Lecture 13
Price discrimination and Entry

Bronwyn H. Hall
Economics 220C, UC Berkeley
Spring 2005
Outline

• Leslie – Broadway theatre pricing
• Empirical models of entry
Leslie 2004

- Demand and price discrimination for a single Broadway show that ran 199 days (*Seven Guitars*)
- Complex ticket sales:
  - variation in quality
  - discount coupons
  - discount at TKTS (booth) day of performance
  - => second and third-degree price discrimination
- Explicit BLP/Nevo style model of demand allows computation of welfare effects:
  - increases profits 5%; not much effect on consumer welfare
  - TKTS does not make the theater money (lose full price customers to discounts)
Leslie’s model

• Consumer heterogeneity \((y_i, \xi_i)\) uncorrelated:
  - income \(y_i\) distributed \(F(y)\)
  - Valuation of seeing a play depends on income
    \[ B(y_i) = \delta_1 y_i^{\delta_2} \]
  - taste for this one relative to other plays \(\xi_i\), distributed \(G(\xi)\)

• Ticket price options
  - quality \(j = \text{low, medium, high}\) (differentiated)
  - full price = \(p_l, p_m, p_h\)
  - coupon with logit probability \(\lambda(y_i, Z_i|y)\): price = \(p_c\)
  - discount booth price = \(p_b + \tau(y_i)\)

• Utility to individual \(i\) of a ticket of quality/price \(j\):
  \[ U_{ij} = q_{ij} [B(y_i) - p_j]^\gamma \]
Leslie’s model

• Summary: full price ticket: \( U_{ij} = q_{ij}[B(y_i) - p_j]^\eta \quad j = l, m, h \)
  coupon (if avail): \( U_{ic} = q_{ih}[B(y_i) - p_c]^\eta \)
  discount booth: \( U_{ib} = q_{ib}[B(y_i) - p_b - \tau_1 y_i - \tau_2]^\eta \)
  outside option: \( U_{i0} = \xi_i^{-1}[B(y_i) - p_0]^\eta_0 \)

• Distribution of taste \( (X_t = \text{advertising}, \text{day of week, etc.}): \)
  \( \xi_i \sim \exp(X_t \beta) \)

• Demand for tickets in category \( j \) is
  \[
  s_{jt}(p_t, X_t, Z_t, \Theta) = M \int_{(y_i, \xi_i) \in A_{jt}} dF(y) dG(\xi | X_t \beta)
  \]
  \( A_{jt} = \{(y_i, \xi_i): U_{ijt} \geq U_{ikt}, \forall k \in (l, m, h, b, c, 0)\} \)

• Parameters \( \Theta = (q_l, q_m, q_{max}, \delta_1, \delta_2, T_1, T_2, \eta, \eta_0, p_0, \alpha, \beta, \gamma) \)
  – in practice \( q_l = 1, \eta_0 = 1, p_0 = 0, \alpha = .01 \) due to lack of identification
Data and likelihood

• Data:
  – prices, seats sold, capacity, for each day of run
  – total Broadway play sales that week

• Likelihood:
  \[ \log L(\Theta) = \sum_{t=1}^{T} \sum_{j} N_{jt} \log s_{jt}(\Theta) \]

  – No explicit uncertainty other than the distribution of tastes (=> significance levels overestimated)
  – Estimation is done by simulating ticket sales (with random ordering of buyers) and searching over the parameter space.
TABLE 1: Summary of Attendances and Revenues for Each Sales Category of *Seven Guitars*

<table>
<thead>
<tr>
<th></th>
<th>Price ($)</th>
<th>Attendance</th>
<th>Revenue ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Std Dev.</td>
<td>Mean</td>
</tr>
<tr>
<td><strong>Full-price:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orchestra</td>
<td>55.08</td>
<td>4.22</td>
<td>162.74</td>
</tr>
<tr>
<td>Front mezzanine</td>
<td>55.08</td>
<td>4.23</td>
<td>40.04</td>
</tr>
<tr>
<td>Rear mezzanine</td>
<td>29.20</td>
<td>1.85</td>
<td>34.80</td>
</tr>
<tr>
<td>Balcony</td>
<td>16.93</td>
<td>4.91</td>
<td>38.60</td>
</tr>
<tr>
<td>Boxes</td>
<td>55.76</td>
<td>4.17</td>
<td>4.97</td>
</tr>
<tr>
<td>Standing</td>
<td>22.27</td>
<td>2.55</td>
<td>6.14</td>
</tr>
<tr>
<td><strong>Discount-price:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10%-off</td>
<td>49.40</td>
<td>3.88</td>
<td>6.71</td>
</tr>
<tr>
<td>Two-fer one</td>
<td>27.23</td>
<td>2.06</td>
<td>16.65</td>
</tr>
<tr>
<td>TKTS</td>
<td>27.53</td>
<td>2.11</td>
<td>158.87</td>
</tr>
<tr>
<td>MTC</td>
<td>22.00</td>
<td>0</td>
<td>258.99</td>
</tr>
<tr>
<td>AENY</td>
<td>50.36</td>
<td>1.81</td>
<td>3.81</td>
</tr>
<tr>
<td>Direct mail</td>
<td>39.51</td>
<td>2.28</td>
<td>48.43</td>
</tr>
<tr>
<td>Group</td>
<td>36.26</td>
<td>10.80</td>
<td>89.91</td>
</tr>
<tr>
<td>Student</td>
<td>26.21</td>
<td>2.01</td>
<td>68.35</td>
</tr>
<tr>
<td>TDF</td>
<td>16.46</td>
<td>5.81</td>
<td>153.72</td>
</tr>
<tr>
<td>Wheelchair</td>
<td>26.94</td>
<td>2.23</td>
<td>2.02</td>
</tr>
<tr>
<td>Complimentary</td>
<td>0</td>
<td>0</td>
<td>38.91</td>
</tr>
</tbody>
</table>
Results

- best seat 3.3 times worst, roughly consistent with price ratio
- booth cost at median income is $18 = $2.74 + 0.67*$2227
- due to capacity constraints, model over-estimates demand
- own price elasticities mostly greater than unity (as they should be)

| $q_m$       | 1.6921    | (0.0064) |
| $Q_{max}$  | 3.3314    | (0.0244) |
| $\delta_1$ | 2.5199    | (0.0163) |
| $\delta_2$ | 0.4414    | (0.0007) |
| $\tau_1$   | 0.0067    | (0.0000) |
| $\tau_2$   | 2.7365    | (0.0405) |
| $\eta$     | 1.0316    | (0.0222) |

$\beta$:  
- Constant 0.0180 (0.0006)
- Advertising($00,000) 0.0100 (0.0005)
- Tony awards 0.0000 (0.0002)
- Saturday evening 0.0307 (0.0015)
- Friday evening 0.0080 (0.0010)
- Sunday evening 0.0237 (0.0038)
- Sunday matinee 0.0045 (0.0016)
- Saturday matinee 0.0040 (0.0004)
- Thursday evening 0.0050 (0.0011)
- No. of other shows 0.0094 (0.0001)
- $t/100$ 0.0525 (0.0008)

$\gamma$:  
- Constant 21.2621 (0.1045)
- Manhattan Theatre Club -0.8105 (0.0406)
- Saturday evening -3.1797 (0.1322)
- Friday evening -1.9682 (0.1144)
- Sunday evening 0.6080 (0.6669)
- Sunday matinee -0.2090 (0.0879)
- Saturday matinee -0.1995 (0.0820)
- Thursday evening -0.3824 (0.1284)
- $t/100$ -4.4849 (0.0635)
- $t^2/10,000$ -0.0653 (0.0076)

No. observations: 4,886,572
Log-likelihood: -776,703.44
Welfare and profits

• Firm behavior - set prices to maximize revenue, conditional on show, $T$, and theater configuration:

$$R = \sum_{t=1}^{T} \sum_{j} p_{jt} q_{jt}(p_t, \cdot)$$

where $q_{jt} = M_t s_{jt}(p_t, X_t, Z_t, \hat{\theta})$

• Consider several scenarios:
  – observed prices
  – optimal prices, constant across all performances
  – all prices the same (no booth)
  – observed prices without booth
  – optimal prices without booth
  – choose booth discount
  – change prices during the run (non-sticky)
Welfare results

TABLE 5: Results of Counterfactual Experiments

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

• Conclusions:
  – little effect on welfare, since consumers simply move to different price alternatives
  – booth discount is probably too high
  – attendance substantially overpredicted
  – but how do we know that consumers willing to pay high price shifted to booth?
Entry

• **Empirical problem:**
  – estimate determinants of entry from cross-sectional data (post-entry equilibrium)
  – implicit or explicit two stage game:
    • first stage – firms choose to enter (sometimes choose location)
    • second stage – firms compete on price or quantity (and sometimes location)
    • subgame perfect – first stage decision evaluates second stage game outcome (under complete information)

• **Most work ignores dynamics and sunk costs**
  – entry conditions long ago may matter
  – but have to start somewhere
Entry – empirical studies

• Homogenous product
  – Berry (1992) – but firms differentiated

• Differentiated products
  – Mazzeo (2002) – endogenous product choice (motels on the interstate)
  – Toivanen and Waterson (2001) – fast food in the UK
Bresnahan and Reiss (1991)

Implied game – static, perfect information; example with two firms:

<table>
<thead>
<tr>
<th></th>
<th>do not enter</th>
<th>enter</th>
</tr>
</thead>
<tbody>
<tr>
<td>firm 1 →</td>
<td></td>
<td></td>
</tr>
<tr>
<td>firm 2 ↓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>do not enter</td>
<td>(\Pi_1 (0,0))</td>
<td>(\Pi_1 (0,1))</td>
</tr>
<tr>
<td></td>
<td>(\Pi_2 (0,0))</td>
<td>(\Pi_2 (0,1))</td>
</tr>
<tr>
<td>enter</td>
<td>(\Pi_1 (1,0))</td>
<td>(\Pi_1 (1,1))</td>
</tr>
<tr>
<td></td>
<td>(\Pi_2 (1,0))</td>
<td>(\Pi_2 (1,1))</td>
</tr>
</tbody>
</table>

\(\Pi_j (a_1,a_2)\) = profits earned by \(j\)th firm when firm 1 takes action \(a_1\) and firm 2 action \(a_2\)

B&R see actions but not profits – assume a specific equilibrium structure to infer form of profit functions
Bresnahan and Reiss

• no price or quantity data
• identical firms – equilibrium number is number with entry value > 0
• isolated markets – cross section of town characteristics, number of establishments
  – druggists, dentists, doctors, etc.
• assume firms enter market $i$ when variable profits cover fixed costs (depends on market demand):

\[ S_N = \frac{S_N}{N} = \frac{F + B_N}{(P_N - AVC_N - b_N)d_N(Z, P)} < 0 \]

  – $F$ is fixed costs, $B$ and $b$ allow different costs as entrants increase, $N$ is number of firms, $P_N$ is price when there are $N$ firms, $Z$ are demand shifters.
Number of dentists by town population

Source: Bresnahan and Reiss (RJE 1991)
Working without a net….

• BR observe $Z$ and $N$ across 202 isolated local markets
  – infer the form of the profit function that must have existed in order to
generate the data.
• Idea: per-firm profits fall as $N$ increases (under a wide range of
assumptions) so with adequate control for market differences ($Z$),
can use ordered probit to estimate profit function.

$$\Pi_N = \bar{\Pi}_N - \varepsilon = S(Y, \lambda)V_N(Z, W, \alpha, \beta) - F_N(W, \gamma) - \varepsilon$$

– $Y$ is market size (pop, nearby pop, growth, commuters)
– $Z, W$ are per capita demand and cost shifters (pop composition, income,
weather, density, house value, agricultural land)
– All firms in the market have the same disturbance $\varepsilon \sim N(0, 1)$

$$\Pr(N \text{ firms}) = \Pr(\Pi_N \geq 0, \Pi_{N+1} < 0)$$

$$= \Pr(\bar{\Pi}_{N+1} < \varepsilon \leq \bar{\Pi}_N) = \Phi(\bar{\Pi}_N) - \Phi(\bar{\Pi}_{N+1})$$
### Table 5

#### A. Entry Threshold Estimates

<table>
<thead>
<tr>
<th>Profession</th>
<th>$S_1$</th>
<th>$S_2$</th>
<th>$S_3$</th>
<th>$S_4$</th>
<th>$S_5$</th>
<th>$S_2/S_1$</th>
<th>$S_3/S_2$</th>
<th>$S_4/S_3$</th>
<th>$S_5/S_4$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doctors</td>
<td>.88</td>
<td>3.49</td>
<td>5.78</td>
<td>7.72</td>
<td>9.14</td>
<td>1.98</td>
<td>1.10</td>
<td>1.00</td>
<td>.95</td>
</tr>
<tr>
<td>Dentists</td>
<td>.71</td>
<td>2.54</td>
<td>4.18</td>
<td>5.43</td>
<td>6.41</td>
<td>1.78</td>
<td>.79</td>
<td>.97</td>
<td>.94</td>
</tr>
<tr>
<td>Druggists</td>
<td>.53</td>
<td>2.12</td>
<td>5.04</td>
<td>7.67</td>
<td>9.39</td>
<td>1.99</td>
<td>1.58</td>
<td>1.14</td>
<td>.98</td>
</tr>
<tr>
<td>Plumbers</td>
<td>1.43</td>
<td>3.02</td>
<td>4.53</td>
<td>6.20</td>
<td>7.47</td>
<td>1.06</td>
<td>1.00</td>
<td>1.02</td>
<td>.96</td>
</tr>
<tr>
<td>Tire dealers</td>
<td>.49</td>
<td>1.78</td>
<td>3.41</td>
<td>4.74</td>
<td>6.10</td>
<td>1.81</td>
<td>1.28</td>
<td>1.04</td>
<td>1.03</td>
</tr>
</tbody>
</table>

#### B. Likelihood Ratio Tests for Threshold Proportionality

<table>
<thead>
<tr>
<th>Profession</th>
<th>Test for $s_4 = s_5$</th>
<th>Test for $s_3 = s_4 = s_5$</th>
<th>Test for $s_2 = s_3 = s_4 = s_5$</th>
<th>Test for $s_1 = s_2 = s_3 = s_4 = s_5$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doctors</td>
<td>1.12 (1)</td>
<td>6.20 (3)</td>
<td>8.33 (4)</td>
<td>45.05* (5)</td>
</tr>
<tr>
<td>Dentists</td>
<td>1.50 (1)</td>
<td>12.30* (2)</td>
<td>19.13* (4)</td>
<td>56.67* (5)</td>
</tr>
<tr>
<td>Druggists</td>
<td>.43 (2)</td>
<td>7.13 (4)</td>
<td>65.28* (5)</td>
<td>113.92* (8)</td>
</tr>
<tr>
<td>Plumbers</td>
<td>1.99 (2)</td>
<td>4.01 (4)</td>
<td>12.07 (6)</td>
<td>15.62* (7)</td>
</tr>
<tr>
<td>Tire dealers</td>
<td>3.59 (2)</td>
<td>4.24 (3)</td>
<td>14.52* (5)</td>
<td>20.89* (7)</td>
</tr>
</tbody>
</table>

**Note.**—Estimates are based on the coefficient estimates in Table 4. Numbers in parentheses in pt. B are degrees of freedom.

* Significant at the 5 percent level.