Graduate IO: Session 6

October 24, 2016

Agenda

- price discrimination
  - basic theory
  - McManus (2007)
  - price discrimination with competition
  - bundling as price discrimination

Price Discrimination

- definition: charging different prices to different consumers for identical products with identical costs
  - basic theory developed in the monopoly setting

Price Discrimination

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  - basic theory developed in the monopoly setting
- feasibility of price discrimination
  - identification problem: the monopolist must know how consumers differ in their demands for its good
  - arbitrage problem: must be able to prevent those consumers who are offered a low price from reselling their purchases to other consumers to whom the monopolists wants to offer a high price

Price Discrimination for Differentiated Products

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- product differentiation or price discrimination?
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  - hotels in a ski area are more expensive in winter than in summer
  - first-class air travel costs more than coach/economy

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- should be careful because the cost incurred in producing goods for different types, such as hardback and paperback books, or first-class vs. coach flights, is different

Definition of Third-Degree Price Discrimination (Group Pricing)

- Phlips(1983)'s definition

> Price discrimination should be defined as implying that two varieties of a commodity are sold (by the same seller) to two buyers at different *net* prices, the net price being the price (paid by the buyer) corrected for the cost associated with the product differentiation. (Phlips, 1983, p. 6)

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- price discrimination among different versions of the same good exists only if the difference in the price is not justified by the difference in the underlying costs

Third-degree Price Discrimination

- also called "group pricing"
- monopoly produces at constant marginal cost c
- two market segments, with demands $D_1(p)$ and $D_2(p)$
- resale is not possible
- monopoly's problem is to choose segment-specific prices to maximize total profits

Third-degree Price Discrimination

- monopolist's problem

$$\max_{p_1,p_2} \pi = (p_1 - c) D_1(p_1) + (p_2 - c) D_2(p_2)$$

- first-order conditions

$$\frac{p_i - c}{p_i} = \frac{1}{\eta_i} \; i = 1, 2$$

  where η_i is the demand elasticity for segment i
- charge a higher price in the segment that is less price-sensitive

Second-degree Price Discrimination

- also called "menu pricing"
- consumer types not directly observable
- monopolist can get different types to pay different prices, but only by offering a menu of options and allowing consumers to self-select
- second-degree P.D. is a problem of optimal *screening* - very common in economic theory more broadly

An Illustrative Model

- monopolist produces at constant marginal cost c
- two consumer types (in equal proportions) with consumption utility

$$u_i = \theta_i v(q) - T$$

- $\theta_1 > \theta_2$, $v(q)$ increasing and concave
- monopolist's problem is to choose price-quantity pairs (T_1, q_1) and (T_2, q_2) to maximize profits, subject to the constraint that types choose the price-quantity pairs intended for them

Optimization Problem

- optimization problem

$$\max_{T_1, q_1, T_2, q_2} \pi = T_1 + T_2 - cq_1 - cq_2$$

subject to

- participation constraints

$$\begin{aligned} \theta_1 v(q_1) - T_1 &\geq 0 \\ \theta_2 v(q_2) - T_2 &\geq 0 \end{aligned}$$

- incentive constraints

$$\begin{aligned} \theta_1 v(q_1) - T_1 &\geq \theta_1 v(q_2) - T_2 \\ \theta_2 v(q_2) - T_2 &\geq \theta_2 v(q_1) - T_1 \end{aligned}$$

Simplifying the Constraints

- the binding constraints are the participation constraint of the low type 2 and the incentive constraint of the high type 1
- participation constraint for low type implies

$$T_2 = \theta_2 v(q_2)$$

- incentive constraint for high type implies

$$\theta_1 v(q_1) - T_1 = \theta_1 v(q_2) - T_2$$

or

$$T_1 - T_2 = \theta_1 [v(q_1) - v(q_2)]$$

Solution

- substituting into the objective, the monopolist solves the unconstrained problem

$$\max_{T_1, q_1, T_2, q_2} \pi = \theta_1 \left[v\left(q_1\right) - v\left(q_2\right) \right] + 2\theta_2 v\left(q_2\right) - cq_1 - cq_2$$

- FOCs

$$\theta_1 v^{'}\left(q_1\right) = c$$

$$\theta_2 v^{'}\left(q_2\right) = c\left(\frac{\theta_2}{2\theta_2 - \theta_1}\right) > c$$

  - high type's consumption is optimal
  - low type's consumption is distorted (MB>MC)

Notes

- same result holds in models with a continuum of types
  - highest type consumes the efficient amount (MB=MC)
  - lower types consume less than efficient amount
- intuition: high type cannot prefer a lower type's offer, so lower type's offers are degraded in order to satisfy this incentive constraint
- we can also interpret q in the model as quality instead of quantity
- impact of second-degree PD on total welfare is theoretically ambiguous

McManus (2007)

- Question: are price schedules for coffee drinks consistent with the predictions of second-degree price discrimination theory?
- in particular, is there evidence that consumption distortions are smaller "at the top"?

Strategy for Answering the Question

- analyze prices for specialty coffee as a function of drink size (in ounces)
- compare MB of consuming an additional ounce to MC of the additional ounce for different types (drip, espresso, sweetened) at different sizes (8, 12, 16oz)
  - MC obtained as data
  - MB obtained from structural utility model, estimated using data on prices and quantities at seven coffee shops on or near campus

Demand Model

- individual i's indirect utility from consuming drink j

$$U_{ijt} = \beta_i q_j^{\gamma} + \alpha p_j + \delta D_{ij} + \xi_j + \epsilon_{ijt}$$

- β_i are random coefficients
- diminishing marginal utility if $\gamma < 1$
- D_{ij} is distance from consumer's location to coffee shop where j is sold

Data

- price data collected manually
- sales data from cash register tapes
  - had to substitute or supplement with survey data in some instances
- cost data from store managers (ingredient costs)
- location data from U.S. Census and university Housing and Facilities Management

Estimating MB

- marginal utility

$$\frac{\partial U}{\partial q} = \beta_i \gamma q^{\gamma - 1}$$

- convert to dollars, divide by price coefficient

$$MB_i = \frac{\beta_i \gamma q^{\gamma - 1}}{|\alpha|}$$

  - average over estimated distribution of β_i to obtain average MB
  - α and γ are crucial, how are these parameters identified?

Identifying Price Elasticities

- usually we need price variation in the data

Product	Price	Market share
A	\$1	5%
B	\$2	10%
A	\$2	2%
B	\$2	11%

- responses to price changes are informative about both own- and cross-price elasticities

Variation in Choice Sets

- what can we learn from changes in the choice set?

Product	Price	Market share
A	\$1	5%
B	\$2	10%
B	\$2	x%

- basic idea: when a product is not available, resulting substitutions depend in part on price elasticities

Analyzing the Main Result

- key result is that $(MB - MC)$ is larger for small-size drinks than for large-size drinks
  - MC is found to be "roughly constant ..."
  - so result must come from declining MB
  - given the functional form chosen, MB must be declining
    - if $\gamma \geq 1$, then model would predict that everyone would buy the largest available size
- are there other markets to which the ideas/findings are applicable?

P.D. with Competition

- most theory about price discrimination is developed in the monopoly setting: how do a firm's incentives to price discriminate change when it faces competition from other firms?

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- a key assumption in the standard second-price P.D. model is that consumers purchase if doing so delivers utility greater than some minimum threshold (assumed to be zero)
  - in equilibrium, the participation constraint binds only for the lowest type
  - strange implication: if entire price schedule were increased by a small constant, there would be no change in purchases except at the very bottom

P.D. with Competition (Cont'd)

- Rochet and Stole (*Review of Economic Studies*, 2002): what happens if we introduce randomness in the participation constraint?
  - buy if $\theta v(q) - T(q) \geq x$, where x is a random variable
  - in an oligopoly model, x can be interpreted as the option of buying from another firm

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- when firms are symmetric and sufficiently competitive (meaning that for every consumer, the relevant outside option is to buy from the other firm)
  - unique equilibrium involves no quality distortions
  - tariffs take the form of cost-plus-fixed-fee
  - consumption is efficient

Empirical Work on Price Discrimination and Competition

- early paper: Shepard (JPE 1991)
- question: can price discrimination persist in competitive market?
- idea: look at gas station prices for full-service vs. self-service
  - $\Delta_{MP} = P_{full} - P_{self}$ at multi-product (both services) stations
  - $\Delta_{SP} = P_{full} - P^{'}_{self}$ at single-product (single service) stations
  - prediction: $\Delta_{MP} > \Delta_{SP}$
  - intuition: multi-product firm could set two prices and thus potentially be able to do price discrimination

Busse and Rysman

- question: how does competition affect price discrimination?
- strategy: look at yellow page ads; measure how the depth of quantity discounting relates to the number of competing yellow-pages publishers in the market

Why Yellow Pages?

- nonlinear pricing prevalent and easy to define/measure
- level of competition varies across markets
- product offerings are relatively standard, facilitating across-market comparisons

Data Summary

- data are summarized quite nicely
  - sources identified
  - clear explanation of how and why the sample was trimmed
  - measurement of key variables explained (e.g., competition)
  - a few useful facts and summary statistics reported
    - e.g., prices range from \$75.6 for quarter page in South Carolina to \$70,000 for full page in Manhattan

Key Test

- how does the slope of the price schedule depend on competition?
- assumptions
  - cost(big ad)/cost(small ad) does not depend on competition
  - relative demand for big vs. small ads does not depend on competition

Regression Model

$$\log(P_{ij}) = \alpha_i + \beta_i \log(\text{size}_j) + \epsilon_{ij}$$

where

$$\beta_i = \gamma_0 + \gamma_1 \text{Competition}_i + \nu_i$$

$$\log(P_{ij}) = \alpha_i + \gamma_0 \log(\text{size}_j) + \gamma_1 \text{Competition}_i \cdot \log(\text{size}_j) + \nu_i \log(\text{size}_j) + \epsilon_{ij}$$

Results

- $\hat{\gamma}_1$ is negative: competition reduces prices disproportionately more for large ads
- explanation of magnitude
  - full-page ad is 16 times larger than a quarter-column ad
  - monopolist charges a price that is 13.51 times larger
  - duopolist charges a price that is 12.54 times larger
  - triopolist charges a price that is 11.63 times larger

What is Bundling?

- most real-world firms sell multiple products or services
- bundling = charging a price for a bundle of products that is different from the sum of the bundled products' individual prices
  - most cable companies have

    $$P(\text{TV+Internet+Phone}) < P(\text{TV}) + P(\text{Internet}) + P(\text{Phone})$$

  - at an online music store: price of an album $<$ sum of prices of songs on that album

Some Terminology and Abbreviations

- suppose a firm sells three products: a, b, c

Pricing scheme	**Prices to set**
Uniform pricing (UP)	p
Component pricing (CP)	$p_a,\ p_b,\ p_c$
Pure bundling (PB)	p_{abc}
Mixed bundling (MB)	$p_a,\ p_b,\ p_c,\ p_{ab},\ p_{ac},\ p_{bc},\ p_{abc}$

Why Bundle?

- because products are complementary
- as a form of price discrimination, i.e., to extract more consumer surplus
- to leverage market power

Bundling as Price Discrimination

- firm sells two products, 1 and 2, to two consumers, Amy and Bob, MC=0

	v_1	v_2
Amy	5	1
Bob	2	4

- UP: $p = 4$ and profit is 8
- CP: $p_1 = 5$ and $p_2 = 4$, profit is 9
- PB: $p_{12} = 6$ and profit is 12

Heterogeneity Reduction

- the intuition for why bundling works as a price discrimination device is that when consumers' valuations aren't perfectly correlated, bundling reduces heterogeneity in consumers' willingness to pay
- this intuition also suggests that negative correlation in tastes makes bundling more profitable
- Bakos and Brynjolffson (1999): "bundling very large number of unrelated information goods can be surprisingly profitable"
  - Law of Large Numbers: consumers' valuations of a large bundle become homogeneous in the limit

Chu, Leslie and Sorensen (2011)

- question: how close can simple pricing schemes come to capturing the full MB profits? considering CP and BSP specifically, which comes closer to MB? and what does this depend on?
- strategy
  - compare performance of CP, BSP and MB in a large number of numerical experiments
  - compare performance of CP, BSP and MB in an empirically estimated demand system (theater tickets)

Bundle-Size Pricing

- BSP: price depends only on the number of products in the bundle (not on which products are in the bundle)

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Bundle-size pricing (BSP)	$p_{(1)}$, $p_{(2)}$, $p_{(3)}$

An Unsolved Hard Problem

- with K products, MB requires setting $2^K - 1$ prices
- suppose the firm can specify any N prices ($1 \leq N \leq 2^K - 1$), plus a rule by which the price of any sub-bundle's price can be determined from those N prices
- question: how quickly does $\pi^*(N)$ approach π^*_{MB} as N increases? what does this depend on?

Results from Numerical Experiments

- BSP seems to
  - outperform CP most of the time
  - come remarkably close to MB most of the time

Empirical Example

- smaller theater company selling tickets to 8 plays
- purchasing options
  - full subscription to all 8 plays
  - discounted "pick-any-5" package
  - individual plays
- data: prices and plays purchased for every buyer

Main Results

- BSP revenue is .9% higher than CP
- BSP revenue is 98.5% of MB
- relatively difficult to get CP to outperform BSP
  - either dramatically increase asymmetry in play popularity
  - or assume very high marginal costs

Reading for Next Class

- Steven Berry, "Estimation of a Model of Entry in the Airline Industry", *Econometrica*, 1992.