Entry and Exit: *

Spring 2009

1 Empirical work: Bresnahan and Reiss (1991): "Entry and Competition in Concentrated Markets"

- Empirical model of entry when one does not observe strategic variables: prices, costs, advertising, etc.
- Only observe market characteristics, and number of firms (not even market shares). So implicitly assume that all firms have the same market shares in equilibrium. In the background: Sutton(-like) model of symmetric firms, and free entry. No dynamics (assume period-by-period static equilibrium).
- Firms face a two stage problem:
  1. Decide whether to enter
  2. If enter, then compete

*These notes draw upon Matt Shum's lecture notes

Behavioral model

- Solve it backwards. Assuming N firms, derive each firms profits. Demand in market m

$$Q_m = d(Z_m, p) \cdot S(Y_m) \tag{1}$$

  where $d(Z_m, p)$ represents the demand function of a representative consumer, $S(Y)$ denotes the number of consumers, and Y and Z denote demographic variables affecting market demand This demand specication has constant returns to scale: double S, you double Q. Inverse demand curve $P(Q, Z, Y)$.

- Assume Cournot competition (just like Sutton). Each firm solves:

$$\max_{q_i} \big\{ P(q_i, q_{-i}, Z_m, Y_m) \cdot q_i - F_N - C(q_i). \tag{2}$$

  Interpret F_N as fixed costs that can change with N – perhaps "endogenous sunk costs" or perhaps just a reflection that with more entry certain inputs are more expensive (e.g. land prices go up?).

- In symmetric equilibrium: $q_i = q_j = q^*, \forall i, j$. By plugging in equilibrium quantities, symmetric N-firm Cournot profits are

$$\Pi_{N,m} = \big[P(q^*, q^*, Z_m, Y_m) - \frac{C(q^*)}{q^*}\big] \cdot q^* - F_N \tag{3}$$

$$= [P_N - AVC(q^*) - b_N] \cdot d(Z_m, P_N)\frac{S}{N} - F_N - B_N \tag{4}$$

  where $q^* = d(Z_m, p_N)\frac{S}{N}$ (so each firm produces the same amount) and we've added b_N and B_N as crude ways to allow AVC and fixed costs to depend on the number of firms.

- Now go back to stage 1 where firms make entry decisions. Number of firms in market m, N_m^* is determined by free entry conditions
  - All entrants make non-negative profits: $\Pi_{N_m^*} > 0$,
  - Any potential entrant would make negative profits: $\Pi_{N_m^*+1} < 0$.

- Alternatively, for each N, there is a breakeven condition that $\Pi_{N,m} = 0$ which defines the per-firm entry threshold s_N or the market demand level at which N firms would enter:

$$s_N = \frac{S}{N} = \frac{F_N + B_N}{[P_N - AVC_N - b_N] \cdot d_N} \tag{5}$$

- Example: Suppose for dentists that a monopolist will enter if there are 500 people. How many people are needed to support 2 dentists? If 2,000 people, then entry is spurring competition by driving down margins. With lower margins, need more consumers to generate enough revenues to cover costs. But suppose see 2 dentists with 1,000 people – then the level of competition has not changed. But don't know if two dentists are colluding or fully competing.

- The ratio of successive entry thresholds is also important:

$$\frac{s_{N+1}}{s_N} = \frac{F_{N+1} + B_{N+1}}{F_N + B_N} \cdot \frac{[P_N - AVC_N - b_N] \cdot d_N}{[P_{N+1} - AVC_{N+1} - b_{N+1}] \cdot d_{N+1}} \tag{6}$$

  If a market is competitive, then this ratio should $\rightarrow 1$ (i.e., new firms enter as market size increases by a multiple of the MES). This is not true, for example, with endogenous sunk costs

- Point of analysis is to estimate these entry thresholds. But do not observe prices, cost components, etc. How to do it?

Empirical Implementation

- Specify a reduced-form profit function (since prices and costs are not observed):

$$\Pi_{N,m} = S(Y_m, \lambda) \cdot V_N(Z_m, W_m, \alpha, \beta) - F_N(W_m, \gamma) + \epsilon_m \tag{7}$$

$$= \bar{\Pi}_{n,m} + \epsilon_m \tag{8}$$

- Assume profits decline with entry, $\bar{\Pi}_{N,m} > \bar{\Pi}_{N+1,m}$

- Data: observe N_m.

$$
\begin{aligned}
\text{Prob}(N_m) &= \text{Prob}\big(\Pi_{N_m,m} > 0, \Pi_{N_m+1,m} < 0\big) && (9)\\
&= \text{Prob}\big(\bar{\Pi}_{N_m,m} + \epsilon_m > 0, \bar{\Pi}_{N_m+1,m} + \epsilon_m < 0\big) && (10)\\
&= \text{Prob}\big(\epsilon_m > -\bar{\Pi}_{N_m,m}, \epsilon_m < -\bar{\Pi}_{N_m+1,m}\big) && (11)\\
&= \text{Prob}\big(\bar{\Pi}_{N_m+1,m} < \epsilon < \bar{\Pi}_{N_m,m}\big) && (12)
\end{aligned}
$$

- Likelihood function depends on assumptions about ϵ. B/R assume $\epsilon \sim N(0, \sigma^2)$ i.i.d. across markets m, so that

$$
\text{Prob}(N_m) = \begin{cases} \Phi(\bar{\Pi}_{N_m,m}) - \Phi(\bar{\Pi}_{N_m+1,m}), & \text{if } N_m > 0, \\ 1 - \Phi(\bar{\Pi}_{1,m}) & \text{if } N_m = 0. \end{cases} \qquad (13)
$$

  This is an ordered probit model.

Specification details

- Recall the specification is:

$$
\Pi_{N,m} = S(Y_m, \lambda) \cdot V_N(Z_m, W_m, \alpha, \beta) - F_N(W_m, \gamma) + \epsilon_m \qquad (14)
$$

(15)

- Market size $S(Y_m, \lambda)$: Y_m includes size characteristics for market m (population, nearby population, growth, commuters)

- Reduced-form per-capita N-firm profits: $V_N = \alpha_1 - \sum_{n=2}^{N} \alpha_n + X'\beta$
  - X are economic variables, includes demand (Z) and cost (W) shifters
  - α_n's allow number of firms to affect intercept of profits, restrict that each one ≥ 0 so that more firms implies lower per-capita profits.
  - N-firm fixed costs $F_N = \gamma_1 + \sum_{n=2}^{N} \gamma_n + \gamma_L w_L$. The γ_n's allow the number of firms to affect magnitude of fixed costs (capture entry deterrence)

Data and Results

- Used yellowbook and Census data to get information on the number of firms (for a variety of industries) across a large number of towns (isolated markets).
- See figure 3 in paper (dentists)
- See Table 5 for entry threshold estimates and table 4 for ratio of entry thresholds (plumbers always near 1).
- Find that the level of competition seems to level out when there are 3 or 4 firms (hopefully at a competitive level). Or perhaps firms start differentiating their products to maintain markups.

General thoughts

1. Clever paper b/c uses a simple model to extract information from widely available data–the number of firms in a market and demographics of towns.
2. Does rely fairly heavily on parametric assumptions (but I think the results are robust across a number of specifications, etc).
3. Can't infer too much, because only see N_m. Need to incorporate prices and/or quantities to estimate cost and revenue functions, etc
4. Is a static analysis, which is a weird approach with entry/exit. Introducing dynamics into entry/exit models is a current frontier of IO and is currently a very active area of research.
5. B/R analysis leaves open the question of why the number of firms affects entry thresholds. Mazzeo (2002) considers this question, focusing on the possibility that firms avoid the "toughness of price competition" via product differentiation. He considers a BR-type model in which firms have two strategic variables: (i) whether or not to enter, and (ii) what type of product to produce. He studies motel markets: geographically isolated markets with clear quality differentiation (2-star, 3-star, etc.) amongst competitors.

2 Berry (1992): "Estimation of a Model of Entry in the Airline Industry"

- Considering airline entry (i.e. having a city X to city Y flight)— incorporating heterogeneity across firms in fixed costs (e.g. is it your hub?)
- There are K_m potential entrants in market m
- Allow for firm (indexed by k) heterogeneity in fixed costs: (m is the market and N is the total number of firms)

$$\Pi_{m,k,N} = v_m(N) - \phi_{m,k} \tag{16}$$

where the first term is the common component and the second term is the firm k component.

$$\Pi_{m,k,N} = X_m\beta - \delta\log(N) + \rho u_m 0 + Z_k\alpha + \sqrt{1-\rho^2}u_{m,k} \tag{17}$$

where the common component (the first three terms) is like B/R. X are market characteristics observed by the econometrician, and u_{m0} are market characteristics unobserved by the econometrician. Similarly,Z are observed firm characteristics and u_{mk} are firm characteristics unobserved by the econometrician.

- The composite error term for firm k is $\epsilon_{m,k} = \rho u_{m0} + \sqrt{1-\rho^2}u_{m,k}$ where ρ essentially measures the correlation between the errors terms of the firms in a given market. Therefore, Berry assumes that

$$\begin{pmatrix} \epsilon_{m,1} \\ \epsilon_{m,2} \\ \vdots \\ \epsilon_{m,K_m} \end{pmatrix} \sim N\begin{pmatrix} 0, & \begin{matrix} 1 & \rho & \dots & \rho \\ \rho & 1 & \dots & \rho \\ \vdots & \vdots & \vdots & \vdots \\ \rho & \rho & \dots & 1 \end{matrix} \end{pmatrix} \tag{18}$$

- Consider a slightly simplied version of Berrys model. Similar free-entry multi-stage theoretical model (as in B/R) underlying empirics, but now there are K_m error terms (rather than 1, as in B/R) for each market, corresponding to the fixed-cost errors for the K potential entrants in market m:

$$\text{Prob}(n_m = N|Z_m) = \text{Prob}\Big(\epsilon_{m,1}, \ldots, \epsilon_{m,K_m}| \sum_{k=1}^{K_m} \mathbf{1}(v_m(N; Z_m, X_m) > \phi_{m,k}) = N\Big)$$
$$= \int \ldots \int \mathbf{1}\Big(\sum_{k=1}^{K_m} \mathbf{1}(v_m(N; Z_m, X_m) > \phi_{m,k}) = N\Big) dF(\epsilon_{m,0}, \ldots, \epsilon_{m,K_m}; \theta)$$

where θ is a parameter vector and v and ϕ in the equations above depend upon the ϵ's.

Estimation

- Likelihood function as defined above features a multivariate integral which is difficult to compute.

- Estimate by non-linear least squares instead: match data (N_m) to predicted mean $E(n_m|Z_m, X_m; \theta)$.

$$\hat{\theta} = \text{argmin}_\theta \Big\{ \frac{1}{M} \sum_{m=1}^{M} (N_m - E(n_m|Z_m, X_m; \theta))^2 \Big\} \tag{19}$$

where

$$E(n_m|Z_m, X_m; \theta) = \int \ldots \int n^*_m(\epsilon_{m,1}, \ldots, \epsilon_{m,K_m}) dF(\epsilon_{m,1}, \ldots, \epsilon_{m,K_m}; \theta) \tag{20}$$

- Since multivariate integration difficult to handle analytically, use simulation methods to compute this integral. The resulting estimation method is Simulated Nonlinear Least Squares (SNLS):

$$E[n_m|Z_m, X_m; \theta] = \frac{1}{S} \sum_{s=1}^{S} n^{*,s}_m(\epsilon^s_{m,1}, \ldots, \epsilon^s_{m,K_m}; \theta) \tag{21}$$

where $n^{*,s}_m(\epsilon^s; \theta)$ is the equilibrium number of firms n_m for a draw of $\epsilon^s \equiv (\epsilon_{m,1}, \ldots, \epsilon_{m,K_m})$. This is calculated as:

$$n^{*,s}_m(\epsilon^s) = \max_{0 \le n \le K_m} \Big\{ n : \sum_{k=1}^{K_m} \mathbf{1}(v_m(n) > \phi_{m,n}|\epsilon^s; \theta) \ge n \Big\} \tag{22}$$

The s superscript denotes simulated draws from the multivariate normal distribution.

- To reiterate, in order to simulate $E[n_m|Z_m, X_m; \theta)$ we follow these three steps:

  1. For $s = 1, \ldots, S$, draw ϵ^s according to the multivariate normal distribution.
  2. For each draw ϵ^s, calculate $n^{*,s}(\epsilon^s)$. Note – this is NOT easy!
  3. Approximate $E[n_m|Z_m, X_m; \theta)$ by the average $\frac{1}{S}\sum_{s=1}^{S} n^{*,s}(\epsilon^s)$. In the paper, Berry talks about the consistency of this estimator and other asymptotic properties.

- Looking at step 2 (solving for entrants), generally, in models with asymmetric firms where entry is just dictated by free-entry conditions, uniqueness of equilbrium is not guaranteed. A given realization of the firm-specific error vector $\epsilon_1, \ldots, \epsilon_{K_m}$ may support multiple values of N as equilibria. Both in the sense that different total numbers of firms may enter, as well as different groups (but the same overall number) of firms enter.

- Berry overcomes this by his assumption about the order of entry: firms with the highest protability get to move first. This is one of several assumptions you can make – need to choose one that is defensible, and which gives you a unique equilibrium.