Introduction to Industrial Organization

Price Discrimination

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Definition

- The price per unit is the same for all consumers in the previous models.
- Nonuniform pricing:
  - Definition: to charge customers different prices for the same product.
  - Examples:
    - Movie theaters offer discounts to students.
    - Airline fares vary so widely for different customers.
- Three main questions in price discrimination (nonuniform pricing):
  - What are the common types of nonuniform pricing?
  - What are the necessary conditions for price discrimination to occur?
  - What are the welfare effects of price discrimination?

Types of Price Discrimination

- Perfect price discrimination (personalized pricing):
  - The firm can charge each customer's willingness to pay.
  - Examples: almost unfeasible in the real world.
- Third-degree price discrimination (group pricing):
  - The firm charges different prices for different groups when the firm can identify the type of each customer.
  - Examples: Movie theaters can give the discounts to those customers with student ID cards.
- Second-degree price discrimination (menu pricing):
  - The firm can not identify the type of each consumer. Different prices are provided for different bundles, and customers select the bundle themselves.
  - Examples: Mobile companies provide different mobile plans.

Outline

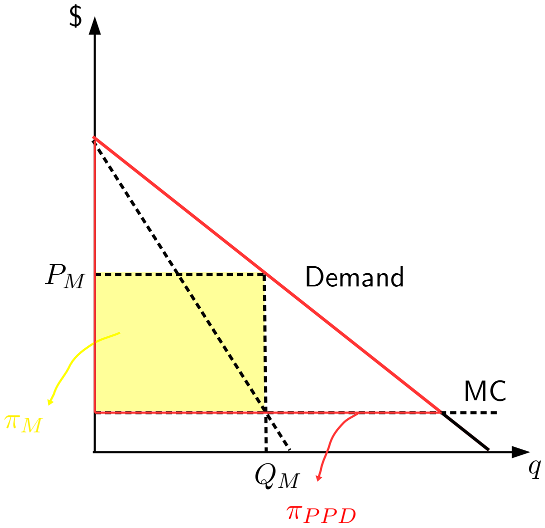
- Perfect Price Discrimination
- Third-Degree Price Discrimination
- Second-Degree Price Discrimination
- Example: Price Discrimination in the Gasoline Market

Perfect Price Discrimination

Perfect Price Discrimination

- Consider a monopoly case: one firm and many consumers.
- Each consumer demands one unit, so the demand curve represents the willingness to pay (WTP).
- If the firm can know each consumer's willingness to pay, the optimal price is equal to WTP.
- No resale between consumers.
- There is no consumer surplus because the monopoly firm takes all of consumer surplus away.
- Profits: $\pi_{PPD} > \pi_M$; quantity: $Q_{PPD} > Q_M$.

Perfect Price Discrimination



Third-Degree Price Discrimination

Third-Degree Price Discrimination

- Consider a monopoly firm and two types of consumers.
- The monopoly firm knows the demand functions for these two types of consumers.
- It also can distinguish the types of consumers.
- No resale between two types of consumers. For instance, two different regions with a long distance.
- Two types of pricing method:
  - Uniform price: the monopoly firm set the same price for all the consumers.
  - third-degree price discrimination (group pricing): the monopoly set different prices for the two types of consumers.

Third-Degree Price Discrimination

- Consider a simple example, the demand for two types of consumers:
  - Type 1: $q_1 = 10 - p_1$.
  - Type 2: $q_2 = 10 - 2p_1$.
- Zero marginal cost.
- The maximization problem under group pricing framework:

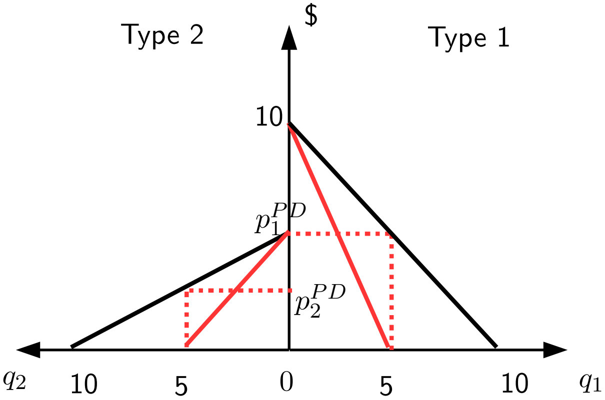
$$\max_{p_1, p_2} p_1(10 - p_1) + p_2(10 - 2p_2)$$

- First-order condition:

$$10 - p_1 - p_1 = 0 \qquad \Rightarrow \; p_1^{PD} = 5; \; q_1^{PD} = 5.$$

$$10 - 2p_2 - 2p_2 = 0 \qquad \Rightarrow \; p_2^{PD} = \frac{5}{2}; \; q_1^{PD} = 5.$$

Third-Degree Price Discrimination



Third-Degree Price Discrimination

- Price: $p_1^{PD} > p_2^{PD}$, the monopoly firm sets higher price for less elastic demand.
- Consumer surplus:

$$\mathsf{CS}_1^{PD} = \frac{5 \times 5}{2} = \frac{25}{2}.$$
$$\mathsf{CS}_2^{PD} = \frac{2.5 \times 5}{2} = \frac{25}{4}.$$

- Profits:

$$\pi_1^{PD} = 5 \times 5 = \frac{25}{2}.$$
$$\pi_2^{PD} = 2.5 \times 5 = \frac{25}{2}.$$

Third-Degree Price Discrimination

- However, if the monopoly firm can only set a uniform price p.
- The profits maximization problem:

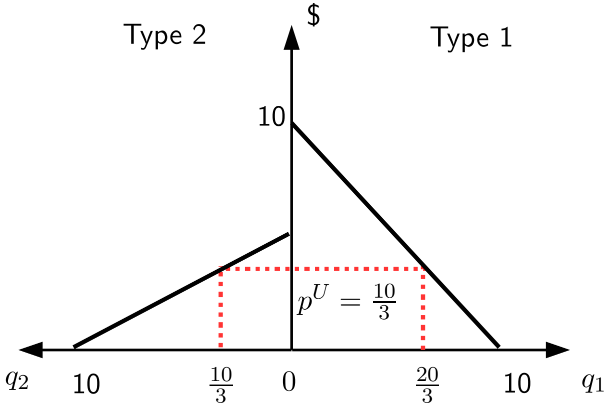
$$\begin{aligned} &\max_p p(10-p) + p(10-2p) && \text{if } p <= 5 \\ &\max_p p(10-p) && \text{if } p >= 5 \end{aligned}$$

- First-order condition:

$$20 - 3p - 3p = 0, \ \Rightarrow \ P^U = \frac{10}{3}.$$

- Quantity: $q_1^U = \frac{20}{3}; q_2^U = \frac{10}{3}$.

Third-Degree Price Discrimination



Third-Degree Price Discrimination

- Consumer surplus:

$$\mathsf{CS}_1^U = \frac{\left(10 - \frac{10}{3}\right)\frac{20}{3}}{2} = \frac{200}{9};$$
$$\mathsf{CS}_2^U = \frac{\left(5 - \frac{10}{3}\right)\frac{10}{3}}{2} = \frac{25}{9}.$$

- Profits:

$$\pi_1^U = \frac{10}{3} \times \frac{20}{3} = \frac{200}{9};$$
$$\pi_2^U = \frac{10}{3} \times \frac{10}{3} = \frac{100}{9}.$$

Third-Degree Price Discrimination

- Comparison between uniform pricing and group pricing:

		uniform pricing		group pricing
Type 1	quantity	$\frac{20}{3}$	$>$	5
(less elastic)	price	$\frac{10}{3}$	$<$	5
	CS	$\frac{200}{9}$	$>$	$\frac{25}{2}$
	profits	$\frac{200}{9}$	$<$	25
Type 2	quantity	$\frac{10}{3}$	$<$	5
(more elastic)	price	$\frac{10}{3}$	$>$	$\frac{5}{2}$
	CS	$\frac{25}{9}$	$<$	$\frac{25}{4}$
	profits	$\frac{100}{9}$	$<$	$\frac{25}{2}$

Third-Degree Price Discrimination

- Higher price for type 1; lower price for type 2 consumers.
  $p_1^{PD} > p^U > P_2^{PD}$.
- Total profits:

$$\pi_1^U + \pi_2^U = \frac{100}{3} < \pi_1^{PD} + \pi_2^{PD} = \frac{75}{2},$$

  so third-degree price discrimination does increase the total profits.
- Per-unit consumer welfare:

$$\left(\frac{\mathsf{CS}}{q}\right)_1^U = \frac{10}{3} > \left(\frac{\mathsf{CS}}{q}\right)_1^{PD} = \frac{5}{2};$$

$$\left(\frac{\mathsf{CS}}{q}\right)_2^U = \frac{5}{6} < \left(\frac{\mathsf{CS}}{q}\right)_1^{PD} = \frac{5}{4},$$

  so type 1 consumers have losses; but type 2 consumers have gains.
- Overall per-unit consumer welfare might increase or decrease.

Third-Degree Price Discrimination

- In general, the monopoly firm separately decide the monopoly price for each type of consumers.
- Recall monopoly pricing:

$$P = \frac{\mathsf{MC}}{1 + \frac{1}{\epsilon}}.$$

- Ramsey pricing rule:

$$\frac{p_i}{p_j} = \frac{\frac{\mathsf{MC}}{1+\frac{1}{\epsilon_i}}}{\frac{\mathsf{MC}}{1+\frac{1}{\epsilon_j}}} = \frac{1 + \frac{1}{\epsilon_j}}{1 + \frac{1}{\epsilon_i}}$$

Third-Degree Price Discrimination

- Applications:
  - Textbook prices are different between USA and other countries.
  - Office software is sold at different prices to home users and to professionals. Students enjoy special discounts.
  - Chain-store retailers set up different prices for different areas.
  - Food in airport is sold at higher prices.
- To do third-degree price discrimination,
  - firm need to have market power to decide the price
  - firm should have ability to identify the types of consumers, or the market is segmented independently.
- The model can also be extended in the product differentiation case.

Second-Degree Price Discrimination

Second-Degree Price Discrimination

- Even though the types of consumers are not observed, the firm still can use self-selecting devices to extract some consumer surplus.
- The idea is to discriminate between heterogeneous buyers by targeting a specific package for each class of buyers.
- Example:
  - New books often appear first in hardcover and later as less expensive paperbacks.
  - Movies can first be viewed in theaters, and they are released on DVD a few months later.
  - Television cable companies provide several bundles of channels.

Second-Degree Price Discrimination

- A simple example: an airline company can provide two types of tickets: first class (F) and economic class (E).
- There are two types of consumers: tourists (T) and business men (B).
- Second-degree price discrimination is to sell economic class tickets to tourists, and to sell first class tickets to business men.
- Assume the utility for type i consumer purchasing j ticket: $U_i(j) - P_j$, where P_j is the price of ticket j.
- Participation constraint:

$$U_T(E) - P_E > 0$$
$$U_B(F) - P_F > 0$$

Second-Degree Price Discrimination

- Self-selection constraint:

$$U_T(E) - P_E > U_T(F) - P_F$$
$$U_B(F) - P_F > U_B(E) - P_E$$

- If we assume that $U_T(F) = 700$, $U_T(E) = 400$, $U_B(F) = 1300$, and $U_B(E) = 500$. How to charge P_F and P_E?
- By constraints:

$$400 - P_E > 0$$
$$1300 - P_F > 0$$
$$400 - P_E > 700 - P_F \Rightarrow P_F - P_E > 300$$
$$1300 - P_F > 500 - P_E \Rightarrow P_F - P_E < 800$$

Second-Degree Price Discrimination

- The optimal price $P_E = 400; P_F = 1200.$
- The firm should give up some information rent to high types of consumers.
- Intuition for pricing:
  - Prices for low-type consumers are equal to their willingness to pays. For instance, $P_E = 400.$
  - Prices for high-type consumers let them be indifferent between these two products. For instance,

$$1300 - P_F = 500 - P_E = 100, \text{ so } P_F = 1200.$$

Second-Degree Price Discrimination

- Participation constraint:

$$U_T(E) - P_E > 0 \quad \text{(binding)}$$
$$U_B(F) - P_F > 0$$

- Self-selection constraint:

$$U_T(E) - P_E > U_T(F) - P_F$$
$$U_B(F) - P_F > U_B(E) - P_E \quad \text{(binding)}$$

Price Discrimination in the Gasoline Market

Price Discrimination in the Gasoline Market

- This example is from Shepard (1991, JPE), "Price Discrimination and Retail Configuration".
- The empirical problem is to distinguish cost-based differentials from discriminatory differentials.
- This paper compares the price differential between full-service and self-service gasoline at stations offering both service types (multiproduct stations) with the price differential across stations offering only full-service and stations offering only self-service (single-product stations).
- A multiproduct station will be able to price discriminate because it can set two prices. The full-service price will be higher and the self-service price lower.

Theoretical Model Settings

- Variable index:
  - f: full-service gasoline
  - s: self-service gasoline
  - MP: multiproduct stations
  - SP: single-product stations
- Consumers' preference:

$$U = \begin{cases} V(g)(t - p_g) & \text{if she consumes one unit of service level } g \\ V(o)t & \text{if she does not purchase,} \end{cases}$$

where $g = f, s$, $V(f) > V(s) > V(o) > 0$, and $t \in [0, 1]$ is consumer's type.

Demand for Gasoline I

- If only one service is available, consumers purchase this quality of gasoline if

$$V(g)(t - p_g) \geq V(o)t$$
$$\Rightarrow \quad t \geq \frac{V(g)p_g}{V(g) - V(o)},$$

so the demand for this quality is

$$D(p_g) = 1 - \frac{V(g)p_g}{V(g) - V(o)}$$

Demand for Gasoline II

- If both services are available, consumers prefer f than s if

$$V(f)(t-p_f) \geq V(s)(t-p_s)$$
$$\Rightarrow \quad t \geq \frac{V(f)p_f - V(s)p_s}{V(f)-V(s)},$$

so the demand for service f is

$$D_f(p_f,p_s) = 1 - \frac{V(f)p_f - V(s)p_s}{V(f)-V(s)}.$$

- If $\frac{V(s)p_s}{V(s)-V(o)} < t < \frac{V(f)p_f - V(s)p_s}{V(f)-V(s)}$, she will purchase service s. The demand for service s is

$$D_s(p_f,p_s) = \frac{V(f)p_f}{V(f)-V(s)} - \frac{V(s)[V(f)-V(o)]p_s}{[V(f)-V(s)][V(s)-V(o)]}.$$

Profits Maximization Problem for Single-Product Stations

- Assume that the marginal cost for self-service is w and for full-service $w + \alpha$.
- Profits Maximization Problem (full-service):

$$\max_{p_f} \Pi_f^{SP} = (p_f - w - \alpha) D(p_f)$$

- First-order condition:

$$p_f^{SP} = \frac{V(f) - V(o)}{2V(f)} + \frac{w + \alpha}{2}.$$

Profits Maximization Problem for Single-Product Stations

- Similarly, profits Maximization Problem (self-service):

$$\max_{p_s} \Pi_s^{SP} = (p_s - w)D(p_s)$$

- First-order condition:

$$p_s^{SP} = \frac{V(s) - V(o)}{2V(s)} + \frac{w}{2}.$$

Profits Maximization Problem for Multiproduct Stations

- To maximize the profits:

$$\max_{p_f, p_s} \Pi^{MP} = (p_f - \alpha - w) D_f(p_f, p_s) + (p_s - w) D_s(p_f, p_s)$$

- The optimal prices are:

$$\begin{aligned} p_s^{MP} =& \frac{[V(f) + V(s)][V(s) - V(o)]}{\delta} + \frac{2wV(f)V(s)}{\delta} \\ &+ \frac{\alpha V(f)[V(s) - V(o)]}{\delta} \\ p_f^{MP} =& \frac{2V(s)[V(f) - V(o)]}{\delta} + \frac{wV(s)[V(f) + V(s)]}{\delta} \\ &+ \frac{\alpha V(s)[2V(f) - V(o) + V(s)]}{\delta}, \end{aligned}$$

where $\delta = 3V(f)V(s) + V(f)V(o) + V(s)^2 - V(s)V(o)$.

Price Differentials

- Definition:

$$\Delta_{MP} \equiv p_f^{MP} - p_s^{MP}$$
$$\Delta_{SP} \equiv p_f^{SP} - p_s^{SP}$$
$$\Delta \equiv \Delta_{MP} - \Delta_{SP}.$$

- This paper shows that

$$\Delta_f \equiv p_f^{MP} - p_f^{SP} \geq 0$$
$$\Delta_s \equiv p_s^{MP} - p_s^{SP} \leq 0.$$

- Compared to single-product prices, the multiproduct self-service price will be no higher ($\Delta_s \leq 0$) and the multiproduct full-service price will be no lower ($\Delta_f \geq 0$). As a result, $\Delta > 0$.

Data

- A cross section of retail prices and characteristics for all 1,528 stations in a four-county area in eastern Massachusetts.

TABLE 1

BRANDED STATION CHARACTERISTICS

	Single-Product Full-Service	Single-Product Self-Service	Multiproduct
Number of stations	1,006	282	239
Number of branded stations	791	136	232
Repair service (%)	89.3	32.4	90.1
Convenience store (%)	3.7	41.9	5.2
Remodeled (%)	44.2	72.8	74.1
Average islands	1.29	2.25	2.11
	(.49)	(1.81)	(.49)
Average fueling places	3.60	5.83	5.51
	(1.64)	(2.09)	(1.89)
Full-service	. . .	. . .	2.63
			(1.02)
Self-service	. . .	. . .	2.88
			(1.16)
Average monthly sales (thousands of gallons)	48.90	96.91	90.18
	(29.93)	(42.49)	(40.33)
Average capacity utilization (thousands of gallons)	14.50	17.64	17.45
	(8.15)	(7.97)	(7.94)

NOTE —Standard deviations are in parentheses.

Empirical Model I

- Prices at station i of type k ($k = MP$ or SP) for gasoline supplied with service quality g (=full or self) in market j can be represented by

$$\begin{aligned} p_{ikgj} =& \beta_0 + \beta_1 D_g + \beta_2 D_k + \beta_3 D_k D_g \\ & + \gamma_1 M_j + \gamma_2 M_j D_k + \phi X_{ikg} + \epsilon_{ikgj}, \end{aligned}$$

  where $D_g = 1$ for full-service, $D_k = 1$ for multiproduct stations, X is a vector of station characteristics, and M is a market fixed effect.

- If we assume that the unobserved market effects are zeros, then we can directly estimate

$$p_{ikgj} = \beta_0 + \beta_1 D_g + \beta_2 D_k + \beta_3 D_k D_g + \phi X_{ikg} + \epsilon_{ikgj}.$$

Empirical Model II

- Identification:

	Full-Service	Self-Service
Multiproduct	$\beta_0 + \beta_1 + \beta_2 + \beta_3$	$\beta_0 + \beta_2$
Single-product	$\beta_0 + \beta_1$	β_0

- The differentials:

$$\Delta_f = \beta_2 + \beta_3 \geq 0$$
$$\Delta_s = \beta_2 \leq 0$$
$$\Delta = \beta_3 \geq 0$$

TABLE 2

PRICE DIFFERENTIALS BY GRADE

	Regular Leaded	Regular Unleaded	Premium Unleaded
Constant	75.47	83.02	97.18
	(1.36)	(1.48)	(1.59)
D_g ($\overline{\Delta}_{SP}$)	6.89	7.64	8.04
	(1.45)	(1.56)	(1.68)
D_n ($\overline{\Delta}_s$)	.00	−2.89	−2.03
	(1.67)	(1.79)	(1.90)
$D_g D_n$ ($\overline{\Delta}$)	9.39	11.23	9.22
	(1.58)	(1.69)	(1.82)
UNBRANDED	−1.97	−4.65	−6.44
	(.55)	(.53)	(.58)
MINI	.19	2.96	2.88
	(.90)	(1.01)	(1.07)
SPFCAP	−.89	−.72	−.70
	(.16)	(.16)	(.17)
SPSCAP	−.21	−.28	−.17
	(.18)	(.20)	(.21)
MPCAP	−.21	.25	.16
	(.18)	(.18)	(.19)
REPAIR	1.80	.38	.11
	(.55)	(.59)	(.63)
CSTORE	1.43	.68	−.57
	(.70)	(.76)	(.81)
NEW	−1.40	−1.66	−1.64
	(.39)	(.41)	(.44)
STATIONS	1,052	1,291	1,237
R^2	.46	.45	.42

NOTE.—Standard errors are in parentheses.

Empirical Model III

- The unobserved effects can be removed by constructing an average price for gasoline of quality g sold at a station of type k for each market and differencing by service quality.
- The model:

$$\bar{\Delta}_{gj} = \bar{p}_{1gj} - \bar{p}_{0gj} = \Theta_j + \phi(\bar{X}_{1gj} - \bar{X}_{0gj}) + \bar{\mu}_{1gj} - \bar{\mu}_{0gj},$$

where $\bar{p}_{1gj}$ ($\bar{p}_{0gj}$) is the average price for gasoline of quality g at multiproduct (single-product) stations in area j.

TABLE 3

AREA REGRESSIONS

Dependent Variable	.5-Mile Radius		1-Mile Radius		1.5-Mile Radius		2-Mile Radius	
	$\bar{\Delta}_{fj}$	$\bar{\Delta}_{gj}$	$\bar{\Delta}_{fj}$	$\bar{\Delta}_{gj}$	$\bar{\Delta}_{fj}$	$\bar{\Delta}_{gj}$	$\bar{\Delta}_{fj}$	$\bar{\Delta}_{gj}$
	All Branded Stations							
Constant	11.44	−1.43	13.09	−.63	12.51	−.15	10.90	−.29
	(1.64)	(1.00)	(1.11)	(.73)	(.91)	(.65)	(.82)	(.77)
Capacity	.21	−.29	−.47	−.49	−.52	−.27	−.33	−.25
	(.57)	(.40)	(.39)	(.29)	(.32)	(.26)	(.34)	(.37)
NEW	−1.81	−1.89	−2.61	−.18	−1.12	.22	2.82	−1.11
	(1.88)	(1.79)	(1.27)	(1.30)	(1.04)	(1.16)	(1.32)	(1.60)
MINI	. . .	6.19	. . .	6.68	. . .	5.44	. . .	6.80
		(2.24)		(1.64)		(1.46)		(2.44)
STATIONS	297	106	547	191	759	251	844	306
MARKETS	124	54	173	97	204	134	217	172
	Branded Stations on Same Route							
Constant	12.81	−3.29	13.21	−3.14	13.62	−1.95	13.66	−1.70
	(2.57)	(1.34)	(2.00)	(1.35)	(1.73)	(1.33)	(1.50)	(1.13)
Capacity	.27	−.61	.56	−.58	−.09	−.36	−.86	−.45
	(.95)	(.56)	(.72)	(.60)	(.62)	(.54)	(.53)	(.46)
NEW	−1.37	−5.31	−4.33	−3.23	−3.21	−2.81	−.32	−3.42
	(2.93)	(2.35)	(2.91)	(2.45)	(2.50)	(2.52)	(2.41)	(2.20)
MINI	. . .	7.59	. . .	7.75	. . .	8.85	. . .	9.49
		(2.47)		(3.04)		(3.25)		(3.03)
STATIONS	123	51	201	74	260	88	302	102
MARKETS	56	25	81	33	96	43	106	50

NOTE.—Standard errors are in parentheses.

Homework 6

- Please provide an example for the price discrimination. (If possible, provide the example which is not covered in the class.)
- Is this example similar to the perfect, second, or third-degree price discrimination?
- In this example, do you have any idea about the prices to further improve the profits for the sellers?