ECO5002 Introduction to Economics

Lecture 5: Firm Behavior and the Organization of Industry

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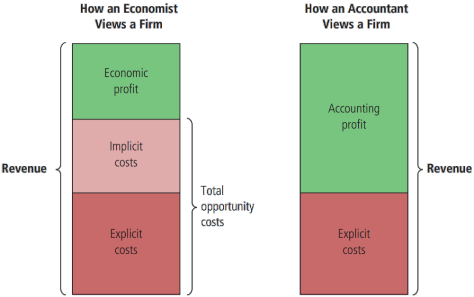
I. The Costs of Production

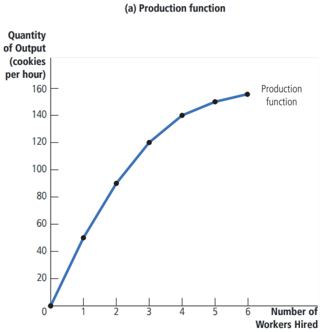
Basic concepts:

- **Total Revenue (TR):** the amount a firm receives for the sale of its output.
- **Total Cost (TC):** the market value of the inputs a firm uses in production. (recall opportunity costs)
- **Profit:** total revenue - total cost



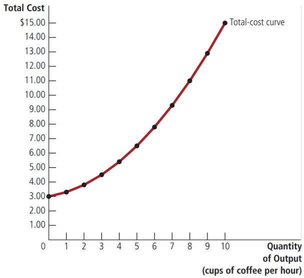
I. The Costs of Production

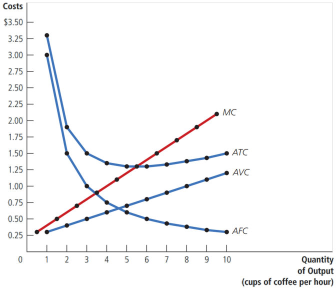
- **Production Function:** the relationship between the quantity of inputs used to make a good and the quantity of output of that good, e.g., $y = f(x_1, x_2)$.
- **Marginal Product:** the increase in output that arises from an additional unit of input, e.g., $\frac{\partial y}{\partial x_1}$ or $\frac{\partial y}{\partial x_2}$.
  - diminishing marginal product: the property whereby the marginal product of an input declines as the quantity of the input increases.
- An example:



I. The Costs of Production

- Fixed costs v.s. Variable costs
  - costs that do not vary with the quantity of output produced.
  - costs that vary with the quantity of output produced.
- Average Costs:
  - avg. total cost (ATC): total cost divided by the quantity of output.
  - avg. fixed cost (AFC): fixed cost divided by the quantity of output.
  - avg. variable cost (AVC): variable cost divided by the quantity of output.
  - marginal cost (MC): the increase in total cost that arises from an extra unit of production.





I. The Costs of Production

Three findings:

- Marginal cost (MC) rises with the quantity of output.
  - due to diminishing marginal product.
  - not always true. (U-shaped)
- The average-total-cost (ATC) curve is U-shaped.
  - increasing AVC due to diminishing marginal product.
  - decreasing AFC.
  - the minimum point is called **efficient scale**.
- The marginal-cost (MC) curve crosses the average-total-cost (ATC) curve at the minimum of average total cost.

$$ATC(Q) = \frac{TC(Q)}{Q}$$

$$\frac{\partial ATC(Q)}{\partial Q} = \frac{MC(Q)Q - TC(Q)}{Q^2} = 0$$

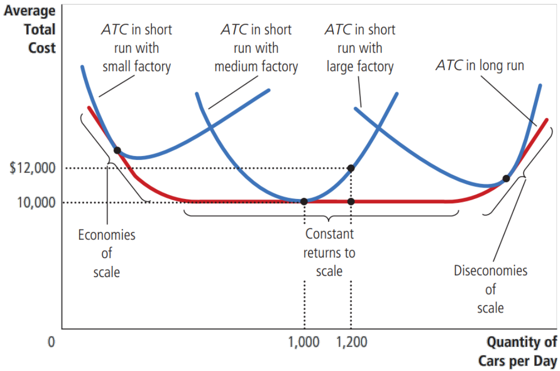
$$MC(Q) = \frac{TC(Q)}{Q} = ATC(Q)$$

I. The Costs of Production

- Short-run Cost v.s. Long-run Cost
  - In the "long-run", every cost is variable cost.
  - short-run: $TC(Q) = VC(Q) + FC$.
  - long-run: $TC(Q) = VC(Q) + FC(Q)$.
- Let's use the following notations (y-output; k-size):
  - short-run cost: $c_s(y, k)$, where k is fixed.
  - long-run cost: $c(y)$, and there is an optimal size $k(y)$ for producing y.
  - the long-run cost function is just the short-run cost function evaluated at the optimal choice of the fixed factors: $c(y) = c_s(y, k(y))$.
- Suppose a level of output: y^*, and hence $k^* = k(y^*)$.
  - short-run cost: $c_s(y, k^*)$; long-run cost: $c(y) = c_s(y, k(y))$.
  - (1) the short-run cost to produce y must always be at least as large as the long-run cost to produce y: $c(y) \leq c_s(y, k^*)$.
  - (2) at one particular level of y, namely y^*, there must be $c(y^*) = c_s(y^*, k^*)$.
- The short-run average cost curve must be tangent to the long-run average cost curve.

I. The Costs of Production

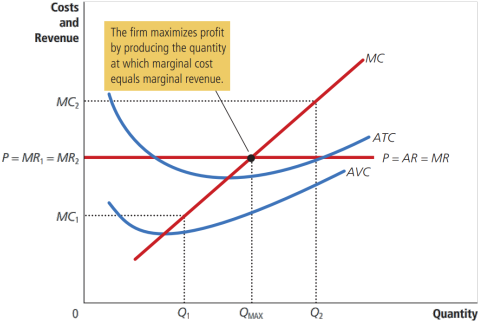
- The long-run average cost curve is the **lower envelope** of the short-run average cost curves.



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

II. Firms in Competitive Markets

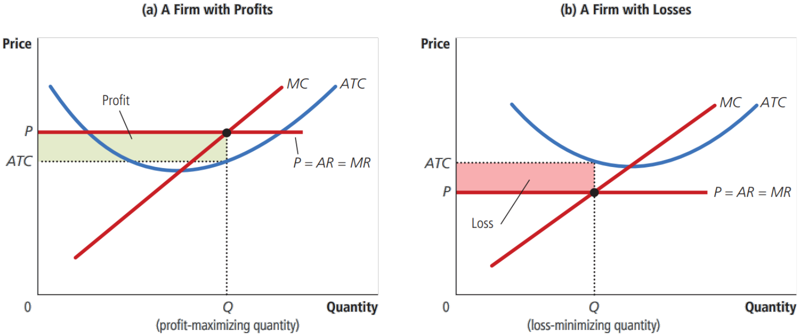
- How about revenue?
  - Total revenue: $TR(Q) = P \times Q$ (take P as given)
  - Marginal revenue: $MR(Q) = \frac{\partial TR(Q)}{\partial Q} = P$
  - Average revenue: $AR(Q) = \frac{TR(Q)}{Q} = P$
  - Thus, AR = MR = P.
- Profit maximization: $\max_Q TR(Q) - TC(Q)$.
  - FOC gives us: $MR(Q) = MC(Q) = P$.



II. Firms in Competitive Markets

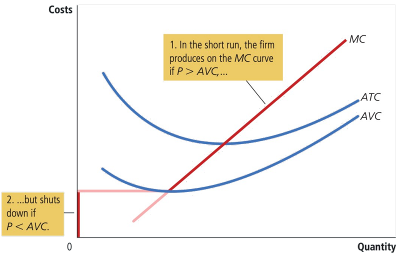
- Plot the profit:

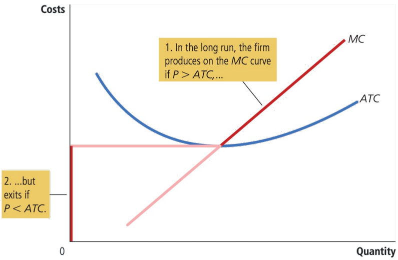
$$\Pi(Q) = TR(Q) - TC(Q)$$
$$= P \cdot Q - ATC(Q) \cdot Q$$



II. Firms in Competitive Markets

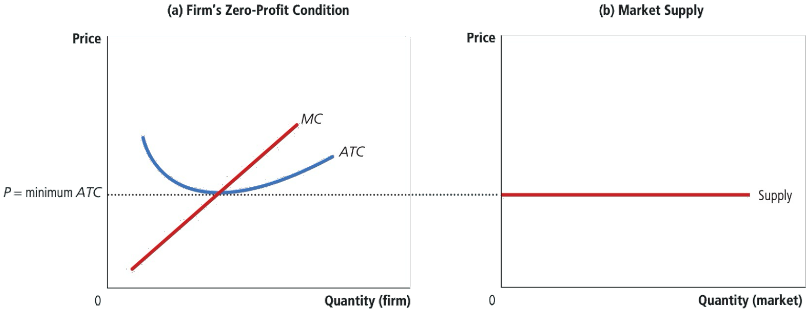
- The firm's short-run/long-run decision to shut down:
  - the firm shuts down if the revenue that it would earn from producing is less than its variable costs of production: $P < AVC$. (fixed cost $=$ sunk)
  - the firm exits the market if the revenue it would get from producing is less than its total cost: $P < ATC$.
- Supply curve of a single firm:





II. Firms in Competitive Markets

- How about the market supply curve?
  - short-run: the number of firms in the market is fixed. the market supply curve is just an aggregation of individual firms' supply curve. (upward-sloping)
  - long-run: firms will enter or exit the market until profit is driven to zero. the supply curve is horizontal.



III. Monopoly

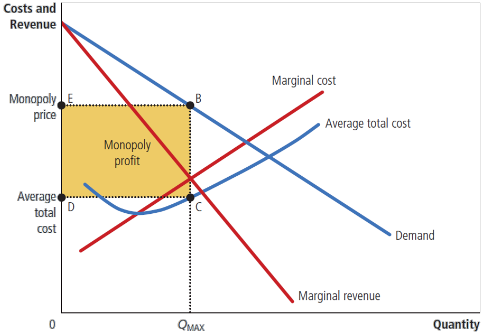
- A firm is a **monopoly** if it is the sole seller of its product and if its product does not have any close substitutes.
  - fundamental cause: barriers to entry.
  - (i) monopoly resources (ii) regulation (iii) production process.
  - an industry is a natural monopoly when a single firm can supply a good or service to an entire market at a lower cost than could two or more firms. (ATC declines = economies of scale)
- A Monopolist can influence the price of its product.
- A Monopolist faces a downward sloping demand curve.
- Profit maximization: $\max_Q P(Q) \cdot Q - TC(Q)$.
  - where $P(Q)$ is the demand function (= also average revenue).
  - FOC gives the following condition:

$$MR(Q) = \frac{\partial P(Q)}{\partial Q} Q + P(Q) = MC(Q)$$

since $\frac{\partial P(Q)}{\partial Q} < 0$ normally, $MR(Q) < P(Q)$.

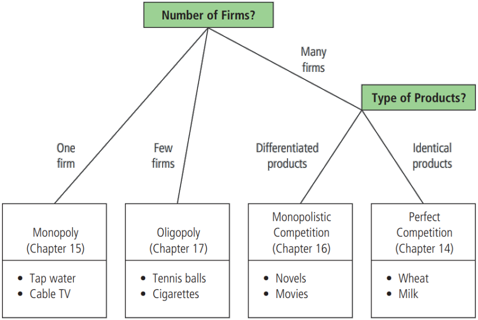
III. Monopoly

- Monopoly price is higher than the marginal cost (MC).
- So that a monopolist can earn strictly positive profit.
  - $(P - ATC) \times Q$
- The socially efficient quantity is found where the demand curve and the marginal-cost curve intersect. Monopoly can generate dead-weight loss.

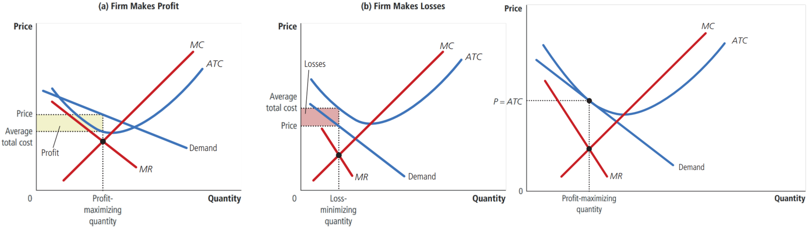


IV. Monopolistic Competition and Oligopoly

- **Monopolistic competition**: a market structure in which many firms sell products that are similar but not identical.
- **Oligopoly**: a market structure in which only a few sellers offer similar or identical products.



IV. Monopolistic Competition and Oligopoly



- Short-run: some make profit; while others make loss.
- Long-run: new firms enter if firms are making profit, causing the demand curves for the incumbent firms to shift to the left; some firms exit the market if firms are making losses, causing the demand curves shift to the right. Eventually, price equals ATC, and each firm earns zero profit.

Modeling Monopolistic Competition.

- Suppose that there is a final good that is a combination of many intermediate goods (continuum on $[0, 1]$).

$$Y = \left(\int_0^1 y(i)^{\frac{\varepsilon - 1}{\varepsilon}} \mathrm{d}i \right)^{\frac{\varepsilon}{\varepsilon - 1}}, \quad \varepsilon > 0,$$

  where $y(i)$ denotes an intermediate good produced by intermediate good producer i. The price of the final good is P. Each intermediate good has a nominal price $p(i)$.
- What is the demand function for product $y(i)$?

$$y(i) = \left(\frac{p(i)}{P} \right)^{-\varepsilon} Y.$$

Modeling Monopolistic Competition.

- Each intermediate good producer i has the monopolistic power to set $p(i)$ because different intermediate goods are not perfect substitutes ($\varepsilon < \infty$).
- Assume that the cost function of producing $y(i)$ is $C(y(i))$.
- Therefore, the partial equilibrium is determined by

$$p(i) = \frac{\varepsilon}{\varepsilon - 1} C^{'}(y(i)),$$

which means that MR $=$ Markup $\times$ MC.

IV. Monopolistic Competition and Oligopoly

- We use **game theory**, the study of how people behave in strategic situations, to deal with oligopoly.
- **Nash equilibrium**: a situation in which agents interacting with one another each choose their best strategy given the strategies that all the other actors have chosen.
- The Prisoners' Dilemma:

		Bonnie's Decision	
		Confess	**Remain Silent**
Clyde's Decision	**Confess**	Bonnie gets 8 years Clyde gets 8 years	Bonnie gets 20 years Clyde goes free
	Remain Silent	Bonnie goes free Clyde gets 20 years	Bonnie gets 1 year Clyde gets 1 year

IV. Monopolistic Competition and Oligopoly

Bertrand Model

- There are two homogeneous firms in the market. They have the same marginal cost, c. They choose the price simultaneously to compete with each other.
- What is the best response for firm 1 given p_2?

$$p_1^* = \begin{cases} c & \text{if} \quad p_2 \leq c \\ p_2 - \varepsilon & \text{if} \quad p_2 > c \end{cases},$$

where ε is a "very" small number.

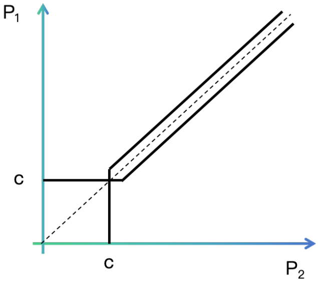
- Similarly, we have

$$p_2^* = \begin{cases} c & \text{if} \quad p_1 \leq c \\ p_1 - \varepsilon & \text{if} \quad p_1 > c \end{cases},$$

IV. Monopolistic Competition and Oligopoly

Bertrand Model

- The Nash equilibrium is given by:



- This is a price competition, and finally $p_1^* = p_2^* = c$.

Cournot Model

- There are two homogeneous firms in the market. They choose the quantity simultaneously to compete with each other.
- The cost function for each firm is $C(Q_i) = c \cdot Q_i$, $i \in \{1, 2\}$.
- Market demand is

$$P(Q_1 + Q_2) = a - Q_1 - Q_2.$$

- What is the best response function for firm 1 given Q_2?

$$Q_1^* = \frac{a - c - Q_2}{2}.$$

- Similarly, we have firm 2's best response given Q_1:

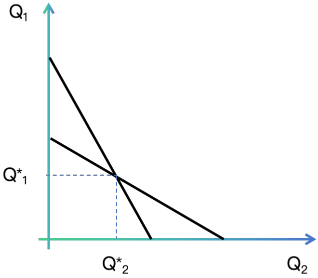
$$Q_2^* = \frac{a - c - Q_1}{2}.$$

IV. Monopolistic Competition and Oligopoly

Cournot Model

- The Nash equilibrium is given by:

$$Q_1^* = \frac{a - c - Q_2^*}{2}, \quad Q_2^* = \frac{a - c - Q_1^*}{2}.$$



- This is a quantity competition, and finally $Q_1^* = Q_2^* = \frac{a-c}{3}$.

Stackelberg Model

- 2-period model. Same assumptions as the Cournot model except that firms decide sequentially.
- In the first period the leader chooses its quantity. This decision is irreversible and cannot be changed in the second period.
- In the second period, the follower chooses its quantity after observing the quantity chosen by the leader.

IV. Monopolistic Competition and Oligopoly

Stackelberg Model

- We solve this problem by backward induction. First, think about the second period.
- The best response for firm 2 given Q_1 is

$$Q_2^* = \frac{a - c - Q_1}{2}.$$

- What about the first period? Firm 1 chooses Q_1 knowing that firm 2 will react to it in the second period according to its reaction function.
- The optimal quantity for firm 1 is

$$Q_1^* = \frac{a - c}{2} > \frac{a - c}{3}$$

Stackelberg Model

- Therefore, the optimal quantity for firm 2 is

$$Q_2^* = \frac{a-c}{4} < \frac{a-c}{3}$$

- The leader produces more. The leader has higher profits, there is an advantage of being the first to choose.
- The sequential game (Stackelberg) leads to a more competitive equilibrium than the simultaneous move game (Cournot).

Reading

- Chapter 13 $\sim$ 17, *Principles of Economics* by Mankiw.