Chapter 7
Read this chapter together with unit five in the study guide

Costs
Topics

• The Nature of Costs.

• Short-Run Costs.

• Long-Run Costs.

• Lower Costs in the Long Run.

• Cost of Producing Multiple Goods.
The Nature of Costs

- Economists measure all relevant costs.
  - Explicit costs – direct, out-of-pocket payments for inputs to its production process within a given time period
  - Implicit costs – reflect only a forgone opportunity rather than an explicit, current expenditure.

- Accountants measure costs in ways that are more consistent with tax laws and other laws.
Opportunity Cost

- **Economic cost or opportunity cost** - the value of the best alternative use of a resource.
Solved Problem 7.1

- Meredith’s firm sends her to a conference for managers and has paid her registration fee. Included in the registration fee is free admission to a class on how to price derivative securities such as options. She is considering attending, but her most attractive alternative opportunity is to attend a talk by Warren Buffett about his investment strategies, which is scheduled at the same time. Although she would be willing to pay $100 to hear his talk, the cost of a ticket is only $40. Given that there are no other costs involved in attending either event, what is Meredith’s opportunity cost of attending the derivatives talk?
Solved Problem 7.1 (cont.)

• Answer:
  - *To calculate her opportunity cost, determine the benefit that Meredith would forgo by attending the derivatives class.*
Costs of Durable Goods

- **Durable good** - a product that is usable for years.

- Two issues arise with measuring the cost of durable goods:
  - How to allocate the initial purchase cost over time.
  - What to do if the value of the capital changes over time.
Sunk Costs

- **Sunk cost** – a past expenditure that cannot be recovered.
Short-Run Cost Measures

- **Fixed cost** (\(F\)) - a production expense that does not vary with output.

- **Variable cost** (\(VC\)) - a production expense that changes with the quantity of output produced.

- **Cost** (total cost, \(C\)) - the sum of a firm’s variable cost and fixed cost:

  \[ C = VC + F \]
Marginal Cost

- **Marginal cost** ($MC$) - the amount by which a firm’s cost changes if the firm produces one more unit of output.

$$MC = \frac{\Delta C}{\Delta q}$$

- And since only variable costs change with output:

$$MC = \frac{\Delta VC}{\Delta q}$$
Average Costs

• **Average fixed cost** (*AFC*) - the fixed cost divided by the units of output produced:
  \[ AFC = \frac{F}{q}. \]

• **Average variable cost** (*AVC*) - the variable cost divided by the units of output produced:
  \[ AVC = \frac{VC}{q}. \]

• **Average cost** (*AC*) - the total cost divided by the units of output produced:
  \[ AC = \frac{C}{q} \]
  \[ AC = AFC + AVC. \]
### Table 7.1 Variation of Short-Run Cost with Output

<table>
<thead>
<tr>
<th>Output, ( q )</th>
<th>Fixed Cost, ( F )</th>
<th>Variable Cost, ( VC )</th>
<th>Total Cost, ( C )</th>
<th>Marginal Cost, ( MC )</th>
<th>Average Fixed Cost, ( AFC = F/q )</th>
<th>Average Variable Cost, ( AVC = VC/q )</th>
<th>Average Cost, ( AC = C/q )</th>
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<td>4.0</td>
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</tr>
</tbody>
</table>
**Figure 7.1 Short-Run Cost Curves**

<table>
<thead>
<tr>
<th>Output, ( q )</th>
<th>Fixed Cost, ( F )</th>
<th>Variable Cost, ( VC )</th>
<th>Total Cost, ( C )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>48</td>
<td>0</td>
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<tr>
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<td>12</td>
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<td>321</td>
<td>369</td>
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</tbody>
</table>
Relationship Between Average and Marginal Cost Curves

When \( MC \) is lower than \( AC \), \( AC \) is decreasing...

and when \( MC \) is larger than \( AC \), \( AC \) is increases

so \( MC = AC \), at the lowest point of the \( AC \) curve!

When \( MC \) is lower than \( AVC \), \( AVC \) is decreasing...

and when \( MC \) is larger than \( AVC \), \( AVC \) is increases

so \( MC = AVC \), at the lowest point of the \( AVC \) curve!
Figure 7.2 Variable Cost and Total Product of Labor

![Graph showing the relationship between quantity of units produced and labor hours. The graph illustrates the total product of labor and variable cost as a function of labor hours. The equation VC = wL, where VC is variable cost, w is the wage rate, and L is the number of labor hours, is also shown.]
Shape of the Marginal Cost Curve

\[ MC = \frac{\Delta VC}{\Delta q}. \]

- But in the short run,

\[ \Delta VC = w\Delta L \]

(can you tell why?)

- Therefore,

\[ MC = \frac{w\Delta L}{\Delta q} \]

- The additional output created by every additional unit of labor is:

\[ \frac{\Delta q}{\Delta L} = MPL \]

- Therefore,

\[ MC = \frac{w}{MPL} \]
Shape of the Average Cost Curves

\[ AVC = VC/q. \]

- But in the short-run, with only labor as an input:

\[ AVC = VC/q = wL/q \]

- And since \( q/L = APL_L \), then

\[ AVC = VC/q = w/APL_L \]
Application: Short-Run Cost Curves for a Furniture Manufacturer
Effects of Taxes on Costs

• Taxes applied to a firm shift some or all of the marginal and average cost curves.
Table 7.2 Effect of a Specific Tax of $10 per Unit on Short-Run Costs

<table>
<thead>
<tr>
<th>Q</th>
<th>AVC&lt;sub&gt;b&lt;/sub&gt;</th>
<th>AVC&lt;sub&gt;a&lt;/sub&gt; = AVC&lt;sub&gt;b&lt;/sub&gt; + $10</th>
<th>AC&lt;sub&gt;b&lt;/sub&gt; = C/q</th>
<th>AC&lt;sub&gt;a&lt;/sub&gt; = C/q + $10</th>
<th>MC&lt;sub&gt;b&lt;/sub&gt;</th>
<th>MC&lt;sub&gt;a&lt;/sub&gt; = MC&lt;sub&gt;b&lt;/sub&gt; + $10</th>
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</tbody>
</table>
Figure 7.3 Effect of a Specific Tax on Cost Curves

A $10.00 tax shifts both the AVC and MC by exactly $10…

\[ \text{MC}^a = \text{MC}^b + 10 \]
\[ \text{AC}^a = \text{AC}^b + 10 \]
Solved Problem 7.2

• What is the effect of a lump-sum franchise tax on the quantity at which a firm’s after-tax average cost curve reaches its minimum? (Assume that the firm’s before-tax average cost curve is U-shaped.)
Solved Problem 7.2

\[ AC^a = AC^b + \frac{L}{q} \]

where \( MC \) is the marginal cost curve, \( AC^a \) is the average cost curve for scenario \( a \), \( AC^b \) is the average cost curve for scenario \( b \), and \( q_b \) and \( q_a \) are the quantities produced in scenarios \( b \) and \( a \) respectively.
Give fish to a man, he eats it at once; teach him how to fish and he will feed himself forever

You have to learn to be independent thinkers – learn to work hard, read text books not only STUDY GUIDES, make notes and NOT BE SPOON-FED
Long-Run Costs

• Fixed costs are *avoidable* in the long run.
  - In the long run $F = 0$.
  - As a result, the long-run total cost equals:
    $$ C = VC $$
Input Choice

• **Isocost line** - all the combinations of inputs that require the same \( (iso-) \) total expenditure (\( cost \)).

• The firm’s total cost equation is:

\[
C = wL + rK.
\]

![Diagram showing labor and capital costs](image-url)
Input Choice (cont.)

• The firm’s total cost equation is:

\[ C = wL + rK. \]

- We get the Isocost equation by setting fixing the costs at a particular level:

\[ \bar{C} = wL + rK. \]

- And then solving for \( K \) (variable along \( y \)-axis):

\[ K = \frac{\bar{C}}{r} - \frac{w}{r} L \]
Table 7.3 Bundles of Labor and Capital That Cost the Firm $100

<table>
<thead>
<tr>
<th>Bundle</th>
<th>Labor, $L$</th>
<th>Capital, $K$</th>
<th>Labor Cost, $wL = 5L$</th>
<th>Capital Cost, $rK = 10K$</th>
<th>Total Cost, $wL + rK$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a$</td>
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<td>0</td>
<td>$100</td>
<td>$0</td>
<td>$100</td>
</tr>
<tr>
<td>$b$</td>
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<td>3</td>
<td>$70</td>
<td>$30</td>
<td>$100</td>
</tr>
<tr>
<td>$c$</td>
<td>10</td>
<td>5</td>
<td>$50</td>
<td>$50</td>
<td>$100</td>
</tr>
<tr>
<td>$d$</td>
<td>6</td>
<td>7</td>
<td>$30</td>
<td>$70</td>
<td>$100</td>
</tr>
<tr>
<td>$e$</td>
<td>0</td>
<td>10</td>
<td>$0</td>
<td>$100</td>
<td>$100</td>
</tr>
</tbody>
</table>
Figure 7.4 A Family of Isocost Lines

For each extra unit of capital it uses, the firm must use two fewer units of labor to hold its cost constant.

Isocost Equation

\[ K = \frac{\bar{C}}{r} - \frac{w}{r}L \]

Initial Values

\[ \bar{C} = $100 \]
\[ w = $5 \]
\[ r = $10 \]

Slope = \(-\frac{1}{2} = \frac{w}{r}\)
Your test

• It shall be marked out of 50
  19 multiple choice questions
  31 marks from structured questions
• Total time will be 2 hours

• Do not bring any paper – you will write on the question papers and hand them in after the test

• You MUST work hard and pass the test

• Missing the test without prior arrangement will result in a mark of ZERO being recorded, and I SHALL NOT ENTERTAIN ANY DISCUSSION ABOUT THIS.
**Figure 7.4 A Family of Isocost Lines**

**Isocost Equation**

\[ K = \frac{\bar{C}}{r} - \frac{w}{r} L \]

**Initial Values**

- \( \bar{C} = $150 \)
- \( w = $5 \)
- \( r = $10 \)

An increase in \( C \)….
**Figure 7.4 A Family of Isocost Lines**

**Isocost Equation**

\[
K = \frac{\bar{C}}{r} - \frac{w}{r} L
\]

**Initial Values**

\[
\bar{C} = $50 \quad w = $5 \quad r = $10
\]

A decrease in \( \bar{C} \)....

Isocost Equation

K = \frac{\bar{C}}{r} - \frac{w}{r} L

Initial Values

\[
\bar{C} = $50 \quad w = $5 \quad r = $10
\]
Combining Cost and Production Information

• The firm can choose any of three equivalent approaches to minimize its cost:

  - **Lowest-isocost rule** - pick the bundle of inputs where the lowest isocost line touches the isoquant.

  - **Tangency rule** - pick the bundle of inputs where the isoquant is tangent to the isocost line.

  - **Last-dollar rule** - pick the bundle of inputs where the last dollar spent on one input gives as much extra output as the last dollar spent on any other input.
Figure 7.5 Cost Minimization

Which of these three isocosts would allow the firm to produce the 100 units of output at the lowest possible cost?

Isocost Equation

\[ K = \frac{C}{r} - \frac{w}{r} L \]

Isoquant Slope

\[-\frac{MP_L}{MP_K} = MRTS\]

Initial Values

\[ q = 100 \]

\[ w = $24 \]

\[ r = $8 \]
Figure 7.5 Cost Minimization

Isocost Equation

\[ K = \frac{\bar{C}}{r} - \frac{w}{r} L \]

Isoquant Slope

\[ -\frac{\frac{MP_L}{MP_K}}{MRTS} \]

Initial Values

\[ q = 100 \]
\[ \bar{C} = $2,000 \]
\[ w = $24 \]
\[ r = $8 \]
Cost Minimization

• At the point of tangency, the slope of the isoquant equals the slope of the isocost. Therefore,

\[ MRTS = -\frac{w}{r} \]

\[ MRTS = -\frac{MP_L}{MP_K} \]

\[ \frac{MP_L}{MP_K} = \frac{w}{r} \]

\[ \frac{MP_L}{w} = \frac{MP_K}{r} \]

*last-dollar rule*: cost is minimized if inputs are chosen so that the last dollar spent on labor adds as much extra output as the last dollar spent on capital.
Figure 7.5 Cost Minimization

Initial Values

\[ q = 100 \]
\[ \overline{C} = \$2,000 \]
\[ w = \$24 \]
\[ r = \$8 \]

\[ MP_L = 0.6q/L \]
\[ MP_K = 0.4q/K \]

\[
\frac{MP_L}{w} = \frac{MP_K}{r} = \frac{1.2}{24} = \frac{0.4}{8} = 0.05
\]

Spending one more dollar on labor at \( x \) gets the firm as much extra output as spending the same amount on capital.
Figure 7.5 Cost Minimization

Initial Values

\[ q = 100 \]
\[ C = \$2,000 \]
\[ w = \$24 \]
\[ r = \$8 \]

\[ MP_L = 0.6q/L \]
\[ MP_K = 0.4q/K \]

\[ \frac{MP_L}{w} = \frac{2.5}{24} = 0.1 \]
\[ \frac{MP_K}{r} = \frac{0.13}{8} = 0.017 \]
Figure 7.6 Change in Factor Price

Minimizing Cost Rule

\[
\frac{MP_L}{w} = \frac{MP_K}{r}
\]

Initial Values

\[
\begin{align*}
q &= 100 \\
C &= $2,000 \\
w &= $24 \\
r &= $8 \\
w_2 &= $8 \\
C_2 &= $1,032
\end{align*}
\]

A decrease in w….
Solved Problem 7.3

- If it manufactures at home, a firm faces input prices for labor and capital of $w^\hat{}$ and $r^\hat{}$ and produces $q^\hat{}$ units of output using $L^\hat{}$ units of labor and $K^\hat{}$ units of capital. Abroad, the wage and cost of capital are half as much as at home. If the firm manufactures abroad, will it change the amount of labor and capital it uses to produce $q^\hat{}$? What happens to its cost of producing $q^\hat{}$?
Solved Problem 7.3

• Answer:
  - Determine whether the change in factor prices affects the slopes of the isoquant or the isocost lines.
  - Using a rule for cost minimization, determine whether the firm changes its input mix.
  - Calculate the original cost and the new cost and compare them.
How Long-Run Cost Varies with Output

- **Expansion path** - the cost-minimizing combination of labor and capital for each output level
Figure 7.7(a) Expansion Path and Long-Run Cost Curve

- Expansion path
- $4,000 isocost
- $3,000 isocost
- $2,000 isocost

Isoquants:
- q = 200
- q = 150
- q = 100

K, Units of capital per hour
L, Workers per hour

q = 100 Isoquant
q = 150 Isoquant
q = 200 Isoquant
Figure 7.7(b) Expansion Path and Long-Run Cost Curve
Solved Problem 7.4

• What is the long-run cost function for a fixed-proportions production function (Chapter 6) when it takes one unit of labor and one unit of capital to produce one unit of output? Describe the long-run cost curve.

• Answer:
  - Multiply the inputs by their prices, and sum to determine total cost.
The Shape of Long Run Cost Curves

- The shape of long run cost curves is determined by the production function relationship between output and inputs.
Figure 7.8 Long-Run Cost Curves

(a) Cost Curve

(b) Marginal and Average Cost Curves
Economies of Scale

- **Economies of scale** - property of a cost function whereby the average cost of production falls as output expands.

- **Diseconomies of scale** - property of a cost function whereby the average cost of production rises when output increases.
Table 7.4 Returns to Scale and Long-Run Costs

<table>
<thead>
<tr>
<th>Output, Q</th>
<th>Labor, L</th>
<th>Capital, K</th>
<th>Cost, $ ( C = wL + rK )</th>
<th>Average Cost, $ ( AC = C/q )</th>
<th>Returns to Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>12</td>
<td>12</td>
<td></td>
</tr>
<tr>
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<td>24</td>
<td>8</td>
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<td>48</td>
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<td>8</td>
<td>8</td>
<td>8</td>
<td>96</td>
<td>12</td>
<td>Decreasing</td>
</tr>
</tbody>
</table>

\( w = r = \$6 \) per unit.
Table 7.5 Shape of Average Cost Curves in Canadian Manufacturing

<table>
<thead>
<tr>
<th>Scale Economies</th>
<th>Share of Manufacturing Industries, %</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Economies of scale:</em> initially downward-sloping AC</td>
<td>57</td>
</tr>
<tr>
<td>Everywhere downward-sloping AC</td>
<td>18</td>
</tr>
<tr>
<td>L-shaped AC (downward-sloping, then flat)</td>
<td>31</td>
</tr>
<tr>
<td>U-shaped AC</td>
<td>8</td>
</tr>
<tr>
<td><em>No economies of scale:</em> flat AC</td>
<td>23</td>
</tr>
<tr>
<td><em>Diseconomies of scale:</em> upward-sloping AC</td>
<td>14</td>
</tr>
</tbody>
</table>

Lower Costs in the Long Run

- In its long-run planning, a firm chooses a plant size and makes other investments so as to minimize its long-run cost on the basis of how many units it produces.
  - Once it chooses its plant size and equipment, these inputs are fixed in the short run.
  - Thus, the firm’s long-run decision determines its short-run cost.
Figure 7.9 Long-Run Average Cost as the Envelope of Short-Run Average Cost Curves
Application: Long-Run Cost Curves in Furniture Manufacturing and Oil Pipelines
Application: Long-Run Cost Curves in Furniture Manufacturing and Oil Pipelines
Application: Choosing an Ink-Jet or a Laser Printer
Figure 7.10 Long-Run and Short-Run Expansion Paths
Learning by doing - the productive skills and knowledge that workers and managers gain from experience
Figure 7.11 Learning by Doing

(a) Learning by Doing on C-141 Aircraft

(b) Economies of Scale and Learning by Doing

Economies of scale

Learning by doing
Why Costs Fall over Time

• Technological or organizational progress may increase productivity.
• Operating at a larger scale in the long run may lower average costs due to increasing returns to scale.
• The firm’s workers and managers may become more proficient over time due to learning by doing.
Cost of Producing Multiple Goods

- **Economies of scope** - situation in which it is less expensive to produce goods jointly than separately.

\[ SC = \frac{C(q_1,0) + C(0, q_2) - C(q_1, q_2)}{C(q_1, q_2)} \]

- **Production possibility frontier** - the maximum amount of outputs that can be produced from a fixed amount of input.
Economies of scope ……

If the cost of producing the two goods separately (C(q1,0) and C(0, q2)) is the same as the cost of producing the two goods together, then SC = 0

If it is cheaper to produce the two goods jointly, then SC >0

If it is more expensive to produce the two goods jointly, then SC<0, i.e. diseconomies of scope
Figure 7.12 Joint Production
Figure 7.13 Technology Choice

Diagram showing the technology choice with isocost lines and isonquant of 200 ten-layer chips per day.