Intermediate Microeconomics Lecture 11

Monopoly

Instructor: Xin Wang

Institute of New Structural Economics, Peking University

Fall 2024

Review: Perfect Competition

- Assumptions of pure competition
  - many buyers and sellers
  - homogeneous product
  - freedom of entry and exit
  - perfect information
- So firms are price takers
- The optimal output in the long run satisfies:

$$p = MC_L = AC_L = AC_S = MC_S$$

  - zero economic profits in the long run

Monopoly

- Perfect competition is one polar extreme on a spectrum of possible market structures
- Pure monopoly is the opposite extreme
- In a pure monopoly
  - there is a single seller of a product for which there are no close substitutes in consumption
  - entry into the market is completely blocked by technological, financial, or legal impediments

Monopoly (cont.)

- Examples of monopoly:
  - utility companies; toll highways; new technology
- Causes of monopoly:
  - legal restrictions
  - control of critical resources
  - government-authorized franchises
  - economies of size (natural monopoly)
  - brand loyalty and extensive advertising (high entry cost)

Monopoly pricing

- Unlike competitive firms which take market price as given, a monopolist has its power to determine what the price of its product is
- It is the freedom of setting price schemes that makes a monopolist's problem much more complicated than that of a competitive firm
  - uniform pricing
  - price discrimination
    - first degree price discrimination
    - second degree price discrimination
    - third degree price discrimination

Profit-Maximization with Uniform Pricing

- The simplest form of monopoly pricing is uniform pricing.
- The monopolist treats the market as a whole and simply adopts a linear pricing strategy
  - i.e. sets a price p for each unit demanded
- This is also known as simple monopoly pricing or standard monopoly pricing
- If the monopolist charges unit price p, then the market demand is $D(p)$
  - total revenue is $pD(p)$
  - total cost is $c(D(p))$

Profit-Maximization with Uniform Pricing (cont.)

- The monopolist's problem is to choose p to maximize its profits:

$$\max_{p} pD(p) - c(D(p))$$

- Because every price determines an output level and vice versa, we can reformulate the monopolist's problem as

$$\max_{y \geq 0} P(y)y - c(y)$$

where $P(y) = D^{-1}(y)$ is the inverse demand function

Profit-Maximization with Uniform Pricing (cont.)

- A necessary condition for the monopolist' problem is

$$P'(y)y + P(y) \leq MC(y) \text{ with equality if } y > 0$$

- When $P(0) > MC(0)$, which will be maintained in our course, this necessary condition boils down to

$$P'(y)y + P(y) = MC(y)$$

.

Profit-Maximization with Uniform Pricing (cont.)

- The LHS $P'(y)y + P(y)$ is the monopolist's marginal revenue:
  - $P'(y)y$ is marginal change in revenue due to price change
  - $P(y)$ is marginal change in revenue due to quantity change
- The RHS $MC(y)$ is the monopolist's marginal cost.
- This necessary condition states that marginal revenue (MR) must equal MC at the monopolist's optimal output level.

Profit-Maximization with Uniform Pricing (cont.)

- Notice $P'(y)y/P(y) = 1/\varepsilon(y)$, where $\varepsilon(y)$ is the elasticity of the demand curve when quantity is y
- This implies the optimality condition can be rewritten as

$$P(y)[1 - \frac{1}{|\varepsilon(y)|}] = MC(y)$$

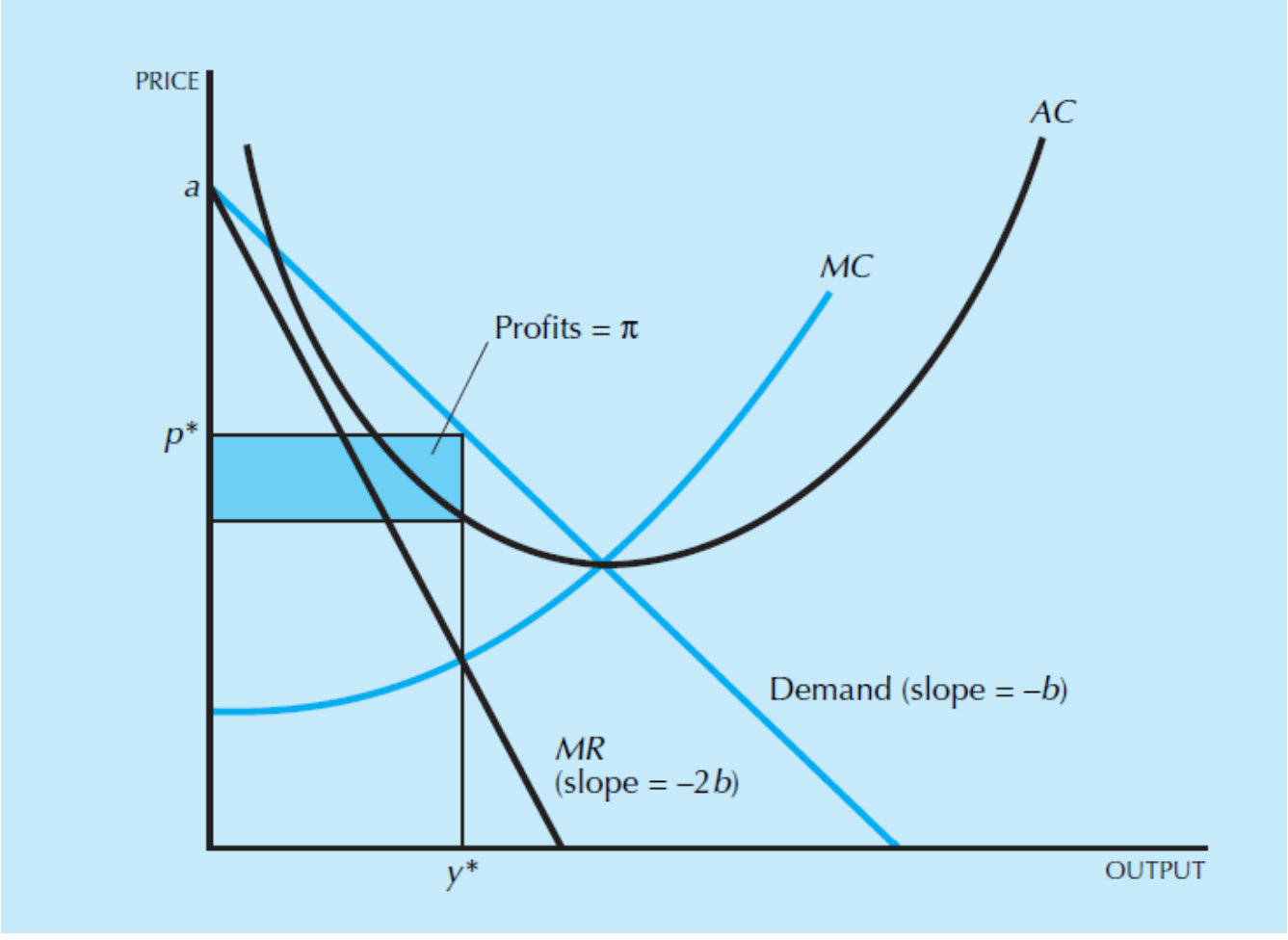
- Notice this equality can not hold when $|\varepsilon(y)| < 1$
  - a monopolist will never choose a quantity level at which the demand elasticity (absolute value) is less than 1
  - when demand elasticity is small, reducing output raises total revenue and decreases total cost
- This further implies that $P(y) > MC(y)$
  - market price is higher than the monopolist's marginal cost

An Example: Linear Demand Curve

- Assume $P(y) = a - by$ and $c(y) = cy^2$, where
- Profit function $P(y)y - c(y)$
  - $P(y)y = ay - by^2$
- $MR(y) = a - 2by$ and $MC(y) = 2cy$
- Profit maximizing:

$$\begin{aligned} MR(y^*) &= MC(y^*) \\ a - 2by^* &= 2cy^* \\ y* &= \frac{a}{2(b+c)} \end{aligned}$$

An Example: Linear Demand Curve (cont.)



Long Run v.s. Short Run

- Monopoly does not guarantee profit in the short run
- However, monopolist typically earn normal profits in long run
- Monopolists will try to maximize profits or minimize losses
- If AC_S lies above AR (demand curve) the monopolist will suffer a loss

Markup Pricing and Monopoly Power

- Markup pricing (加成定价):
  - output price is the marginal cost of production plus a "markup"
- Rearranging the previous equation we have

$$p(y) = \frac{MC(y^*)}{1 - 1/|\varepsilon(y)|}$$

- This formulation indicates that the market price is a markup over marginal cost
  - the markup is given by $\frac{1}{1-1/|\varepsilon(y)|}$
  - if $|\varepsilon(y)|$ is large, markup is small

Inefficiency of Monopoly (cont.)

- Assume there are n consumers.
- Consumer i has a quasilinear utility $v_i(y) + m$
- Then consumer i's inverse demand curve is $p = v_i'(y)$
- Let consumer i's demand curve be $D_i(p) \equiv v_i'^{-1}(p)$
- The market demand is $D(p) = \sum_i D_i(p)$
- Finally, assume the representative producer's cost function is $c(y)$

Inefficiency of Monopoly (cont.)

- Recall that social surplus is maximized if

$$v_1'(y_1) = v_2'(y_2) = \cdots = v_n'(y_n) = c'(\sum_i y_i)$$

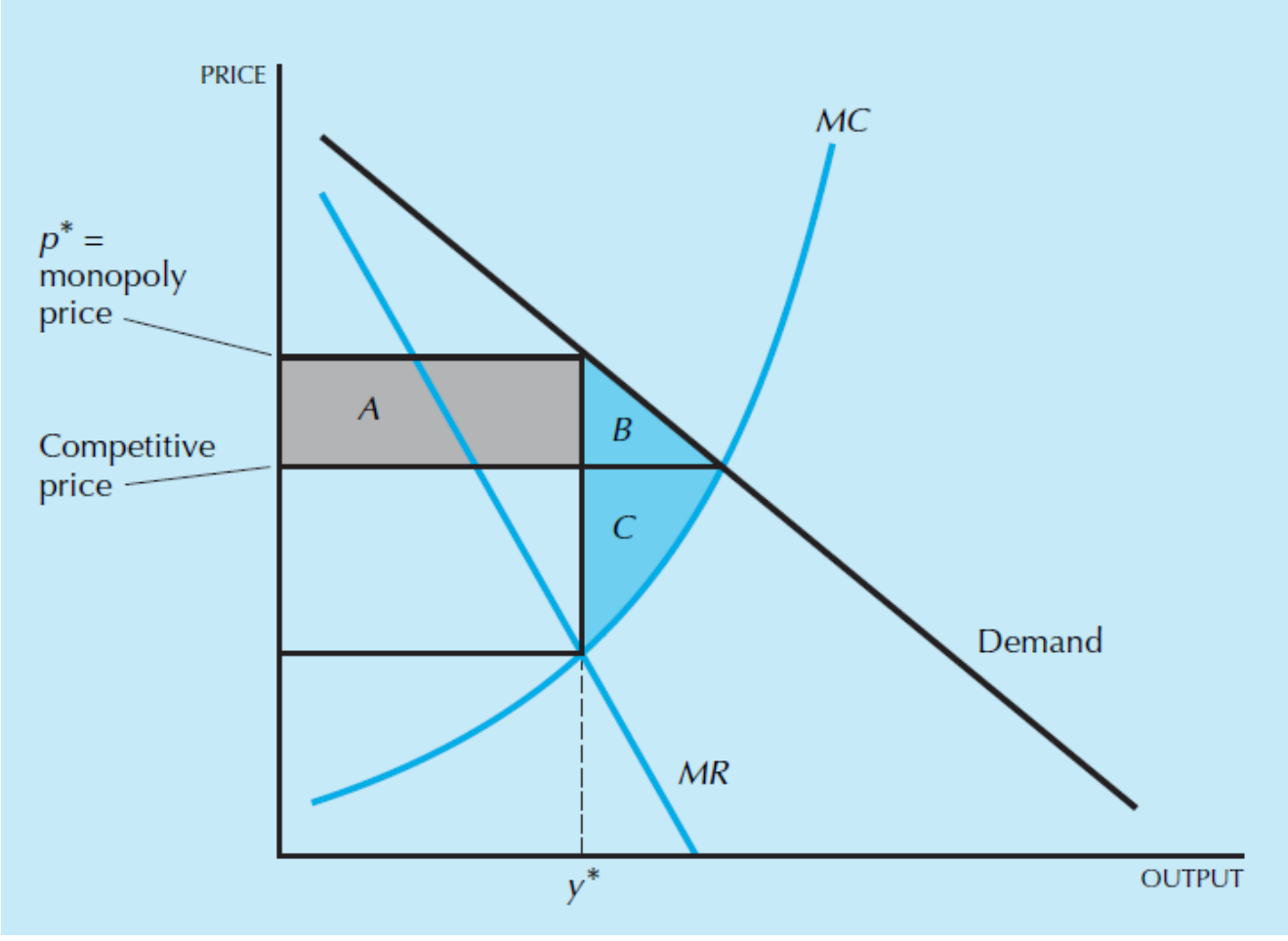
  - the optimal amount of consumption good is determined by the intersection of firm's MC and market demand

Inefficiency of Monopoly (cont.)

- We've already known that monopolist's price is higher than it's marginal cost.
- This means the output is lower than the one determined by the intersection of demand and marginal curves.
- Thus a monopolist usually produced too little compared to socially optimal level
- In terms of social surplus, this leads to a deadweight loss of welfare
  - changes in the producer's and consumers' surplus from a movement from monopolistic to competitive output

Inefficiency of Monopoly (cont.)

- The deadweight loss due to the monopoly is given by the area $B + C$



Price Discrimination

- So far a monopoly has been thought of as a firm which has to sell its product at the same price to every customer
- However, there is no a priori reason to restrict attention to trading mechanisms where the firm sets a unit price and all customers decide how much to buy
- In fact there are more clever pricing schemes that gives a monopolist higher profits than those obtained from uniform pricing
  - if the consumers are considered as heterogeneous(异质的)

Price Discrimination (cont.)

- Price discrimination is the practice of selling different units of a good or service for different prices.
- Note that price differences that arise from cost differences are not price discrimination
- Types of price discrimination
  - 1st-degree (一级价格歧视): each output unit is sold at a different price. Prices may differ across buyers.
  - 2nd-degree (二级价格歧视): price paid by a buyer can vary with the quantity demanded by the buyer (but all customers face the same price schedule)
  - 3rd-degree (三级价格歧视): price paid by buyers in a given group is the same for all units purchased, but price may differ across buyer groups

First Degree Price Discrimination

- Let's first consider a simple case.
- Assume there is only one consumer, i.e. n $= 1$.
- Facing this consumer, the monopolist adopts the following pricing strategy:

$$P(y) = \begin{cases} 0 & \text{if } y = 0, \\ v_1(y^*) - v_1(0) & \text{if } y = y^*, \\ +\infty & \text{if otherwise} \end{cases}$$

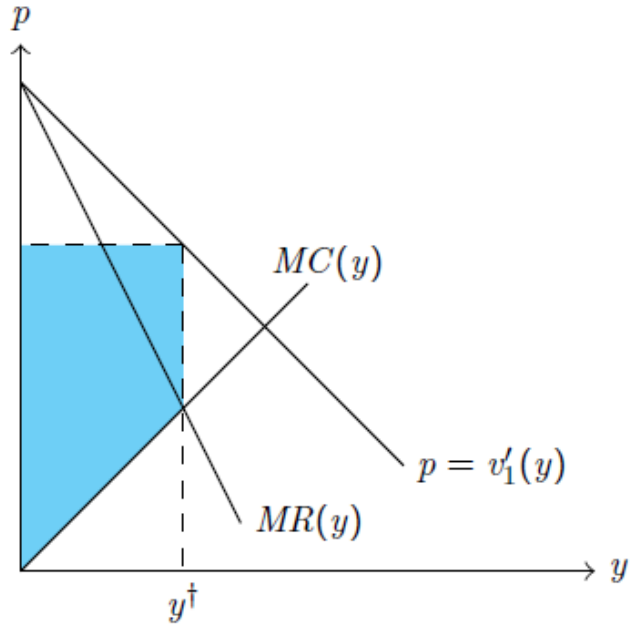
where y^* is the intersection of firm's marginal curve and this consumer's demand curve, i.e. $MC(y^*) = v_1'(y^*)$

First Degree Price Discrimination (cont.)

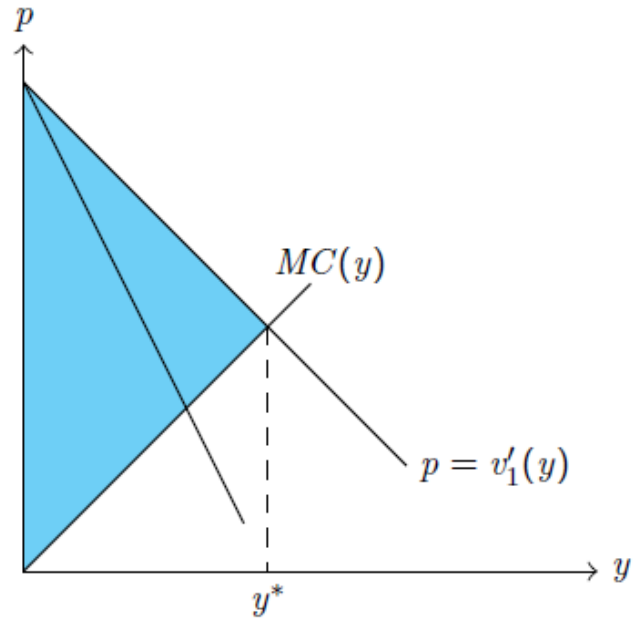
- Essentially, the monopolist offers two choices to the consumer:
  - either to buy y^* units for a price $v_1(y^*) - v_1(0)$
  - or not to buy anything
- Notice the price $v_1(y^*) - v_1(0)$ is just the price at which a consumer is just indifferent between purchasing or not purchasing a good for y^* units (reservation price, 保留价格)
  - we know the consumer will buy
- This results in
  - profits $v_1(y^*) - v_1(0) - c(y^*)$
  - consumer surplus: 0
  - firm's surplus: $v_1(y^*) - v_1(0) - c(y^*) + c(0)$

First Degree Price Discrimination (cont.)

- Comparing firm's surplus



(a) Surplus for optimal unit price



(b) Surplus for optimal nonlinear price

First Degree Price Discrimination (cont.)

- When there are more than one consumers in the market, if the monopolist is able to perfectly identify consumers and treat each consumer individually, then previous analysis still applies
  - adopting a nonlinear price strategy for each consumer and extract all the surplus
- The monopolist's problem is

$$\begin{aligned} \max_{\{(P_i,y_i)\}_{i=1}^n} \quad & \textstyle\sum_{i=1}^n \quad P_i - c(\sum_{i=1}^n y_i) \\ \text{s.t.} \quad & P_i \leq v_i(y_i) - v_i(0) \; \forall i = 1, \cdots, n \end{aligned}$$

  - the monopolist simply decides how much to sell to each consumer and how much to charge

First Degree Price Discrimination (cont.)

- By replacing each P_i by $v_i(y_i) - v_i(0)$, the monopolist's problem reduces to

$$\max_{\{(P_i,y_i)\}_{i=1}^n} \sum_{i=1}^n v_i(y_i) - \sum_{i=1}^n v_i(0) - c(\sum_{i=1}^n y_i)$$

- This is maximized when

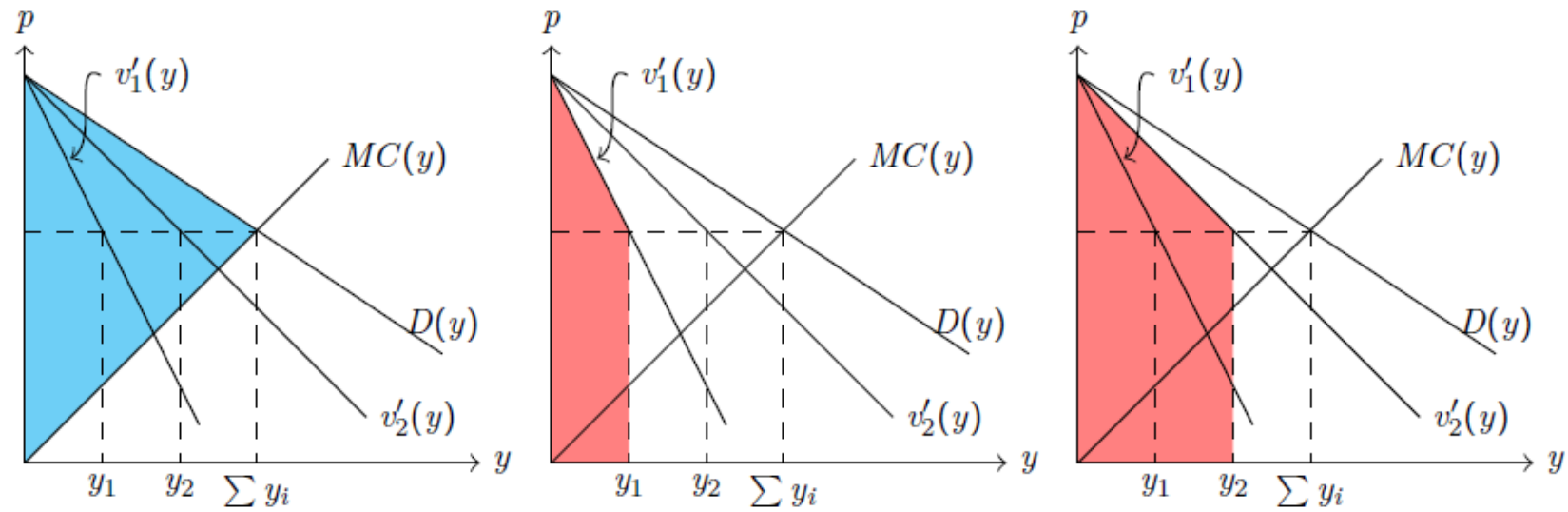
$$v_1'(y_1) = v_2'(y_2) = \cdots = v_n'(y_n) = c'(\sum_i y_i)$$

First Degree Price Discrimination (cont.)

- Again, the optimal total amount of products is determined by the intersection of the monopolist's marginal curve and the market demand curve.
- Moreover, because $P_i = v_i(y_i) - v_i(0)$, each consumer gets a surplus 0 and the firm extracts all the surplus
  - 1st-degree price discrimination is also known as perfect price discrimination
- Note: this is efficient because it maximizes social surplus
  - market efficiency can be achieved even with a monopoly firm

First Degree Price Discrimination (cont.)

- Consider when $n = 2$



(a) Quantity determination and firm's surplus

(b) Total price for consumer 1

(c) Total price for consumer 2

First Degree Price Discrimination (cont.)

- So far, we assumed that
  - the monopolist can fully identify each consumer and thus completely separate consumers into each individual
  - the monopolist adopts a nonlinear pricing scheme for each individual
- However, in reality it is hard
  - for the firm to know exactly each consumer's preference
  - for the monopolist to prevent consumers from trading with each other

Third Degree Price Discrimination

- Another form of price discrimination is called third degree price discrimination.
- The monopolist first divide all consumers into groups and then charge uniform price within each groups
  - price discriminate "imperfectly"
- For example:
  - international companies charge different unit price for the same product in different countries
  - children/student/veteran/senior citizen discount

Third Degree Price Discrimination (cont.)

- Suppose the monopolist divide the n consumers into two groups, A and B.
- The inverse market demand within each group is $P_A(y)$ and $P_B(y)$
- Then the monopolist's problem is

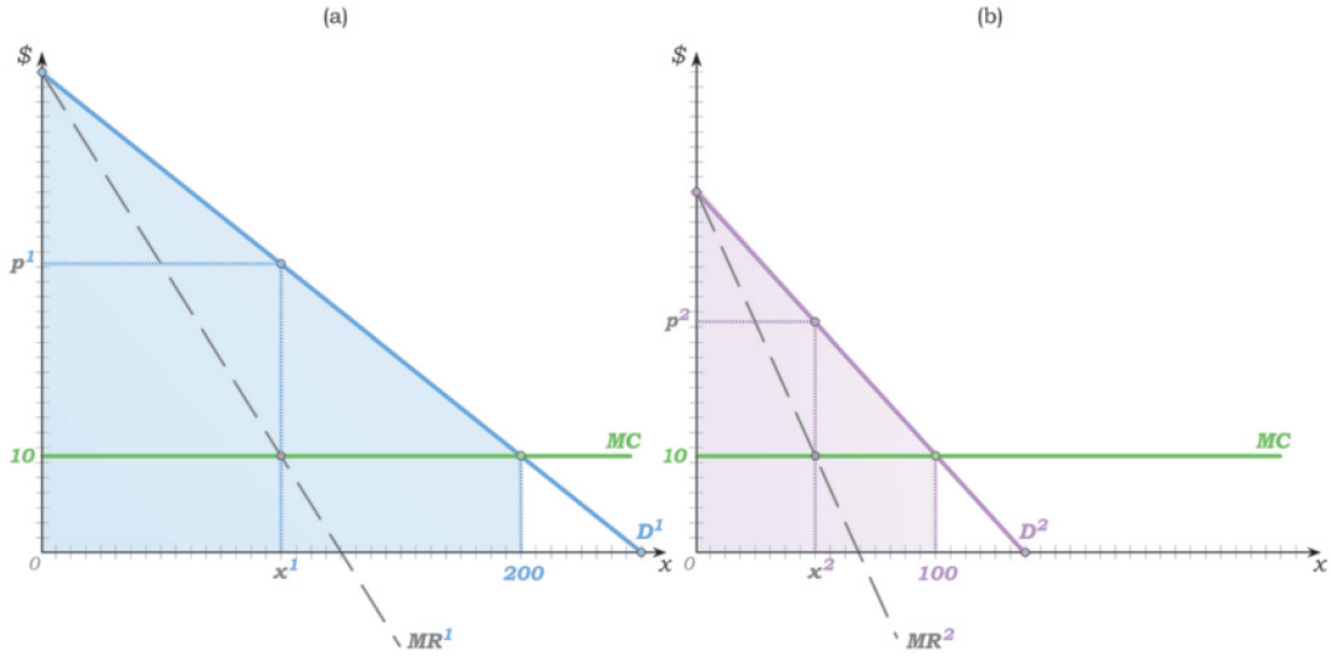
$$\max_{y_A, y_B} y_A P(y_A) + y_B P(y_B) - c(y_A + y_B)$$

- Optimality condition is

$$MR_A(y_A) = MR_B(y_B) = c'(y_A + y_B)$$

Third Degree Price Discrimination (cont.)

- Comparing 1st degree and 3rd degree price discrimination with 2 consumers and constant MC



Third Degree Price Discrimination (cont.)

- Optimality condition can also be written as

$$P_A(y_A)[1 - \frac{1}{|\varepsilon_A(y_A)|}] = P_B(y_B)[1 - \frac{1}{|\varepsilon_B(y_B)|}] = c'(y_A + y_B)$$

- This implies

$$P_A(y_A) \geq P_B(y_B) \Leftrightarrow |\varepsilon_A(y_A)| \leq |\varepsilon_B(y_B)|$$

  - i.e.higher price for price-insensitive market and lower price for price-sensitive market

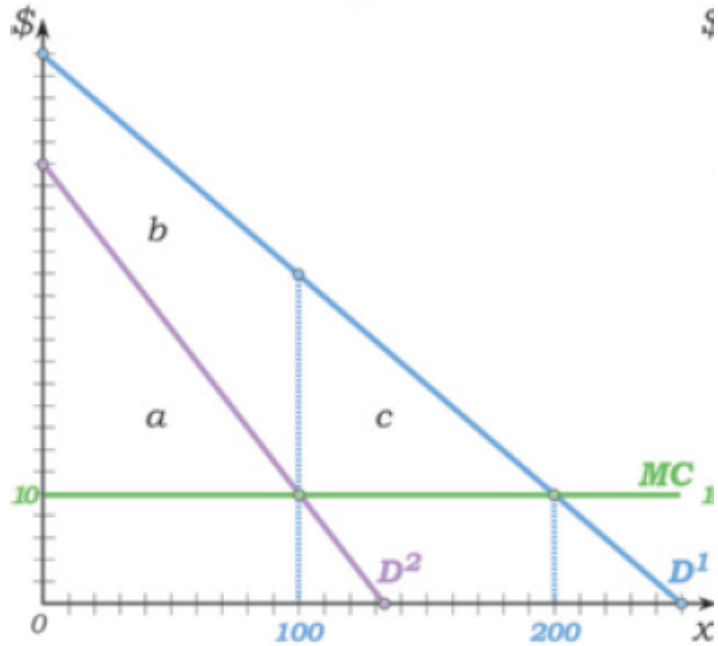
- A deadweight loss will arise under imperfect (or third degree) price discrimination

Second Degree Price Discrimination

- We have said that the assumption that the monopolist can distinguish each consumer is too stringent and not realistic.
- A much more realistic assumption is that the monopolist knows that there are n consumers but does not know who is who.
- Then the monopolist can not separate the consumers and must treat the market as a whole.
- But then the pricing scheme in first degree price discrimination will fail immediately

Second Degree Price Discrimination (cont.)

- Consider previous example with 2 consumers and constant MC again.



Second Degree Price Discrimination (cont.)

- If the monopolist could price discriminate perfectly, she would want to
  - offer 200 units of output to type 1 consumers and charge the entire area under D_1 (i.e., $2,000 + a + b + c$)
  - offer 100 units of the output to type 2 consumers and charge the entire area under D_2 (i.e., $1,000 + a$).
- This would result in no consumer surplus and a surplus for the monopolist of $2a + b + c$ assuming there is one consumer of each type.

Second Degree Price Discrimination (cont.)

- When the monopolist cannot tell which consumers are type 1 and which are type 2, she cannot implement this perfect price discrimination
- This is because type 1 consumers now have an incentive to simply pretend to be type 2 consumers
  - purchase 100 units at the price $1,000 + a$
  - get consumer surplus of b
- No one will pick the 200 unit package, leaving the firm with surplus of only $2a$

Second Degree Price Discrimination (cont.)

- In order to induce type 1 consumers to behave differently from type 2 consumers, the monopolist must therefore come up with a different set of price/quantity packages.
- For instance, the monopolist might continue to offer 100 units at the price $1,000 + a$ while reducing the price of 200 units to $2,000 + a + c$
  - would equalize the surplus a type 1 consumer will get under the two packages
- The monopolist would be able to expect a surplus of $2a + c$, larger than the surplus of $2a$

Second Degree Price Discrimination (cont.)

- We see that even if the monopolist can not identify and thus separate the consumers, the monopolist can still discriminate by carefully choosing price schemes.
- When a monopolist treats the market as a whole but adopts a nonlinear pricing strategy, we call this second degree price discrimination.
- In general, second degree price discrimination gives the monopolist higher profits than uniform pricing but lower profits than first degree price discrimination.

Second Degree Price Discrimination (cont.)

- Real examples
  - Quantity:
    - bulk discounts
    - charges for phone service
  - Quality:
    - first/business/economy class,
    - different storage capacities for cell phone

Summary

- The four pricing schemes we have just discussed can be summarized in the following table.

	Integrated market	Segmented market
Linear pricing	uniform pricing	3rd degree
Nonlinear pricing	2nd degree	1st degree

- There are many many other pricing strategies and what pricing scheme is profit maximization depends on the specific situation that a monopolist is facing.