATC$, AVC & ATC decrease
- When $MC > AVC$ or $MC > ATC$, AVC & ATC increase

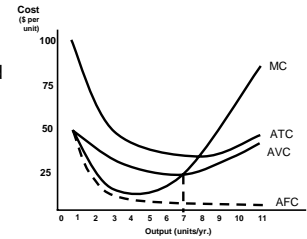


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Cost Curves for a Firm

Unit Costs

- $MC = AVC$ and $MC = ATC$ at minimum AVC and ATC
- Minimum AVC occurs at a lower output than minimum ATC due to FC



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Cost in the Long Run

The User Cost of Capital

- User Cost of Capital = Economic Depreciation + (Interest Rate)(Value of Capital)

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Cost in the Long Run

The User Cost of Capital

Example

- Delta buys a Boeing 737 for \$150 million with an expected life of 30 years
 - ◆ Annual economic depreciation = $\$150 \text{ million} / 30 = \5 million
 - ◆ Interest rate = 10%

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Cost in the Long Run

The User Cost of Capital

Example

- User Cost of Capital = \$5 million + $(.10)(\$150 \text{ million} - \text{depreciation})$
 - ◆ Year 1 = \$5 million + $(.10)(\$150 \text{ million}) = \20 million
 - ◆ Year 10 = \$5 million + $(.10)(\$100 \text{ million}) = \15 million

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Cost in the Long Run

The User Cost of Capital

Rate per dollar of capital

- $r = \text{Depreciation Rate} + \text{Interest Rate}$

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Cost in the Long Run

The User Cost of Capital

- Airline Example
 - Depreciation Rate = $1/30 = 3.33\%$ per yr
 - Rate of Return = 10% per yr
- User Cost of Capital
 - $r = 3.33 + 10 = 13.33\%$ per yr

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Cost in the Long Run

The Cost Minimizing Input Choice

- Assumptions
 - Two Inputs: Labor (L) & capital (K)
 - Price of labor: wage rate (w)
 - The price of capital
 - ◆ $R =$ depreciation rate + interest rate

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Cost in the Long Run

The Cost Minimizing Input Choice

- The Isocost Line
 - $C = wL + rK$
 - Isocost: A line showing all combinations of L & K that can be purchased for the same cost

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Cost in the Long Run

The Isocost Line

- Rewriting C as linear:
 - $K = C/r - (w/r)L$
 - Slope of the isocost: $\Delta K / \Delta L = -(w/r)$
 - ◆ is the ratio of the wage rate to rental cost of capital.
 - ◆ This shows the rate at which capital can be substituted for labor with no change in cost.

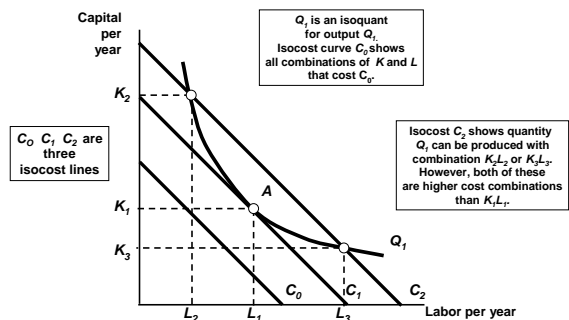
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Choosing Inputs

- We will address how to minimize cost for a given level of output.
 - We will do so by combining isocosts with isoquants

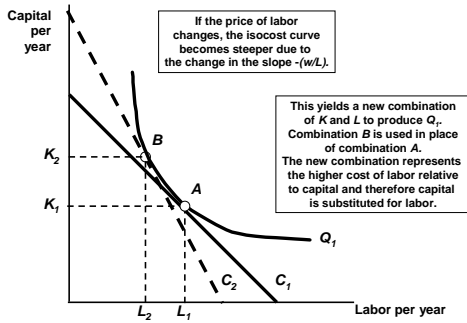
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Producing a Given Output at Minimum Cost



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Input Substitution When an Input Price Change



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Cost in the Long Run

- Isoquants and Isocosts and the Production Function

$$MRTS = -\Delta K / \Delta L = MP_L / MP_K$$

$$\text{Slope of isocost line} = \Delta K / \Delta L = -w/r$$

$$MP_L / MP_K = w/r$$

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Cost in the Long Run

- The minimum cost combination can then be written as:

$$MP_L / w = MP_K / r$$

- Minimum cost for a given output will occur when each dollar of input added to the production process will add an equivalent amount of output.

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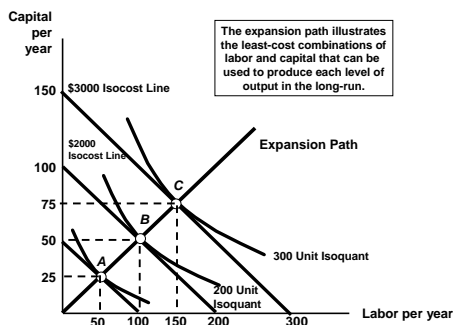
Cost in the Long Run

- Cost minimization with Varying Output Levels

- A firm's expansion path shows the minimum cost combinations of labor and capital at each level of output.

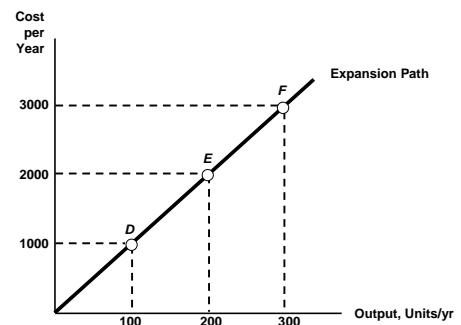
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A Firm's Expansion Path



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A Firm's Long-Run Total Cost Curve



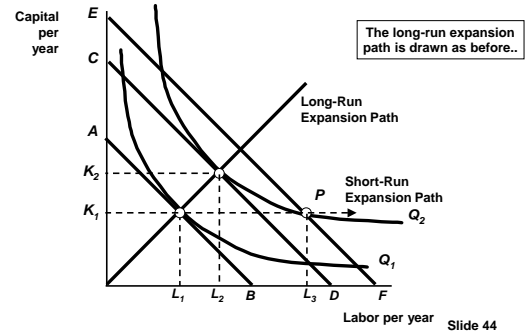
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Long-Run Versus Short-Run Cost Curves

- What happens to average costs when both inputs are variable (long run) versus only having one input that is variable (short run)?

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The Inflexibility of Short-Run Production



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Long-Run Versus Short-Run Cost Curves

- Long-Run Average Cost (LAC)
 - Constant Returns to Scale
 - ◆ If input is doubled, output will double and average cost is constant at all levels of output.

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Long-Run Versus Short-Run Cost Curves

- Long-Run Average Cost (LAC)
 - Increasing Returns to Scale
 - ◆ If input is doubled, output will more than double and average cost decreases at all levels of output.

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Long-Run Versus Short-Run Cost Curves

- Long-Run Average Cost (LAC)
 - Decreasing Returns to Scale
 - ◆ If input is doubled, the increase in output is less than twice as large and average cost increases with output.

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Long-Run Versus Short-Run Cost Curves

- Long-Run Average Cost (LAC)
 - In the long-run:
 - ◆ Firms experience increasing and decreasing returns to scale and therefore long-run average cost is "U" shaped.

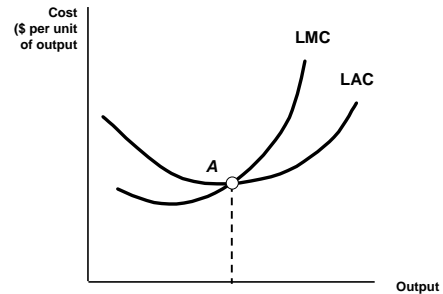
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Long-Run Versus Short-Run Cost Curves

- Long-Run Average Cost (LAC)
 - Long-run marginal cost leads long-run average cost:
 - ◆ If $LMC < LAC$, LAC will fall
 - ◆ If $LMC > LAC$, LAC will rise
 - ◆ Therefore, $LMC = LAC$ at the minimum of LAC

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Long-Run Average and Marginal Cost



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Long-Run Versus Short-Run Cost Curves

- Economies and Diseconomies of Scale
 - Economies of Scale
 - ◆ Increase in output is greater than the increase in cost.
 - Diseconomies of Scale
 - ◆ Increase in output is less than the increase in cost.

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Long-Run Versus Short-Run Cost Curves

- It differs from returns to scale: when we consider returns to scale, input proportions are fixed. But economies of scale allow input proportions to change.
- Measuring Economies of Scale: percentage change in cost from a 1% increase in output

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Long-Run Versus Short-Run Cost Curves

- Measuring Economies of Scale

$$E_c = (\Delta C / C) / (\Delta Q / Q)$$

$$E_c = (\Delta C / \Delta Q) / (C / Q) = MC / AC$$

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Long-Run Versus Short-Run Cost Curves

- Therefore, the following is true:
 - $E_c < 1$: $MC < AC$
 - ◆ economies of scale
 - $E_c = 1$: $MC = AC$
 - ◆ constant economies of scale
 - $E_c > 1$: $MC > AC$
 - ◆ diseconomies of scale

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Production with Two Outputs--Economies of Scope

- Economies of scope exist when the joint output of a single firm is greater than the output that could be achieved by two different firms each producing a single output (with equivalent inputs allocated between the two firms).
- What are the advantages of joint production?
 - Consider an automobile company producing cars and tractors

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Production with Two Outputs--Economies of Scope

- Advantages
 - 1) Both use capital and labor.
 - 2) The firms share management resources.
 - 3) Both use the same labor skills and type of machinery.

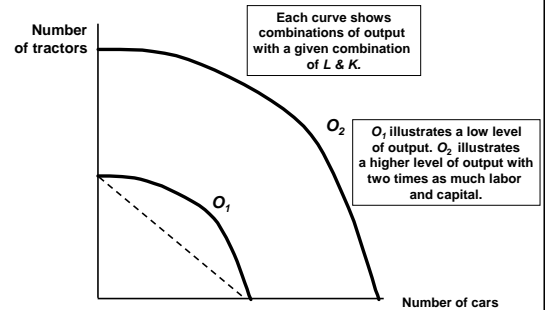
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Production with Two Outputs--Economies of Scope

- Production:
 - Firms must choose how much of each to produce.
 - The alternative quantities can be illustrated using product transformation curves.

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Product Transformation Curve



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Production with Two Outputs--Economies of Scope

- Observations
 - Product transformation curves are negatively sloped
 - Constant returns exist in this example
 - Since the production transformation curve is concave is joint production desirable?

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Production with Two Outputs--Economies of Scope

- Observations
 - There is no direct relationship between economies of scope and economies of scale.
 - ◆ May experience economies of scope and diseconomies of scale
 - ◆ May have economies of scale and not have economies of scope

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