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

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
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

Production in the long-run

- 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.

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?

Production in the long-run

- Recall cost of capital is $75 and a worker is $60

<table>
<thead>
<tr>
<th>Method</th>
<th>Quantity of Capital</th>
<th>Quantity of Labor</th>
<th>Cost</th>
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<tbody>
<tr>
<td>A</td>
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<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>
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<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

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

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**Figure 8** The Shape of LRATC

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

<table>
<thead>
<tr>
<th>Units of Output</th>
<th>LRATC</th>
<th>Dollars</th>
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<tbody>
<tr>
<td>130</td>
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<tr>
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