Intermediate Microeconomics, Lecture 13

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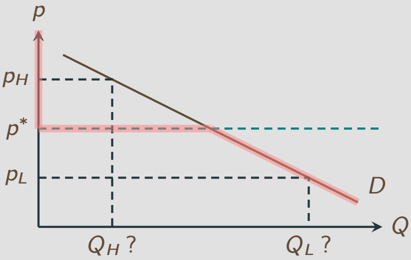
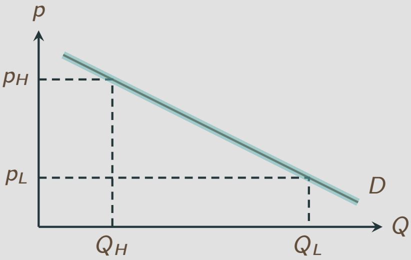
Monopoly: Definition, Feature, and Causes

- A **monopoly** is a *market structure* where a *single* seller or producer, called the *monopolist*, controls the entire supply of a particular good or service.
- A **monopoly** features *lack of competition*: unlike a competitive market, a monopolist can charge a high price without being undercut by other producers/sellers, which is often called the *market power*.



Competitive Firm



Monopolist

Main causes of monopoly

- Technology/resource dominance
- Large minimum efficient scale (natural monopoly)
- Legal barriers (like licensing, patents, copyrights, etc.)
- Colluding behavior between firms (merging, cartel, syndicate, edt.)

- An important economic influence of monopoly is through the monopolist's *pricing strategy*.
- Typically, a monopolist has much more freedom than a competitive firm in choosing its price because of its market power.
- A common categorization of monopoly pricing strategies:
  - *Linear pricing*: applying the same price to all consumers and each unit of the product;
  - *Non-linear pricing*: all pricing strategies that are not linear.
- In this course, we focus on the case of *single perishable good/service*.

Optimal Linear Pricing

Total revenue and marginal revenue

- The *total revenue* (TR) of a firm is the total income from all sales of its good before the deduction of any expenses.
- For a monopolist which faces a demand curve of $Q(p)$, by charging a price of p, its total revenue

$$TR(p) = pQ(p).$$

- Equivalently, if we treat Q as the variable and let $P(Q)$ be the *inverse demand function*, the total revenue

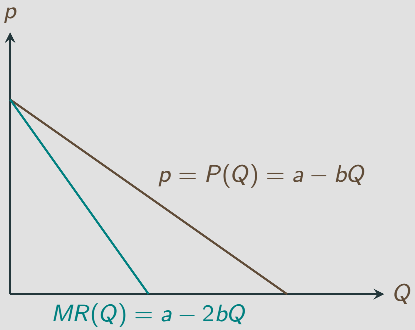
$$TR(Q) = P(Q)Q.$$

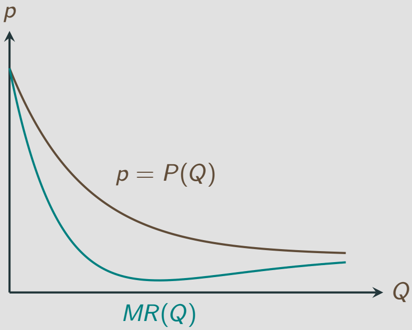
- *Marginal revenue*: Change rate of revenue

$$MR(p) = \frac{\mathrm{d}TR(p)}{\mathrm{d}p} = Q(p) + pQ'(p),$$

$$MR(Q) = \frac{\mathrm{d}TR(Q)}{\mathrm{d}Q} = P(Q) + QP'(Q) \quad \text{(conventional MR)}$$

- Observe that the marginal revenue curve is dominated by the demand curve.


p
$p = P(Q) = a - bQ$
Q
$MR(Q) = a - 2bQ$


p
$p = P(Q)$
Q
$MR(Q)$

Optimal price: MR = MC rule

- **Treating p as the choice variable:**
  - The monopolist's profits is $\pi(p) = TR(p) - C(Q(p)) = pQ(p) - C(Q(p))$.
  - Differentiating with respect to p and let p^m be the optimal price, we have the FOC:

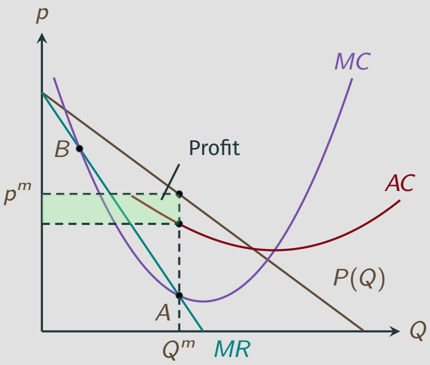
$$\frac{d\pi(p)}{dp}\bigg|_{p=p^m} = \underbrace{\frac{dTR(p)}{dp}\bigg|_{p=p^m}}_{MR(p^m)} - \underbrace{\frac{dC(Q(p))}{dp}\bigg|_{p=p^m}}_{MC(p^m)} = Q(p^m) + p^m Q'(p^m) - C'(Q(p^m))Q'(p^m) = 0$$

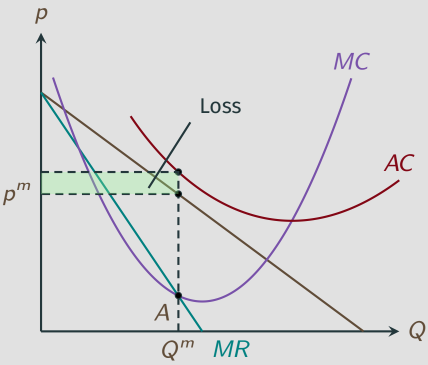
$$\Rightarrow \quad p^m = C'(Q(p^m)) - \frac{Q(p^m)}{Q'(p^m)}, \text{ where } Q(p^m) \text{ is the optimal output level.}$$

- **Treating Q as the choice variable:**
  - The monopolist's profit is $\pi(Q) = TR(Q) - C(Q) = P(Q)Q - C(Q)$.
  - The FOC is (Q^m being the optimal output level)

$$\frac{d\pi(Q)}{dQ}\bigg|_{Q=Q^m} = \underbrace{\frac{dTR(Q)}{dQ}\bigg|_{Q=Q^m}}_{MR(Q^m)} - \underbrace{\frac{dC(Q)}{dQ}\bigg|_{Q=Q^m}}_{MC(Q^m)} = P'(Q^m)Q^m + P(Q^m) - C'(Q^m) = 0$$

$$\Rightarrow \quad p^m = P(Q^m) = C'(Q^m) - P'(Q^m)Q^m$$


p
MC
Profit
B
p^m
AC
$P(Q)$
A
Q
Q^m
MR


p
MC
Loss
AC
p^m
A
Q
Q^m
MR

- The monopolistic price is higher than the marginal cost:

$$p^m - MC(Q(p^m)) = p^m - MC(Q^m) = p^m - C'(Q(p^m)) = -\frac{Q(p^m)}{Q'(p^m)} > 0.$$

In competitive market, $p^c = MC(Q^c)$: Monopolist has more "market power".

- The FOC can be written in another form (the *inverse elasticity rule*):

$$p^m - MC(Q^m) = -\frac{Q(p^m)}{Q'(p^m)} \quad \Rightarrow \quad \frac{p^m - MC(Q^m)}{p^m} = -\frac{Q(p^m)/p^m}{Q'(p^m)} = -\frac{1}{\varepsilon_{Dp}(p^m)} = \frac{1}{|\varepsilon_{Dp}(p^m)|}$$

  - **Observation:** (Q^m, p^m) must be located on the *elastic* portion of the demand curve if $MC > 0$.
  - The ratio (a *price markup*)

$$\frac{p^m - MC(Q^m)}{p^m} \in [0, 1]$$

   is called the *Lerner index*, a common measure of a firm's market power. A higher Lerner index means a bigger share of the price is not due to the production cost, and hence points to higher market power.

  - The Lerner index of each firm on a competitive market is 0.

  - The Lerner index is higher for less elastic demand, provided the same marginal cost.

Example

Suppose a monopolist faces the demand curve $Q(p) = 12 - p$ and has the cost function $C(Q) = 4Q - 1$.

- What is the optimal price the monopolist will charge? What is the quantity of the product the monopolist will produce and sell on the market?
- What is the Lerner index of the monopolist?

Solution.

- We have $TR(p) = Q(p) \cdot p = (12 - p)p$, and so $MR(p) = 12 - 2p$. Thus, using the FOC of optimality, we have $MR(p^m) = MC(12 - p^m) \cdot Q'(p^m)$, that is,

$$12 - 2p^m = -4,$$

  from which we can solve $p^m = 8$, and so $Q^m = Q(p^m) = 12 - 8 = 4$.

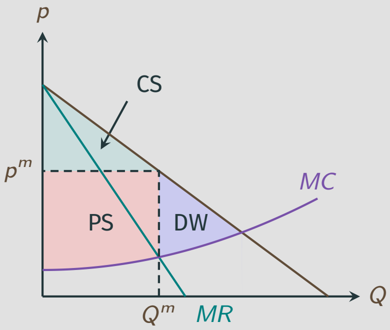
  Alternatively, we can treat Q as the choice variable. The inverse demand curve is $P(Q) = 12 - Q$, and so $TR(Q) = P(Q)Q = (12 - Q)Q$. Thus, $MR(Q) = 12 - 2Q$. Since $MC(Q) = 4$, the FOC implies that

$$12 - 2Q^m = 4,$$

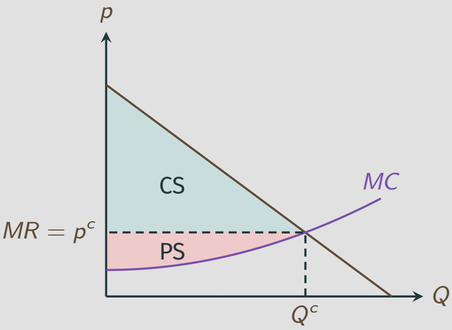
  from which we can solve $Q^m = 4$, $p^m = P(Q^m) = 12 - 4 = 8$.

- The Lerner index of the monopolist is

$$\frac{p^m - MC(Q^m)}{p^m} = \frac{8 - 4}{8} = \frac{1}{2} = 50\%.$$



Monopolistic market



Competitive market

- Monopoly causes a *deadweight loss* in social welfare because it produces too little (to maintain a high market price and benefit). Hence, the outcome is NOT *Pareto optimal/efficient* and features an *allocative inefficiency*.
- Monopoly also leads to a *redistribution* of social welfare: CS $\downarrow$, PS $\uparrow$.

Pros of Monopoly

Two typical argument for monopoly

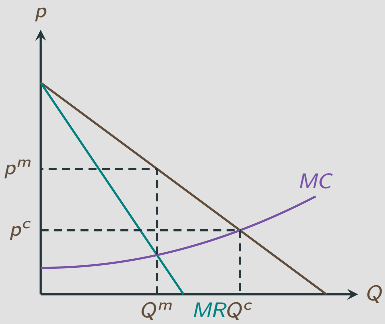
- *Production efficiency:* Monopoly can increase the efficiency of production if there is increasing returns to scale.

  Example: Networks (like pipeline of gas or water), where monopoly can avoid a wasteful duplication of fixed/setup costs.

- *Supporting long-run development:* Monopoly may be a necessary condition to generate enough funds for R&D, which helps the long-run development of the industry and benefits consumers through product upgrade.

Governmental Regulation of Monopolies

- *Price caps*: The government sets an upper bound for the prices that can be charged by the monopolist.
  - The price cap that maximizes the social welfare (as measured by the sum of CS and PS) should be set at the competitive price level p^c (if it does not cause a loss to the monopolist).
  - A price cap will increase CS, reduce PS, and incur no fiscal cost to the government, although it might involve some implementation cost in practice.
  - A successful implementation of a price cap requires the knowledge about the market demand and the monopolist's marginal cost.



- *Offering subsidies*: The government offers a per unit subsidy to each unit of product that the monopolist produces and sells.
    - Unlike the efficient price cap, the optimal per unit subsidy will not induce the monopolist to produce at the competitive level Q^c, because offering the subsidy itself is costly to the government.
    - More often used in subsidizing unprofitable industry (which requires a huge setup cost/fixed cost).

Price Discrimination

Definition

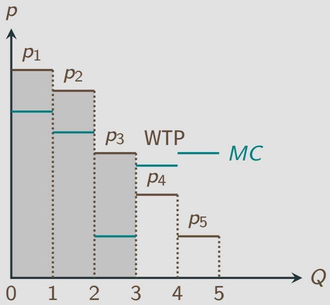
- *Price discrimination* is the pricing strategy of *charging different prices* for the same/very similar product or service based on various factors, including *customer characteristics*, *purchasing quantities*, and *purchasing circumstances*, etc..
- Price discrimination typically requires
  - *market power*, as otherwise the price could be driven down due to competition. Note that the *ability to prevent resale* is part of market power;
  - *information about consumers*.

Types of price discrimination

- Pigou (1920) defined three types of price discrimination
  - First-degree price discrimination (perfect price discrimination)
  - Second-degree price discrimination
  - Third-degree price discrimination

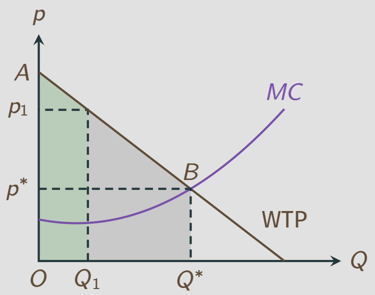
First-degree price discrimination (FDPD)

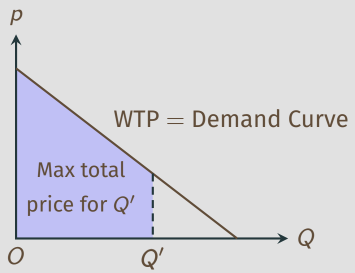
- First-degree price discrimination is the pricing strategy that charges each consumer the *highest* price the consumer is willing to pay (i.e., the consumer's willingness to pay) for each unit of a product or service.



- The best for the monopolist: charge p_1 for the first unit of the product, p_2 for the second unit, and p_3 for the third unit, and in total sell 3 units to the consumer. Selling more than 3 units is not profitable. That is, the monopolist optimally sells 3 units of the good at a total price of $p_1 + p_2 + p_3$.
- By practicing the FDPD, the monopolist managed to extract the entire consumer surplus.

- The continuous case: for each Q_1, the corresponding p_1 is the consumer's WTP for the Q_1th unit of good.
- The total WTP for Q_1 units of good is the green area under the WTP curve.
- The monopolist will optimally produce and sell each unit of good where WTP $>$ MC. So the optimal output level is Q^*, and p^* is the price charged for the *last unit* of good.
- Under FDPD, the consumer pays a total price equal to the area of $OABQ^*$ to buy Q^* units of good from the monopolist.
- FDPD can be implemented via a *two-part tariff*: Sell the good to the consumer at the per unit price p^* and a fixed fee = the area Ap^*B.
- **Clarification:** We will treat the WTP curve as the demand curve, although this is NOT universally true. Importantly, this assumption implies that a consumer's WTP is the area below the demand curve. Thus, the total WTP is also the total surplus, denoted by TS.





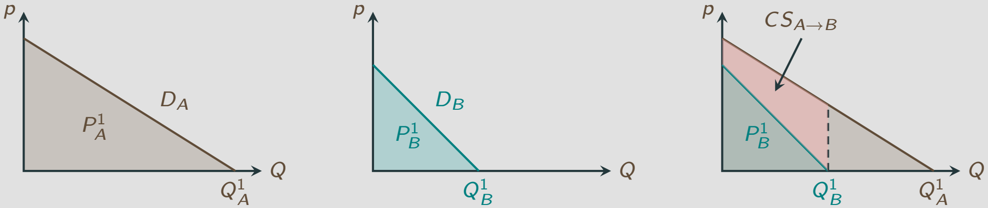
- **Welfare effect:** FDPD will eliminate the deadweight loss caused by linear monopoly pricing, because the price of the last unit of product/service equals its marginal cost. And so the output level is the same as the competitive level.
- **Problem:** FDPD might cause tremendous unfairness in the allocation of welfare as consumer surplus is entirely appropriated by the firm.
- **Feasibility:** Two important conditions are underpinning the exercise of first-degree price discrimination:
  - *the monopolist knows the consumer's WTP*; and
  - *the monopolist can prevent resale*.

  Since both requirements are quite strong, FDPD is rare in reality.

Second-degree price discrimination (SDPD)

- Second-degree price discrimination is a pricing strategy based on consumer's *self-selection*: consumers with different preferences/demand schedules choose to buy different goods/different quantities of goods at different prices.
- To exercise SDPD, a firm typically offers an array of "plans" from which consumers can choose by themselves.
- Real-life examples: data plans, health insurance contracts, and many others.
- Unlike FDPD, to exercise SDPD a monopolist only needs to know the types of demand that consumers possess. It does not need to know the demand type of each particular consumer.
- Exercising SDPD cannot yield a benefit as much as exercising FDPD can, due to the lack of information about consumers (as consumers can mimic each other). This may yield to some of the consumers a positive consumer surplus, which is called their *information rent*.

- There are two consumers, A and B, their demand curves (WTP) are shown below. Assume $MC = 0$.

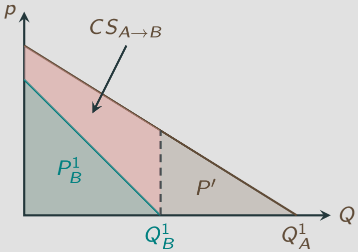


- If the firm knows who is whom, then it can implement FDPD: A pays P_A^1 for Q_A^1; B pays P_B^1 for Q_B^1.
- FDPD is not possible if "who is whom" is not known: A will find it profitable to choose the plan for B.
- Such a lack of information will cause some of the consumers to receive a positive CS, i.e., the information rent.

- The menu of plans has to be designed to induce *self-revelation*: A should find it optimal to choose the plan for A, and B should find it optimal to choose the plan for B.
- A menu of plans that induces self-revelation is called *incentive compatible*.
- For example, the menu

$$M = \{(P_B^1 + P', Q_A^1),\ (P_1^B, Q_B^1)\}$$

is incentive compatible, by which the firm appropriates all the CS of B but leaves $CS_{A\to B}$ to A.



- The optimal way to exercise SDPD is to choose an incentive compatible menu of plans that maximizes the firm's profit.
- The monopolist's problem can be formulated as

$$
\begin{aligned}
&\max P_A + P_B \\
\text{s.t.} \quad & TS_A(Q_A) - P_A \geqslant 0 \\
& TS_B(Q_B) - P_B \geqslant 0 \\
& TS_A(Q_A) - P_A \geqslant TS_A(Q_B) - P_B \\
& TS_B(Q_B) - P_B \geqslant TS_B(Q_A) - P_A
\end{aligned}
$$

The solution to this problem is the best menu to exercise SDPD that sells to both consumers.

Third-degree price discrimination (TDPD)

- Third-degree price discrimination is the pricing strategy based on limited *observed* characteristics, like age, gender, health status, nationality, etc., but not unobservable characteristics.
- Consumers with the same characteristic are charged the same linear price, but the prices can vary across characteristics. For this reason, it is also called *group pricing*.
- **Examples:** All students enjoy a lower price, but a higher price applies to all non-students; all consumers in US pay a price, but a different price applies to all consumers in UK; etc..

- Suppose a monopolist can divide consumers into n groups/types based on observable characteristics. The demand curve of type i consumers is $Q_i(p)$.
- The monopolist needs to decide a price for each type of consumers, p_i.
- Production is cumulative: the total cost is

$$C\left(\sum_{i=1}^{n} Q_i(p_i)\right).$$

- The monopolist's problem:

$$\max_{p_1,p_2,\ldots,p_n} \sum_{i=1}^{n} p_i Q_i(p_i) - C\left(\sum_{i=1}^{n} Q_i(p_i)\right)$$

  or equivalently,

$$\max_{Q_1,Q_2,\ldots,Q_n} \sum_{i=1}^{n} Q_i P_i(Q_i) - C\left(\sum_{i=1}^{n} Q_i\right)$$

- Assuming interior solution (i.e., the monopolist sells to each group), the FOC is

$$MR_1(Q_1^m) = MR_2(Q_2^m) = \cdots = MR_n(Q_n^m) = C'\left(\sum_{i=1}^{n} Q_i^m\right).$$

That is, all groups should yield the same marginal revenue, which is equal to the marginal cost at the total quantity of output.

- The optimal TDPD must satisfy the optimal condition (assuming interior solution): For each i,

$$Q_i(p_i^m) + p_i^m - C'\left(\sum_{i=1}^{n} Q_i(p_i^m)\right) Q_i'(p_i^m) = 0$$

or

$$P_i(Q_i^m) + Q_i^m P_i'(Q_i^m) - C'\left(\sum_{i=1}^{n} Q_i^m\right) = 0,$$

from which we obtain

$$\frac{p_i^m - C'\left(\sum_{i=1}^{n} Q_i^m\right)}{p_i^m} = \frac{1}{|\varepsilon_i(p_i^m)|}.$$

- A more elastic group of consumers will enjoy a lower price.

Example

A monopolist is producing with zero marginal cost and is facing two consumers whose demand functions are

$$Q_1(p) = 10 - p \quad \text{and} \quad Q_2(p) = 4 - 0.5p.$$

- Find the firm's optimal pricing strategy if it cannot engage in any price discrimination.
- Formulate the monopolist's problem for the optimal second-degree price discrimination strategy.
- If the firm can charge different consumers different prices but for each consumer the price has to be linear, find the firm's optimal pricing strategy.