Lecture 2

The Production Process

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Economic Growth and Economic Fluctuations

Purpose of this Lecture

This lecture is NOT intended to give you a comprehensive understanding of firm behavior.

If you're interested in how economists model firm behavior, then take my course in Microeconomics.

The purpose is to provide you with a basic understanding of:

- marginal product of labor and marginal product of capital
  - why firms hire labor until the wage rate is equal to price times the marginal product of labor, i.e. $w = p \cdot MPL$
  - why firms hire capital until the rental rate on capital is equal to price times the marginal product of capital, i.e. $r = p \cdot MPK$
- assumption that firms make zero economic profit in the long-run if they face **constant returns to scale**

Intro to Firm Behavior

- **<u>production</u> – process by which inputs are combined, transformed, and turned into outputs**
- **<u>firm</u> – person or a group of people that produce a good or service to meet a perceived demand**
- **we'll assume that firms' goal is to <u>maximize</u> <u>profit</u>**

Perfect Competition

- **many firms, each small relative to overall size of the industry, producing homogenous** (virtually identical) **products**
- **no firm is large enough to have any control over price**
- **new competitors can freely enter and exit the market**

Competitive Firms are Price Takers

- **firms have no control over price**
- **price is determined by the market**

Firms' Basic Decisions

1. **How much of each input to demand**
2. **Which production technology to use**
3. **How much supply**

Short-Run vs. Long-Run

In the <u>short-run</u>, two conditions hold:

1. **firm is operating under a fixed scale of production – i.e. at least one input is held fixed** (ex. it may be optimal for a firm to buy new machinery, but it can't do so overnight)
2. **firms can neither enter nor exit an industry**

In the <u>long-run</u>:

- **there are no fixed factors of production, so firms can freely increase or decrease scale operation**
- **new firms can enter and existing firms can exit the industry**

Profit-Maximization

(economic) **profit = total revenue – total** (economic) **cost**

total revenue – **amount received from the sale of the product** (price times number of goods sold)

total (economic) **cost** – **the total of:**

1. **out of pocket costs** (ex. prices paid to each input)
2. **opportunity costs:**
   a. **normal rate of return on capital and**
   b. **opportunity cost of each factor of production** – ex. if an employee in my firm could earn $30,000 if he/she worked for another firm, then I'd have to pay him/her at least $30,000, otherwise he/she would leave. (In reality, you might work in your parents' firm and not be paid. In such a case, their firm's accounting profit would be higher than their firm's economic profit).

normal rate of return on capital – **rate of return that is just sufficient to keep investors satisfied** (ex. real interest rate on corporate bonds)

- **nearly the same as the real interest rate on risk-free government bonds for relatively risk-free firms**
- **higher for relatively more risky firms**

Production Process

optimal method of production minimizes cost

production technology – **relationship betw/n inputs & outputs**

- **labor-intensive technology relies heavily on labor instead of capital**
- **capital-intensive technology relies heavily on capital instead of labor**

production function – **units of total product as func. of units of inputs**

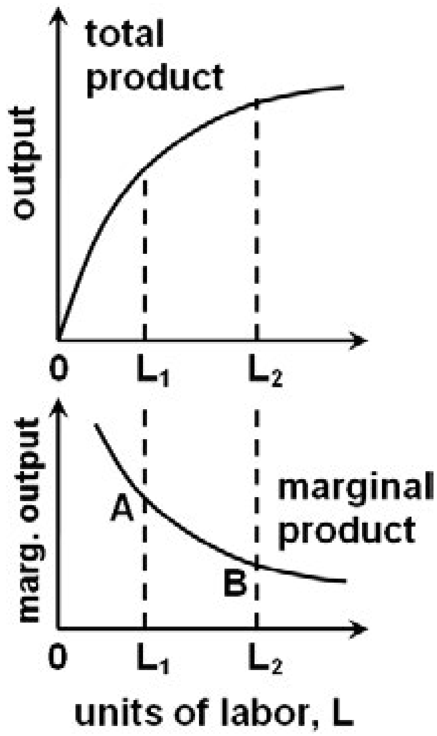
average product – **average amount produced by each unit of a variable factor of production (input)**

$$\text{avg. product of labor} = \frac{\text{total product}}{\text{total units of labor used}}$$

marginal product – **additional output produced by adding one more unit of a variable factor of production (input), ceteris paribus**

$$\text{marg. product of labor} = \frac{\Delta \text{ total product}}{\Delta \text{ units of labor used}}$$

Total and Marginal Product



diminishing marginal returns – **when additional units of a variable input are added to fixed inputs, the marginal product of the variable input declines**

marginal product is the slope of the total product function

at labor input L_1, the slope of the total product function is relatively higher than it is at L_2, so the marginal product of labor is higher at point A than it is at point B

in the case depicted, the marginal product of labor diminishes over entire range of labor input

Production with Two Inputs

Inputs often work together and are complementary.

- **Ex. cooks** (Labor) **and grills** (Capital)
- **If you hire more cooks, but don't add any more grills, the marginal product of labor falls** (too many cooks in the kitchen)
- **If you hire (rent) more grills, but don't add any more cooks, the marginal product of capital falls** (grills sit idle).

Given the technologies available, a profit-maximizing firm:

- **hires labor up to the point where the wage equals the price times the marginal product of labor (MPL)**
- **hires capital up to the point where the rental rate on capital equals the price times the marginal product of capital (MPK)**

$$\text{Profits } (\Pi) = \text{Total Revenue} - \text{Total Cost}$$
$$\Pi = p_X X(K,L) - wL - rK$$

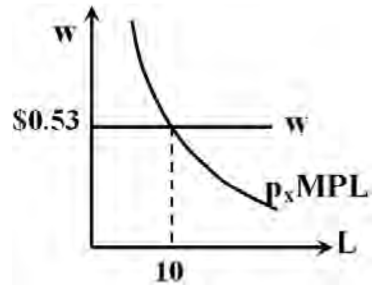
at profit maximum:

$$w = p_X MPL$$
$$r = p_X MPK$$

Profit Maximization with Two Inputs

- **In a perfectly competitive industry:**
  - **firms are price takers in both input output markets,**
  - **firms cannot affect the price of their product, nor can they affect the price of inputs** (wages, rental rate on capital)**.**
- **Assume that a firm produces X with capital and labor and that its production function is given by:**

$$X = K^{2/3} * L^{1/3}$$



- **Assume also that:**
  - **price of the firm's output is $1**
  - **wage rate and rental rate are both $0.53**
- **So its profits are given by:**

$$\Pi = p_x X - r*K - w*L$$
$$= \$1 * K^{2/3} * L^{1/3} - \$0.53*K - \$0.53*L$$

- **and firm should hire labor until** $w = p_X MPL$

Profit Maximization with Two Inputs

- **If the firm has 20 units of capital on hand** (this is the short-run)**:**
  - **how much labor should it hire?**
  - **how much should it produce?**
  - **how much profit will it make?**

Output of X	Capital	Labor	MPL
14.74	20	8	0.61
15.33	20	9	0.57
15.87	**20**	**10**	**0.53**
16.39	20	11	0.50
16.87	20	12	0.47

- **In the case depicted, the firm:**
  - **would hire 10 labor units**
  - **would produce 15.87 units of X**
  - **would make zero profit** … (I'm foreshadowing a little here)

$$\Pi^* = \$1*\mathbf{15.87} - \$0.53*20 - \$0.53*\mathbf{10} = \$0$$

- **Hiring more labor or less labor would lower profit:**

$$\Pi_8 = \$1*\mathbf{14.74} - \$0.53*20 - \$0.53*\mathbf{8} = -\$0.14$$
$$\Pi_9 = \$1*\mathbf{15.33} - \$0.53*20 - \$0.53*\mathbf{9} = -\$0.07$$

$$\Pi_{11} = \$1*\mathbf{16.39} - \$0.53*20 - \$0.53*\mathbf{11} = -\$0.03$$
$$\Pi_{12} = \$1*\mathbf{16.87} - \$0.53*20 - \$0.53*\mathbf{12} = -\$0.06$$

Costs in the Short Run

Fixed cost:

- **any cost that does not depend on the firm's level of output.** (The firm incurs these costs even if it doesn't produce any output).
- **firms have no control over fixed costs in the short run.** (For this reason, fixed costs are sometimes called sunk costs).
  - **obvious examples:** property taxes, loan payments, etc.
  - **not-so-obvious example:** firm must pay "rent" to hired capital. If that level of capital cannot be adjusted immediately ("fixed factor"), then rental payments are a fixed cost in the short-run

Variable cost:

- **depends on the level of production**
- **derived from production requirements and input prices**
  - **variable cost rises as output rises because firm has to hire more inputs** (capital and labor) **to produce larger quantities of output**
  - (in the Long Run all costs are variable)

Marginal Cost

Marginal cost:

- **increase in total cost from producing one more unit of output** (the additional cost of inputs required to produce each successive unit of output)
- **only reflects changes in variable costs**
  - fixed cost does not increase as output increases
  - marginal cost is the slope of both total cost and variable cost

Shape of the Marginal Cost Curve

In the short run, the firm is constrained by a fixed input, therefore:

1. **the firm faces diminishing returns to variable inputs and**
2. **the firm has limited capacity to produce output**

As the firm approaches that capacity it becomes increasingly costly to produce successively higher levels of output. Marginal costs ultimately increase with output in the short run.

Short-Run Average and Marginal Cost

- **If a firm's capital stock is fixed in the short-run, then the rental payments that the firm makes on its capital stock is a fixed cost.**
- **We can use that assumption to derive short-run average and marginal cost curves.**
- **So start by assuming that a firm's production function is given by:**

$$X=K^{2/3}L^{1/3}$$

- **Since the firm's capital stock is fixed** (by assumption) **we can solve the production function for labor to find the amount of labor needed to produce various levels of output:**

$$L=\frac{X^3}{K^2}$$

- **Its total costs are given by:**

$$TC=rK+wL$$

$$TC=rK+w\frac{X^3}{K^2}$$

Short-Run Average and Marginal Cost

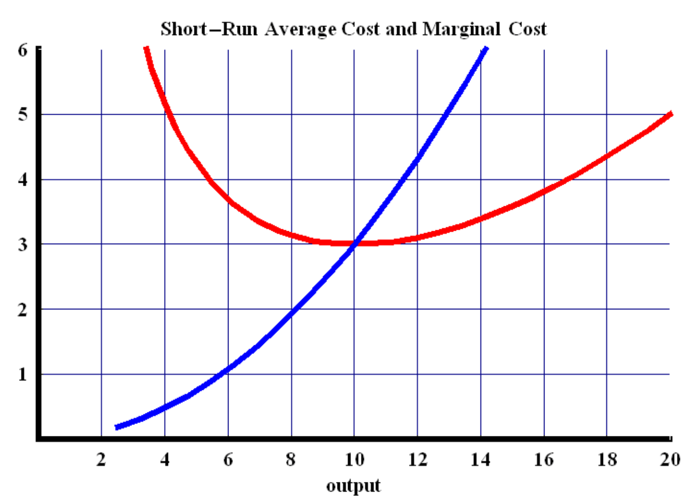
To find Short-Run Average Cost simply divide by Total Cost by X:

$$AC=\frac{TC}{X} \quad \Rightarrow \quad AC=\frac{rK}{X}+w\frac{X^2}{K^2}$$

To find Short-Run Marginal Cost take the derivative of Total Cost with respect to X:

$$MC\equiv\frac{d\,TC}{d\,X} \quad \Rightarrow \quad MC=3w\frac{X^2}{K^2}$$

So if the wage rate is \$1 per unit of labor, i.e. $w=\$1$**, and the rental rate is \$2 per unit of capital, i.e.** $r=\$2$**, and the firm has a capital stock of 10 units, then:**

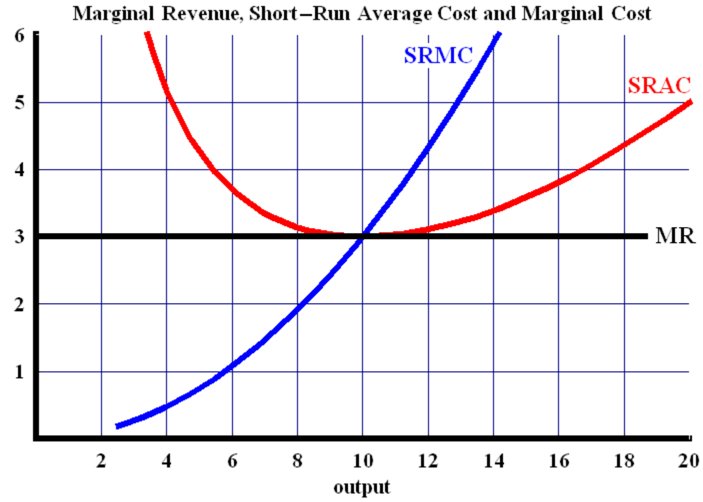


Revenue, Costs and Profit-Maximization

- **Total Revenue – amount that firm receives from sale of its output**
- **Marginal Revenue – additional revenue that a firm takes in when it increases output by one additional unit.**
- For example, if a firm is operating in a competitive industry – so that it has no ability to influence the market price – and if the market price is $3, then:

Comp. Firm's MR = p*

p	Q	TR	MR
3	0	0	3
3	1	3	3
3	2	6	3
3	3	9	3
3	4	12	3
3	5	15	3
3	6	18	3



- **Profit-maximizing level of output occurs where a firm's MR = MC**
- **Since MR = p*, it will produce up to the point where p* = MC**

But wait …

- **In the example above, the firm is making zero** (economic) **profit**
- **If it produces up to the point where p* = MC, then:**
  - **it will produce 10 units of output and**
  - **sell it at a price of $3, for total revenue of $30**
  - **but it's total costs will also be $30,**
    - **since at an output of 10 units, its average cost** (per unit) **is $3**
    - **and average cost times output equals total cost**
  - **so its total revenue equals its total cost**

Could a firm ever make positive (economic) **profit? Yes.**

- **If the price were higher** (say: $4)**, then it would make positive** (economic) **in the SHORT RUN, but**
- **in the LONG RUN new firms will enter the market and push down the market price until the firm's profit is zero**
- **It could also make positive** (economic) **profit if it's a monopoly**

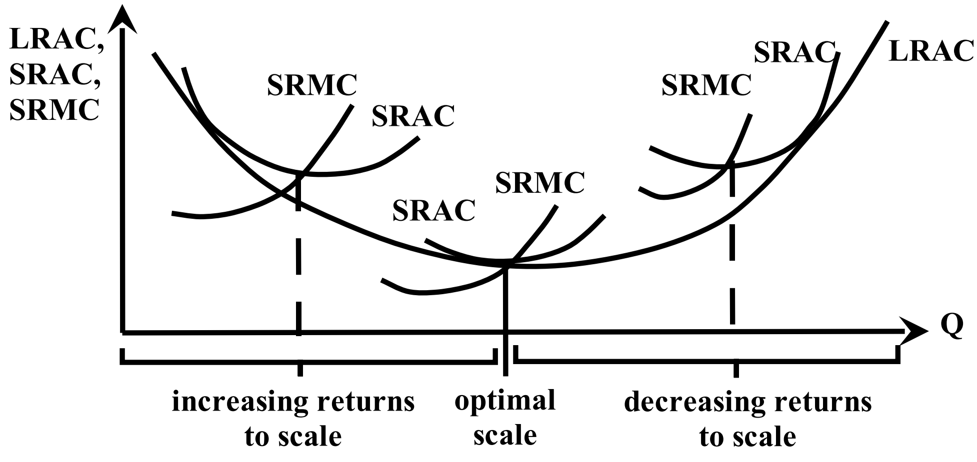
Long-Run Costs: Returns to Scale

- **In the SHORT RUN, firms have to decide how much to produce in the current scale of plant** (factory size is fixed).
- **In the LONG RUN firms, have to choose among many potential scales of plant** (they can expand the factory).

- **Increasing returns to scale** (or economies of scale), **refers to an increase in a firm's scale of production, which leads to lower average costs per unit produced.**
- **Constant returns to scale refers to an increase in a firm's scale of production, which has no effect on average costs per unit produced.**
- **Decreasing returns to scale** (or diseconomies of scale) **refers to an increase in a firm's scale of production, which leads to higher average costs per unit produced.**

Long-Run Average Cost Curve

- **The Long-Run Average Cost (LRAC) curve shows the different scales on which a firm can operate in the long-run. Each scale of operation defines a different short-run.**
- **The Long-Run Average Cost curve of a firm:**
  - **is downward-sloping when the firm exhibits increasing returns to scale.**
  - **is upward sloping when the firm exhibits decreasing returns to scale.**
- **The optimal scale of plant is the scale that minimizes long-run average cost.**

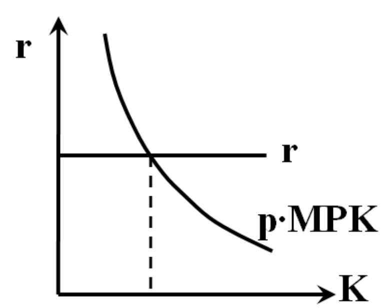


Returns to Scale

- **As mentioned previously, the only two cases where a firm can make positive profit is:**
  - if the firm is a monopoly
  - if there is not enough competition to drive the price down to the point where competitive firms make zero profit
- **Monopoly arises when the firm faces increasing returns to scale over the whole range of output**
  - So if the monopolist were to double his/her inputs of capital and labor, then his/her output would more than double
  - So his/her costs would double, but he/she would be able to sell more than two times the amount of output
- **The production process of a competitive firm faces exhibits constant returns to scale**
  - So if the firm were to double its inputs of capital and labor, then its output would exactly than double
  - So its costs would double and it would be able to sell exactly two times the amount of output

Factor Demand in the Long Run

- **When we derived the firm's short-run marginal and average cost functions, we assumed that the firm was operating under a fixed scale of production.**
- **Specifically, we assumed that the firm's capital stock was held fixed.**
- **So when we derived the condition for profit-maximization, we focused on the condition that:**
  - the firm hires labor up to the point where the wage equals the price times the marginal product of labor (MPL): $w = p \cdot MPL$
- **In the long run, the other condition must also hold:**
  - firm hires capital up to the point where the rental rate on capital equals the price times the marginal product of capital (MPK): $r = p \cdot MPK$



Zero Profit in the Long Run

Now let's bring it all together.

- **Firm's profit is given by:** $\Pi = p \cdot K^{2/3} \cdot L^{1/3} - r \cdot K - w \cdot L$
- **Firm's factor demands are given by:** $r = p \cdot MPK$ **and** $w = p \cdot MPL$
- **Using the calculus tricks that you learned:**
  - $MPK = \frac{2}{3} \cdot K^{-1/3} \cdot L^{1/3}$ **and** $MPL = \frac{1}{3} \cdot K^{2/3} \cdot L^{-2/3}$
- **Plugging the factor demands into the profit function:**

$$\Pi = p \cdot K^{2/3} \cdot L^{1/3} - \left(p \cdot \frac{2}{3} \cdot K^{-1/3} \cdot L^{1/3}\right) \cdot K - \left(p \cdot \frac{1}{3} \cdot K^{2/3} \cdot L^{-2/3}\right) \cdot L$$

$$= p \cdot \left(K^{2/3} \cdot L^{1/3}\right) - \frac{2}{3} \cdot p \cdot \left(K^{2/3} \cdot L^{1/3}\right) - \frac{1}{3} \cdot p \cdot \left(K^{2/3} \cdot L^{1/3}\right) = 0$$

Zero Profit in the Long Run

So what does this mean?

- **If the firm operates in a competitive industry**
  - **with a large number of firms**
  - **so that it cannot affect market prices**
- **if the firm's production process exhibits constant returns to scale, and**
- **if the firm varies capital and labor optimally, in order to maximize** (economic) **profit, then**

- **its <u>maximum</u>** (economic) **profit will be zero in the long run**
- **even though it is producing at the lowest possible cost per unit of output** (lowest possible average cost)