Price Discrimination

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Basic Concepts

- Stigler (1987): Price discrimination is present when two or more similar goods are sold at prices that are in different ratios to marginal price.
  - Stigler uses the example of book in "hard copy" vs "paperback"

- Three conditions are necessary for price discrimination
  - market power (i.e. monopoly or oligopoly)
  - ability to sort consumers (lower the price only to the marginal consumer, via exogenous consume characteristics or "self-selection")
  - able to prevent resale (trade frictions, legal restriction, modify product)

- Theoretical literature
  - Welfare implication of the PD often ambiguous, making empirical studies policy relevant.

Types of Price Discrimination

Our definition follows Varian's adaptation of Pigou (1920)

- First-degree (perfect) PD: price equals to maximum willingness to pay for each unit. (Benchmark)
- Third-degree PD: different groups of consumers are charged different prices, but constant amount for each unit.
- Second-degree PD: often called non-linear pricing, prices differ depending on the number of units of the good bought (but not across consumers).
- Pigou's original definition has second-degree PD as an "ideal" market segmentation for highest-to-lowest willingness-to-pay – i.e. could rely on other general characteristics of purchases (quality, bundle, menu)
- Also notice the information requirement of the 3rd-degree PD vs 2nd-degree PD

Second Degree PD

- Consumer heterogeneity: t_1 (f_1) (L type) and t_2 (f_2) (H type), quasi-linear utility. $u(x,t_2) > u(x,t_1), \partial u(x,t_2)/\partial x > \partial u(x,t_1)/\partial x$ (non-crossing)

- Participation

$$\mathbf{u(x_1,t_1) - r_1 \geq 0}, u(x_2,t_2) - r_2 \geq 0$$

- Self-selection

$$\begin{aligned} u(x_1,t_1) - r_1 &\geq u(x_2,t_1) - r_2 \\ \mathbf{u(x_2,t_2) - r_2} &\mathbf{\geq u(x_1,t_2) - r_1} \end{aligned}$$

- Two constraints will be binding: low-type is charged his maximum WTP, high-type is charged the price to induce x_2.

- Substitute the above into firm's profit and choose x_1, x_2 to max

$$[u(x_1,t_1) - cx_1]\, f_1 + [u(x_2,t_2) - u(x_1,t_2) + u(x_1,t_1) - cx_2]\, f_2$$

- Can be extended to continuum type

Third Degree PD

- Simplest version of third-degree DP is easy to work with. Let the inverse demand curve be $p_i(x_i)$, the FOC is

$$p_i(x_i)\left[1-\frac{1}{\epsilon_i}\right]=c_i$$

  So firms always charge higher price for the less price sensitive segment.

- What about the slightly more complicated case $p_i(x_i, x_j)$, i.e., richer cross-substitution. Varian (1989) shows that the same intuition carries through. If $x_i > x_j$, then

$$\frac{p_i}{p_j} > \frac{1-1/\epsilon_j}{1-1/\epsilon_i}$$

- (social) Welfare effect is in general ambiguous, but output will be a good indicator for the direction of the change. (i.e. whether price discrimination create new market segment that was not served before)

Shepard 1991

- This is one of the first papers to ask whether observed price dispersion of seemingly similar goods can be attributed to price discrimination
- Competition will "discipline" price discrimination, but to what extent?
- Challenges: distinguish cost vs price discrimination. This paper exploits a **natural experiment**
  - full-service vs self-service gasoline at the station (offering both)
  - control: stand-alone full-service or stand-alone self-service stations
  - key assumption: no cost difference if stand-alone or joint
- The ability to price discriminate varies, i.e. only the "multi-product" station can choose discriminatory prices.

Simple Model

- Abstract from horizontal differentiation (i.e. spatial competition)
- Service type g: f and s. Product configuration: MP and SP.
- Consumer type $t \in [0,1]$ uniformly distributed, with utility

$$U = \begin{cases} V(g)(t - p_g) & \text{if consume one unit} \\ V(0)t & \text{if no purchase} \end{cases}$$

where $V(f) > V(s) > V(0) > 0$

- The resulting linear demand (based on cutoff t) for SP is

$$D(p_g) = 1 - \frac{V(g)p_g}{V(g) - V(0)}$$

while for MP is

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

$$D_s(p_s, p_f) = \frac{V(f)p_f}{V(f) - V(s)} - \frac{V(s)[V(f) - V(0)]p_s}{[V(f) - V(s)][V(s) - V(0)]}$$

Simple Model

- Assume the short-run (marginal) cost of self-service and full-service are w and $w + \alpha$.
- The profit maximizing pricing rule is

$$
\begin{aligned}
p_f^{SP} &= \frac{V(f) - V(0)}{2V(f)} + \frac{w + \alpha}{2} \\
p_s^{SP} &= \frac{V(s) - V(0)}{2V(s)} + \frac{w}{2}
\end{aligned}
$$

and

$$
\begin{aligned}
p_f^{MP} &= \frac{2V(s)[V(f) - V(0)]}{\delta} + \frac{wV(s)[V(f) + V(s)]}{\delta} \\
&\quad + \frac{\alpha V(s)[2V(f) - V(0) + V(s)]}{\delta} \\
p_s^{SP} &= \frac{[V(f) + V(s)][V(s) - V(0)]}{\delta} + \frac{2wV(f)V(s)}{\delta} \\
&\quad + \frac{\alpha V(f)[V(s) - V(0)]}{\delta}
\end{aligned}
$$

Simple Model

- Key predictions: in a (w, α) space where all types of services/stations have positive sales, we have

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

- Intuition: MP station has more scope to raise price on f. High WTP consumer could switch to s, but still purchase (in contrast, SP station will lose them).

- Intuition: MP station has also incentive to lower price on s – attract more consumers. It also induces the marginal f consumer to switch, net effect positive (in contrast, SP station will lose if deviate from p_s^{SP}.)

- Overall $\Delta = \Delta_f - \Delta_s > 0$.

Empirical Specification

- Long discussion of cost differences (economies of scale/scope): if anything, it increases Δ_s more than Δ_f, and bias towards finding no PD.

- Empirical specification

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

  i station, j market, $k = MP, SP$, $g = f, s$.

- $\beta_2 = \Delta_s$, $\beta_2 + \beta_3 = \Delta_f$, $\beta_3 = \Delta$.

Results

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.

Leslie 2004

- Price discrimination in Broadway theater
  - 2nd-degree: seat qualities, discount booth (day-of-performance)
  - 3rd-degree: target coupon
- Price and quantity for different ticket categories for Seven Guitars.
- Use random-utility discrete choice model with *endogenously* random choice sets.
- Counterfactual analysis compare PD with uniform pricing, abolishing discount booth, etc.

Price Variation

- Price categories (orchestra, mezzanine, etc.)
- Peak-load time (Sat evening, etc.)
- Discount (Booth TKTS, Coupon)

TABLE 1 **Summary of Attendance and Revenues for Each Sales Category of *Seven Guitars***

	Price ($)		Attendance		Revenue ($)	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Full price						
Orchestra	55.08	4.22	162.74	77.22	9,112.29	4,765.14
Front mezzanine	55.08	4.23	40.04	41.70	2,262.27	2,462.55
Rear mezzanine	29.20	1.85	34.80	18.91	1,007.10	533.49
Balcony	16.93	4.91	38.60	17.26	679.26	421.85
Boxes	55.76	4.17	4.97	4.88	281.36	279.95
Standing room	22.27	2.55	6.14	4.50	134.77	96.24
Discount price						
10% off	49.40	3.88	6.71	5.55	335.74	286.61
Two-fer one	27.23	2.06	16.65	20.17	467.28	591.53
TKTS	27.53	2.11	158.87	71.29	4,358.12	1,956.91
MTC	22.00	0	258.99	60.28	5,697.71	1,326.18
AENY	50.36	1.81	3.81	2.46	193.07	128.17
Direct mail	39.51	2.28	48.43	36.80	1,925.78	1,461.92
Group	36.26	10.80	89.91	63.84	3,309.46	2,688.23
Student	26.21	2.01	68.35	56.38	1,775.98	1,440.68
TDF	16.46	5.81	153.72	90.67	2,306.93	1,163.35
Wheelchair	26.94	2.23	2.02	0.66	54.56	17.67
Complimentary	0	0	38.91	75.57	0	0

Notes: "Two-fer one" are two-for-one coupon sales. "TKTS" are tickets sold via the day-of-performance discount booths. "MTC" stands for Manhattan Theatre Club, which is a subscriber organization. "AENY" stands for Arts Entertainment New York, which is a private

Modeling Choices

- Individual heterogeneity (y_i, ξ_i) (income, taste), respective distributed F and G.

- Subject to *Availability*, consumer's utility from quality $j \in l, m, h$ full-price ticket is (given budget $B(y_i)$):

$$U_{ij} = q_{ij}[B(y_i) - p_j]^\eta$$

- "Self-selection" of high-income consumer into high quality segments. $B(y_i) = \delta_1 y^{\delta_2}$

- With prob $\lambda(y_i|\gamma)$ (targeting tech of the firm), receive a coupon price $p_c < p_h$ for h (orchestra) ticket.

- Booth price and quality are separately modeled as

$$U_{ib} = q_{ib}[B(y_i) - p_b - (\tau_1 y_i + \tau_2)]^\eta$$

- Outside option is $U_{i0} = \xi_i^{-1}[B(y_i) - p_0]^{\eta_0}$

Empirical Implementation

- Each quality segment has capacity limits C_j. Randomly simulate the sequence of N_t consumers (y_i, ξ_i)'s choice. If C_j is reached –option removed. (1000 random permutations).

- If consumer doesn't receive coupon, then option c not feasible. Overall, consumers' choice sets differ.

- ξ_{it} include various time dummies, advertising, and Tony Award.

- Conditional on attending the show (ξ_{it}), all the variation in purchase share s_{jt} is coming from (unobservable) y_i

- Parametrization $\xi_{it} \sim exp(X_t\beta)$ and $\lambda_{it} = \frac{1}{1+exp(\alpha y_i - Z_t\gamma)}$

Empirical Implementation

- Identification?
    - Argue for the plausible exogenous price setting, conditional on quality
    - Discounts time schedule (i.e coupon) was set in advance, not responding to demand fluctuation
    - Rest relies on functional form.

- At each t, for simulated consumer (y_i, ξ_{it}), solve for the choice set

$$A_{jt} = [U_{ijt} \geq U_{ikt}, \forall k]$$

- The simulated market share is

$$s_{jt}(p_t, X_t, Z_t, \Theta) = \int_{A_{jt}} dF(y) dG(\xi | X_t \beta)$$

- Similar to BLP, but with no unobserved quality heterogeneity (and no inversion). Can be estimated with SML.

TABLE 3 **Estimated Parameters**

	q_m	1.6921	(.0064)
	$Q_{\max}$	3.3314	(.0244)
	δ_1	2.5199	(.0163)
	δ_2	.4414	(.0007)
	τ_1	.0067	(.0000)
	τ_2	2.7365	(.0305)
	η	1.0316	(.0022)
β:	Constant	.0180	(.0006)
	Advertising ($'00,000)	.0100	(.0005)
	Tony Awards	.0008	(.0002)
	Saturday evening	.0307	(.0015)
	Friday evening	.0080	(.0010)
	Sunday evening	.0237	(.0038)
	Sunday matinee	.0045	(.0016)
	Saturday matinee	.0040	(.0004)
	Thursday evening	.0050	(.0011)
	Number of other shows	.0094	(.0001)
	$t/100$	.0525	(.0008)
γ:	Constant	21.2021	(.1045)
	Manhattan Theatre Club	−.8105	(.0406)
	Saturday evening	−3.1797	(.1322)
	Friday evening	−1.9682	(.1144)
	Sunday evening	.6080	(.6669)
	Sunday matinee	−.2090	(.0879)
	Saturday matinee	−.1995	(.0820)
	Thursday evening	−.3824	(.1284)
	$t/100$	−4.4849	(.0635)
	$t^2/10,000$	−.0653	(.0076)
	Number of observations		4,886,572
	Log-likelihood		−776,703.44

Notes: Standard errors are in parentheses. The following normalizations were applied: $q_l = 1$, $\eta_o = 1$, $p_o = 0$, and $\alpha = .01$. Advertising is a moving average over the previous 28 days.

Counter-factuals

- Firms choose $p = \{p_l, p_m, p_h, p_b, p_c\}$ to maximize revenue (assuming zero marginal cost).
- Compare actual price and the model "optimal price" (Base-A vs Base-B) validates the model estimates and supply side assumptions.
- The rest of experiments compare
  - Uniform pricing (no booth/coupon): consumer welfare slightly higher. But revenue is also surprisingly higher – get rid of the non-optimal booth discount (i.e. 50%).
  - No booth, but optimize on other prices increases revenue further, and achieve a comparable utility level as Uniform pricing.

Leslie, 2004, Table 5.

TABLE 5 **Results of Counterfactual Experiments**

Experiment	Revenue ($ million)	Utility	Average Attendance	p_l	p_m	p_h	p_b	p_c
Actual	4.6951	NA	661.56	16.93	29.20	55.08	27.53	31.01
Base-A	6.2698	3.5859	906.86	16.93	29.20	55.08	27.53	31.01
Base-B	7.8965	3.5775	864.11	23.90	29.80	60.22	30.11	45.26
Uniform	8.0204	3.6039	809.57	50.04	50.04	50.04	NA	NA
No-booth-A	6.7301	3.5837	873.01	16.93	29.20	55.08	NA	31.01
No-booth-B	8.3495	3.5925	873.73	22.28	38.33	51.53	NA	43.23
Booth not 50%	8.4516	3.5900	850.30	24.47	40.86	54.21	38.05	46.32
Nonsticky	8.0194	3.5800	887.37	24.11	30.11	59.73	29.87	46.03

Notes: See Section 5 for explanations of each experiment. The prices shown are the average prices across all performances. For some experiments, prices do not change from performance to performance, for others they do. The figure for average actual attendance does not include wheelchair tickets, standing room, and complimentary tickets. If these categories are included, the average actual attendance is 707.

Additional Topics

A few active areas in PD that we haven't covered.

- Bundling
- Quality (and price) discrimination
- Inter-temporal price discrimination