Classnotes for chapter 13

Chapter 13:

- Very important
- Focuses on firms production and costs
- Examines firm behavior in more detail (previously we simply looked at the supply curve to understand firm behavior)
  ⇒ will give you a better understanding of what decision lie behind the supply curve

Ch. 14, 15, 16, 17 look at how revenue differs depending on industry structure

**Ch. 14:** Perfect competition  
**Ch. 15:** Monopoly  
**Ch. 16:** Oligopoly  
**Ch. 17:** Monopolistic competition
**Basic Question:** how does firm behavior differ when industry structure differs?

Industrial organization --- the study of how firms' decisions regarding prices and quantities depends on the market conditions they face

*Example from Mankiw of an industrial organization question ---*

There are many pizzerias in New Brunswick but only one cable television company.

How does this difference in the number of firms affect:

- prices in these markets?
- efficiency of these markets?

We will start by looking at costs....

Why? A firm’s costs are key determinant of production and pricing decisions.

**But first....**

**What is a firm?**
A firm is an institution that hires productive resources and that organizes those resources to produce and sell goods and services.

**What is the firm's goal?**
To maximize profits.

**What is a firm's profits?**
Starting point: **Profits** = Total revenue - Total costs

**Total revenue** = the amount that the firm receives for the sale of its output (easy to measure)

**Total costs** = the amount that the firm pays to buy inputs (easy to measure???)
What are costs?
(recall that economists always use the notion of opportunity cost)

For the firm, the opportunity cost of production is the value of the firm's best alternate use of its resources. (The cost of something is what you give up to get it.)

- Sometimes this is easy to measure (example - payments to workers)
- Sometimes this is hard to measure (example - foregone interest on investment funds)

It is useful to break costs into 2 groups:

**Explicit costs**
= input costs that can easily be measured (wages, rent)
= input costs that require an outlay of money by the firm

**Implicit costs**
= an opportunity cost
= a cost that is incurred but for which no actual payment may actually be made

A firm incurs an implicit cost when it:
- Uses its own capital (funds)
- Uses its owner's time or financial resources

**Example 1.** You are a journalism major.
Example 2. You graduate and open a restaurant.

Relevant information:

- Savings = $100,000
- You are offered a job for $80,000
- You rent a space in a building for $100,000 a year rent.
### Revenue and Costs

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Revenue</strong></td>
<td>$300,000</td>
<td>Accounting and Economic</td>
</tr>
<tr>
<td><strong>Costs:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wages</td>
<td>$120,000</td>
<td>Accounting and Economic Costs</td>
</tr>
<tr>
<td>Rent</td>
<td>$100,000</td>
<td>Accounting and Economic Costs</td>
</tr>
<tr>
<td>Ingredients</td>
<td>$ 50,000</td>
<td>Accounting and Economic Costs</td>
</tr>
<tr>
<td><strong>Total explicit costs</strong></td>
<td>$270,000</td>
<td></td>
</tr>
</tbody>
</table>

**Accounting profit** $300,000 - $270,000 = $30,000

**Implicit costs:**

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foregone wages</td>
<td>$80,000</td>
<td>Economic Cost</td>
</tr>
<tr>
<td>Foregone return on savings</td>
<td>$ 7,000</td>
<td>Economic Cost</td>
</tr>
<tr>
<td>(an assumption about return you would have earned on $100,000 if placed in a savings account)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total implicit costs</strong></td>
<td>$87,000</td>
<td>Economic Cost</td>
</tr>
</tbody>
</table>

**TOTAL COSTS** $87,000 + $270,000 = $357,000

**ECONOMIC PROFIT** $300,000 (revenues) - $357,000

(costs) = -$57,000 (a loss!)
To review:

Economic profit = Total revenue - explicit costs - implicit costs

Accounting profit = Total revenue - explicit costs

(Accountants keep track of the money that flows into and out of firms. Do not include implicit costs as a result.)
**Production and Costs**

What do firms do?

- They transform inputs into outputs.

- One way to represent the relationship between inputs and outputs is a production function: \( Q = F(K, L) \)

- \( F(K, L) \) is a production function. It shows how different amounts of capital and labor can be transformed into different amounts of output.

  \[
  \begin{align*}
  K & = \text{units of capital} \\
  L & = \text{units of labor} \\
  Q & = \text{units of output}
  \end{align*}
  \]

- The function will differ across firms. However, production functions have some attributes in common --- they will be crucially important.

**Short-run versus Long-run Costs**

K and L differ in the ease in which they can be changed (adjusted) by the firm.

- It is relatively easy to change L
- It takes longer (and is therefore relatively harder) to change K

**Short-run (SR):** period of time over which at least one input **can not** be changed.

**Long-run (LR):** period of time long enough so that all inputs can be changed.
Hiring inputs generates costs

Example: A company in the short-run. Suppose the company makes pizza.

We start by making a simplifying assumption. The size of the pizza company is fixed. The owner can only vary the quantity of pizzas produced by changing the number of workers.

\[ Q = \text{Pizzas per hour} \]

<table>
<thead>
<tr>
<th>( K )</th>
<th>( L )</th>
<th>( Q=F(K,L) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
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<tr>
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<td>4</td>
<td>5</td>
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<tr>
<td>4</td>
<td>6</td>
<td>15 1/2</td>
</tr>
</tbody>
</table>

\( K = \text{units of capital (number of pizza ovens)} \)
fixed since we are in the short-run

\( L = \text{units of labor (number of workers)} \)
a variable input
Marginal product of labor

\[ \text{MP} = \frac{\Delta Q}{\Delta \text{Input}} \]

\[ \text{MP} = \text{marginal product} \]

\[ = \text{the increase in output that arises from an additional unit of input} \]

\[ = \frac{\Delta Q}{\Delta \text{Input}} \]

\[ \text{MP}_L = \text{marginal product of labor} \]

\[ = \text{the increase in output that arises from an additional unit of labor} \]

\[ = \frac{\Delta Q}{\Delta L} \]

<table>
<thead>
<tr>
<th>K</th>
<th>L</th>
<th>Q=F(K,L)</th>
<th>MP_L</th>
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<td>15 1/2</td>
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</table>
Diminishing marginal product

$MP_L$ starts out small, grows, reaches maximum and then shrinks again (diminishing $MP_L$).

Definition: The property whereby the marginal product of an input declines as the quantity of the input increases.

Why? (Specialization)

We can see this graphically.

Draw the production function.

Put quantity of pizzas on y-axis (output = $Q$)
Put number of workers on the x-axis (input = $L$)

Note that the production function gets flatter as the number of workers hired increases. The slope gets smaller.

This reflects diminishing marginal product.
From Production Function to Total Cost Curve

Costs paid to the fixed inputs are called fixed costs.

Fixed costs = payments to fixed inputs = FC
= costs that do not vary with the quantity of output produced

Variable costs = payments to variable inputs = VC
= costs that do vary with the quantity of output produced

Total costs = fixed costs + variable costs = FC + VC

Suppose each unit of capital costs $50 ⇒ FC = 4 * ($50) = $200

<table>
<thead>
<tr>
<th>K</th>
<th>L</th>
<th>Q=F(K,L)</th>
<th>MP_L</th>
<th>FC</th>
<th>VC</th>
<th>TC</th>
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<td>$200</td>
<td>$120</td>
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Note: Fixed costs are the same no matter how many units of output are produced.

Adding variable costs.

Suppose each worker costs $20 per hour.

Note: VC are different from FC. As Q↑, VC↑. (Variable costs vary!)
Adding total costs

Notes:
1. As $Q \uparrow$, $TC \uparrow$
2. The change in total costs is always equal to the change in VC.

We can graph the TC curve (relation between quantity of output produced and total cost of production).

Put total cost on y-axis and quantity of output on x-axis.

Note that the TC curve gets steeper as quantity of output increases.

Why? Diminishing marginal product

<table>
<thead>
<tr>
<th>$K$</th>
<th>$L$</th>
<th>$Q$</th>
<th>$MP_L$</th>
<th>FC</th>
<th>VC</th>
<th>TC</th>
<th>AFC</th>
<th>AVC</th>
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<td>$280$</td>
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<td>$100$</td>
<td>$300$</td>
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<td>$200$</td>
<td>$120$</td>
<td>$320$</td>
<td>$12.90$</td>
<td>$7.74$</td>
</tr>
</tbody>
</table>

Average fixed costs $= \frac{FC}{Q} = AFC$

Note: As $Q \uparrow$, $AFC \downarrow$. Why?

Average variable costs $= \frac{VC}{Q} = AVC$
Note: AVC is different than AFC. Starts out big, falls to minimum, then ↑ again. Why?

Average total costs = \( \frac{TC}{Q} = \frac{FC}{Q} + \frac{VC}{Q} = AFC + AVC \)

Note: ATC inherits its shape from the AFC and AVC curves.

Starts big, shrinks, reaches a minimum and then increases again.

Why?

(cost spreading)

What is the significance of the bottom of the U-shape?

♦ It is the quantity of output that minimizes ATC

♦ It is sometimes called the efficient scale of the firm
Marginal Cost

Marginal cost = \frac{\Delta TC}{\Delta Q} = MC

MC answers the question, if Q increases how much does TC increase?

MC has same shape as AVC and ATC. Starts large, shrinks, then increases.

<table>
<thead>
<tr>
<th>K</th>
<th>L</th>
<th>Q</th>
<th>MP_L</th>
<th>FC</th>
<th>VC</th>
<th>TC</th>
<th>AFC</th>
<th>AVC</th>
<th>ATC</th>
<th>MC</th>
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<td>12.90</td>
<td>7.74</td>
<td>20.64</td>
<td>40</td>
</tr>
</tbody>
</table>
Thinking carefully about average costs versus variable costs.

Two questions:

Q: How much does it cost to make the typical sweater?

A: ATC or MC?

Q: How much does it cost to increase production by one sweater?

A: ATC or MC?

ATC tells us the cost of a typical unit of output if total cost is divided evenly over all units produced.

MC tells us the increase in total cost that arises from producing an additional unit of output.
The Shape of Cost Curves

We will see that:

• where ATC is at minimum it equals MC

• where AVC is at minimum it equals MC

Let's draw these graphs.

1. Draw ATC. It is U-shaped.

2. Draw AVC. It's minimum is to the left of ATC minimum. Why?

3. Draw MC. It also has U shape.

CRUCIAL - it goes through the minimum of the ATC and AVC curves.

Why?
The Marginal/Average Rule

If the marginal anything exceeds the average anything, the average will increase.

and

If the marginal anything is less than the average anything, the average will decrease.

**Example.** Think about grades. Say your GPA = 3.0

If the next grade (the marginal grade) is a 4.00 (A), then GPA ↑

If the next grade (the marginal grade) is a 2.00 (C), then GPA ↓

Same with MC and ATC. (Same with MC and AVC.)

*When MC is below ATC, ATC falls.*

*When MC is above ATC, ATC rises.*
**Long-run cost**

In the long run the firm can vary both the quantity of labor and the quantity of capital.

Now let's see how costs vary when K and L can both vary.

Let's use the example in the book now:

**Sidney's Sweater Shop**

<table>
<thead>
<tr>
<th>Labor (workers per day)</th>
<th>Output (sweaters per day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plant 1</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
</tr>
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<td>3</td>
<td>13</td>
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<td>4</td>
<td>15</td>
</tr>
<tr>
<td>5</td>
<td>16</td>
</tr>
</tbody>
</table>

**Knitting machines (number)**

|                     | 1 | 2 | 3 | 4 |

The table is a representation of Sidney's Sweater's production function.

\[
F(K,L) = Q
\]

\[
F(3,3) = 22
\]

\[
F(4,2) = ??
\]

\[
F(1,1) = ??
\]
Long-run versus short-run costs

Say labor costs $25 per worker per day
Say capital costs $25 per machine per day

<table>
<thead>
<tr>
<th>Labor</th>
<th>Plant 1</th>
<th>ATC</th>
<th>Plant 2</th>
<th>ATC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Q</td>
<td>TC</td>
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<td>Q</td>
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<tr>
<td>1</td>
<td>4</td>
<td>$25*1+$25=50</td>
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<td>100</td>
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<td>18</td>
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<table>
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<th>Plant 4</th>
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<tr>
<td>Knitting machines</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>4</td>
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</tbody>
</table>

We can graph the ATC curves.
Which one will Sidney operate on?

It depends on the plant size that Sidney chooses.
In the short-run, Sidney has to use whatever short-run curve he chose in the past.

How will Sidney choose which plant size?

It depends on the output he wants to produce.

Say he wants to produce 13 sweaters a day.

When $K = 1$, $ATC = 7.69 = TC/13$
When $K = 2$, $ATC = \text{between } 6.67 \text{ and } 7.50 = TC/13$
When $K = 3$, $ATC = 7.69 = TC/13$
When $K = 4$, $ATC > 8.33 = TC/13$

Sidney minimizes average total costs when $K = 2$. 
$\Rightarrow$ efficient plant size is 2 machines for producing 13 sweaters.
Notes:

1. When a firm is producing a given output at the least possible cost, it is operating on its long-run average cost curve.

2. As the firm moves along its long-run average cost curve, it is adjusting the size of the factory to the quantity of production.

3. The long-run ATC is flatter than the short-run ATC curves. And the short-run curves lie on or above the LR curve.

Why? These properties arise because of the greater flexibility firms have in the long-run. In essence, in the long-run, the firm gets to choose which short-run curve it wants to use. But in the short run, it has to use whatever short-run curve it chose in the past.

When Sidney wants to increase output from 10 to 13 sweaters, it must hire another worker and average total cost goes up due to diminishing MP of labor. But in the long run, Sidney can expand both the size of the factory and the workforce. It minimizes ATC when it hires between 2 and 3 workers and uses 2 knitting machines.

At any output level, the long-run ATC curve tells the firm the plant size and the quantity of labor to use to minimize costs. Once the plant size is chosen, the firm operates on the short-run cost curves that applies to the chosen plant size.

- For output up to 10 sweaters, ATC is lowest on ATC1
- For output from 10 to 18, ATC is lowest on ATC2
- For output from 18 to 24, ATC is lowest on ATC3
- For output from 24 and up, ATC is lowest on ATC4
- Putting the segments together gives the long-run ATC.
4. How long does it take the firm to get to the long run? The answer depends on the firm.

Mankiw suggests it can take a year or longer for a major manufacturing firm such as a car company to build a larger factory.

Takes much less time to increase capital for a lemonade stand (buy a larger pitcher!).
Economies and diseconomies of scale

When long-run ATC declines as output increases, there are said to be economies of scale.

Economies of scale: the property whereby long-run average total cost falls as the quantity of output increases.

When long-run ATC rises as output increases, there are said to be diseconomies of scale.

Diseconomies of scale: the property whereby long-run average total cost increases as the quantity of output increases.

When long-run ATC does not vary with the level of output, there are said to be constant returns to scale.

Constant returns to scale: the property whereby long-run average total cost stays the same as the quantity of output increases.

What might cause economics or diseconomies of scale?

• Specialization

• Coordination problems

Conclusion: Long-run ATC is falling at low levels of production because of increasing specialization and rising at high levels of production because of increasing coordination problems.