Economics 101 – Section 5
Lecture #14 – March 2, 2004
Production – long run production

Overview

- Recap of short run production
- What happens when all inputs are variable?
  - Large capital investments are not fixed in the long run
- Next lecture will start into the firms problem
  - Profit maximization
    - Marginal revenue and marginal cost together
Basics from last class

- In the short-run at least one input is variable, in the long-run all inputs are variable
- Fixed inputs
  - Inputs whose quantities do not change as output is varied are called fixed inputs

### Short-Run Production at Spotless Car Wash

<table>
<thead>
<tr>
<th>Quantity of Capital</th>
<th>Quantity of Labor</th>
<th>Total Product (Cars Washed per Day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>90</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>130</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>161</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
<td>184</td>
</tr>
<tr>
<td>1</td>
<td>6</td>
<td>196</td>
</tr>
</tbody>
</table>
Basics from last class

- In the short-run must incur fixed costs even if you do not produce anything
  - Pay rent even if you don’t use the building
  - Make payments on the factory even if it is not in use

<table>
<thead>
<tr>
<th>Output (per Day)</th>
<th>Capital</th>
<th>Labor</th>
<th>TFC</th>
<th>TVC</th>
<th>TC</th>
<th>MC</th>
<th>AFC</th>
<th>AVC</th>
<th>ATC</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
<td>$75</td>
<td>$75</td>
<td>$75</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>1</td>
<td>1</td>
<td>$75</td>
<td>$60</td>
<td>$135</td>
<td>2.50</td>
<td>$2.00</td>
<td>$4.50</td>
<td>$1.00</td>
</tr>
<tr>
<td>90</td>
<td>1</td>
<td>2</td>
<td>$75</td>
<td>$120</td>
<td>$195</td>
<td>0.83</td>
<td>$1.33</td>
<td>$2.17</td>
<td>$1.50</td>
</tr>
<tr>
<td>130</td>
<td>1</td>
<td>3</td>
<td>$75</td>
<td>$180</td>
<td>$255</td>
<td>0.58</td>
<td>$1.38</td>
<td>$1.96</td>
<td>$1.94</td>
</tr>
<tr>
<td>161</td>
<td>1</td>
<td>4</td>
<td>$75</td>
<td>$240</td>
<td>$315</td>
<td>0.48</td>
<td>$1.49</td>
<td>$1.96</td>
<td>$2.61</td>
</tr>
<tr>
<td>184</td>
<td>1</td>
<td>5</td>
<td>$75</td>
<td>$300</td>
<td>$375</td>
<td>0.44</td>
<td>$1.63</td>
<td>$2.04</td>
<td>$5.00</td>
</tr>
<tr>
<td>196</td>
<td>1</td>
<td>6</td>
<td>$75</td>
<td>$360</td>
<td>$435</td>
<td>0.41</td>
<td>$1.84</td>
<td>$2.22</td>
<td>$5.41</td>
</tr>
</tbody>
</table>
Production in the long-run

- In the long run all inputs are variable
- How long is “long-run”?
  - 6 months
  - A year
  - Five years
  - 50 years
  - Until “we are all dead”
- The long run is sufficiently long enough so that all inputs used in production can be varied

- In the long-run there are no fixed inputs or fixed input costs
- All inputs and all costs are variable
- In the long-run the firm needs to decide what combination of inputs to use in producing any level of output
Production in the long-run

☐ How does the firm choose where to produce in the long-run?
  ■ To produce at any given level of output, the firm will choose the input mix with the lowest cost.

Production in the long-run

☐ Some definitions

☐ Long-run total cost (LRTC)
  ☐ Is the cost of producing each quantity of output when the least-cost input mix is chosen in the long-run

☐ Long-run average total cost (LRATC)
  ☐ Is the cost per unit of output in the long run when all inputs are variable

$$LRATC = \frac{LRTC}{Q}$$
Production in the long-run

- Recall from last class that to wash 196 cars cost $435 in total
  - In the short run the manager was restricted to using only one automated car washing line
- What if the manager could acquire more capital in the future? What would be the lowest cost alternative?

<table>
<thead>
<tr>
<th>Method</th>
<th>Quantity of Capital</th>
<th>Quantity of Labor</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0</td>
<td>9</td>
<td>$540</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>6</td>
<td>$435</td>
</tr>
<tr>
<td>C</td>
<td>2</td>
<td>4</td>
<td>$390</td>
</tr>
<tr>
<td>D</td>
<td>3</td>
<td>3</td>
<td>$405</td>
</tr>
</tbody>
</table>
Production in the long-run

- By looking at what amount of capital and labor used together will give the lowest cost we can come up with the long run cost schedule.
- With the existing technology, there is no way we could produce a given quantity at a lower total cost.

### Production in the long-run

<table>
<thead>
<tr>
<th>Output</th>
<th>LRT C</th>
<th>LRATC</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$0</td>
<td>–</td>
</tr>
<tr>
<td>30</td>
<td>$100</td>
<td>$3.33</td>
</tr>
<tr>
<td>90</td>
<td>$195</td>
<td>$2.17</td>
</tr>
<tr>
<td>130</td>
<td>$255</td>
<td>$1.96</td>
</tr>
<tr>
<td>161</td>
<td>$315</td>
<td>$1.96</td>
</tr>
<tr>
<td>184</td>
<td>$360</td>
<td>$1.96</td>
</tr>
<tr>
<td>196</td>
<td>$390</td>
<td>$1.99</td>
</tr>
<tr>
<td>250</td>
<td>$650</td>
<td>$2.60</td>
</tr>
<tr>
<td>300</td>
<td>$1,200</td>
<td>$4.00</td>
</tr>
</tbody>
</table>
Production in the long-run

- Some intuitive results from the long-run
  - The long-run cost of producing a given level of output can be less than or equal to, but never greater than, the short-run total cost
    - i.e. LRTC<=(short-run)TC
  - The long-run average cost of producing a given level of output can be less than or equal to, but never greater than the short-run average total cost
    - i.e. LRATC<=(short-run)ATC

Production in the long-run

- Why should these results be intuitive?
  - In the long-run you have production options you did not have in the short-run so greater freedom in choosing the input mix could never make you worse off
  - The LRATC will never be above any of the short-run TC curves
Production in the long-run

- In the short-run the firm can only move along the current ATC, but in the long-run can move along the LRATC by varying large capital investments like the number and size of the plant.
Production in the long-run

- Economies of scale
  - Economies of scale exist when you can double the inputs and more than double the amount of output
  - When doubling the inputs the firm costs will double but output is more than double
    - So long-run average total cost will decrease over regions where economies of scale exist

- Constant returns to scale
  - Doubling of all the inputs leads to a doubling of output

- Diseconomies of scale
  - Doubling all the inputs leads to less than a doubling of output
    - The LRATC will be upward sloping over regions of diseconomies of scale
Figure 8  The Shape of LRATC

- **Dollars**
  - $4.00
  - $3.00
  - $2.00
  - $1.00

- **Units of Output**
  - 0
  - 130
  - 184

- **LRATC**

- **Economies of Scale**
- **Constant Returns to Scale**
- **Diseconomies of Scale**