1 Sutton: Entry and Equilibrium Market Structure

Sutton (1991)

Main question: how do markets become concentrated? How to interpret the "stylized fact" that advertising is higher in concentrated industries?

Compare the role of sunk costs in different market structures.

1. Perfect competition, with exogenous (and symmetric) sunk costs and free entry. Familiar characteristics of competitive equilibrium: production at minimum efficient scale, (p, q) at $\min AC$.

Effect of increasing market size: as $M \to \infty$, #firms $\to \infty$.

Sutton: when would this relationship not hold?

2. Try imperfect competition, but still exogenous sunk costs and free entry.

Generally, consider two stage game: (1) firms decide whether to enter (and pay fixed costs A); (2) firms play noncooperative oligopolistic game (Sutton considers symmetric Cournot). Note: in general, results are probably sensitive to game played second period (i.e., if homogeneous products Bertrand, then you immediately get perfect competition result).

Suppose N firms enter, and market size is M. Each firm's profits is $\Pi(N, M)$. Free entry determine N:

$$N^*(M, A) : \Pi(N, M) > A, \Pi(N + 1, M) < A.$$

Usual (regularity?) conditions: For a given M, $\Pi(N, M)$ decreasing in N. For a given N, $\Pi(N, M)$ increasing in M. (True for Cournot?)

Limiting behavior: as $M \to \infty$, $N^* \to \infty$, but "entry thresholds" may not be equally spaced, as in perfect competition case. Like Bresnahan/Reiss, size of thresholds may be rising in M (which we would expect if more firms makes market more competitive). This is the framework basically considered by BR.

3. So you still don't get concentration in the limit. Now Sutton considers **endogenous sunk costs**, endogenous in the sense that scale of costs varies depending on N: $A(N)$.

Three-stage game: (1) entry; (2) advertising; (3) Cournot

Free entry:

$$N^*(M) : \Pi(N, M) > A(N), \Pi(N + 1, M) < A(N + 1).$$

$N^*(M)$ may not be monotonic increasing in M, could even be decreasing (i.e., when industry "jumps" from no-advertising to positive advertising).

Possibility that as $M \rightarrow \infty$, $N^* < \infty$: Sutton's "nonconvergence" result. There is a lower bound on concentration.

2 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 firms' market shares). So implicit assume: 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).

Behavioral model Solve it backwards. Assuming N firms, derives each firm's profits.

Demand in market m

$$Q_m = d(Z_m, p) * S(Y_m)$$

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 specification has "constant returns to scale": double S, you double Q. Inverse demand curve $P(Q, Z, Y)$.

Implicitly (??), assume Cournot competition (just like Sutton). Each firm solves:

$$\max_{q_i} P(q_i, q_{-i}, Z_m, Y_m) * q_i - F_N - C(q_i).$$

Interpret F_N are "endogenous sunk costs" (depend on N)?

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

$$\begin{aligned}\Pi_{N,m} &= \left[P(q^*, q^*, Z_m, Y_m) - \frac{C(q^*)}{q^*}\right] * q^* - F_N \\ &= [P_N - AVC(q^*) - b_N] * d(Z_m, P_N)\frac{S}{N} - F_N - B_N\end{aligned}$$

where $q^* = d(Z_m, P_N)\frac{S}{N}$ (so each firm produces the same amount), and b_N and B_N allow AVC and fixed costs, respectively, to depend on the number of firms.

Now go back to first stage. Number of firms in market m, N^*_m, is determined by free entry conditions: $\Pi_{N^*_m,m} > 0$, but $\Pi_{N^*_m+1,m} < 0$.

Alternatively, for each N, breakeven condition $\Pi_{N,m} = 0$ defines the per-firm entry threshold s_N (i.e., market demand level at which N firms would enter):

$$s_N = \frac{S_N}{N} = \frac{F_N + B_N}{(P_N - AVC_N - b_N)\, d_N}.$$

The ratio of successive entry thresholds is also important:

$$\frac{s_{N+1}}{s_N} = \frac{F_{N+1} + B_{N+1}}{F_N + B_N} \frac{(P_N - AVC_N - b_N)\, d_N}{(P_{N+1} - AVC_{N+1} - b_{N+1})\, d_{N+1}}.$$

If 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 (there the ratio $\rightarrow \infty$)??

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

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

$$\begin{aligned} \Pi_{N,m} &= S\,(Y_m, \lambda) * V_N\,(Z_m, W_m, \alpha, \beta) - F_N(W_m, \gamma) + \epsilon_m \\ &\equiv \bar{\Pi}_{nM} + \epsilon_m. \end{aligned}$$

Assume: $\bar{\Pi}_{N,m} + \bar{\Pi}_{N+1,m}$.

Data: observe N_m.

$$\begin{aligned} Prob(N_m) &= Prob(\Pi_{N_m,m} > 0, \Pi_{N_m+1,m} < 0) \\ &= Prob(\bar{\Pi}_{N_m,m} + \epsilon_m > 0, \bar{\Pi}_{N_m+1,m} + \epsilon_m < 0) \\ &= Prob(\epsilon_m > -\bar{\Pi}_{N_m,m}, \epsilon_m < -\bar{\Pi}_{N_m+1,m}) \\ &= Prob(\bar{\Pi}_{N_m+1,m} < \epsilon_m < \bar{\Pi}_{N_m,m}). \end{aligned}$$

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

$$Prob(N_m) = \begin{cases} \Phi(\bar{\Pi}_{N_m,m}) - \Phi(\bar{\Pi}_{N_m+1,m}) & N_m > 1 \\ 1 - \Phi(\bar{\Pi}_{2,m}) & N_m = 1. \end{cases}$$

This is an "ordered probit" model.

Problem: parametric restrictions real important. Without regressors (homogeneous markets), "cut points" chosen to match actual proportions in the data.

Example: in the data, ten markets with $N = 1$, 10 with $N = 2$, ten with $N = 3$, and 10 with $N \geq 4$. For any distribution function F, will find cutpoints $\bar{\Pi}_2 \geq \bar{\Pi}_3 \geq \bar{\Pi}_4$ so that $F(\bar{\Pi}_2) = 3/4$, $F(\bar{\Pi}_2) - F(\bar{\Pi}_3) = 1/4$, etc.

Specification details

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

BR 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.

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

Allow for firm (indexed by k) heterogeneity in fixed costs:

$$\begin{aligned}
\Pi_{m,k,N} &= \underbrace{v_m(N)}_{\text{common component}} - \underbrace{\phi_{m,k}}_{\text{firm } k \text{ component}} \\
&= \underbrace{X_m\beta - \delta \log N + \rho u_{m0}}_{v_m(N)} + \underbrace{Z_k\alpha + \sqrt{1-\rho^2}u_{mk}}_{-\phi_{m,k}}
\end{aligned}$$

where common component is like $\bar{\Pi}_{m,N}$ in B/R.

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

$$\begin{pmatrix} \epsilon_{m,1} \\ \epsilon_{m,2} \\ \vdots \\ \epsilon_{m,K_m} \end{pmatrix} \sim N \left(\mathbf{0}, \begin{bmatrix} 1 & \rho & \cdots & \rho \\ \rho & 1 & \cdots & \rho \\ \vdots & \cdots & \ddots & \vdots \\ \rho & \rho & \cdots & 1 \end{bmatrix} \right). \tag{1}$$

In what follows, I go over a slightly simplified version of Berry's 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_m potential entrants in market m:

$$\begin{aligned} Prob(n_m = N|Z_m) &= Prob\left(\epsilon_{m,1}, \ldots, \epsilon_{m,K_m} : \sum_{k=1}^{K_m} \mathbf{1}(v_m(N; Z_m) > \phi_{m,k}) = N \right) \\ &= \underbrace{\int \cdots \int}_{K_m \text{ times}} \mathbf{1}\left(\sum_{k=1}^{K_m} \mathbf{1}(v_m(N; Z_m) > \phi_{m,k}) = N \right) dF(\epsilon_{m0}, \epsilon_{m1}, \ldots, \epsilon_{mK_m}; \theta) \end{aligned} \tag{2}$$

where θ is a parameter vector. It is understood that the $v(\cdot)$'s and $\phi(\cdot)$'s in the equation depend on the errors ϵ.

Estimation Likelihood function as defined in equation (2) features multivariate integral which is difficult to compute.

Estimate by nonlinear least squares instead: match data (on number of market participants N_m) to predicted mean $E_{\phi_{m,1},\ldots,\phi_{m,K_m}}(n_m|Z_m;\theta)$.

$$\hat{\theta} = argmin_\theta \frac{1}{M} \sum_m (N_m - E_{\epsilon_{m,1},\ldots,\epsilon_{m,K_m}}(n_m|Z_m;\theta))^2$$

where

$$\begin{aligned} &E_{\epsilon_{m,1},\ldots,\epsilon_{m,K_m}}(n_m|Z_m;\theta) = \\ &\int \cdots \int n_m^*(\epsilon_{m,1}, \ldots, \epsilon_{m,K_m}) dF(\epsilon_{m,1}, \ldots, \epsilon_{m,K_m}; \theta). \end{aligned} \tag{3}$$

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

$$E_{\epsilon_{m,1},\cdots,\epsilon_{m,K_m}}(n_m|Z_m;\theta) \approx \\ \frac{1}{S}\sum_s n_m^{*,s}(\epsilon^s_{m,1},\ldots,\epsilon^s_{m,K_m};\theta)$$

where $n_m^{*,s}(\epsilon^s;\theta)$ 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:

$$n_m^{*,s}(\epsilon^s) \equiv \max_{0\leq n\leq K_m}\left\{n: \sum_{k=1}^{K_m}\mathbf{1}\left(v_m(n) > \phi_{m,n}|\epsilon^s;\theta\right) \geq n\right\}. \quad (4)$$

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

To reiterate, in order to simulate $E_{\epsilon_{m,1},\cdots,\epsilon_{m,K_m}}(n_m|Z_m;\theta)$, we following these three steps:

1. For $s = 1,\ldots,S$, draw ϵ^s according to the multivariate normal distribution (1).
2. For each draw ϵ^s, calculate $n^{*,s}(\epsilon^s)$ according to equation (4). (This is not easy!)
3. Approximate $E_{\epsilon_{m,1},\cdots,\epsilon_{m,K_m}}(n_m|Z_m;\theta)$ by the average $\frac{1}{S}\sum_{s=1}^S n^{*,s}(\epsilon^s)$. Consistency and asymptotic (in S) properties of simulated quantity follows from *i.i.d.* LLN and CLT.

How could you use data on prices? Look at predatory models? Look at limit pricing models?

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 $\epsilon_1,\ldots,\epsilon_{K_m}$ ($\bar{N}$ is the number of potential entrants) may support multiple values of N as equilibria, in the sense of

$$\sum_{k=1}^{K_m}\mathbf{1}(v_m(N;Z_m) > \phi_{m,k}) = N$$

for multiple values of $N \in \{1,\ldots,K_m\}$. (In the next section, we go into this in more detail.)

- Berry overcomes this by his assumption about the order of entry: firms with the highest profitability get to move first. (See discussion on pg. 904.)

- More recent entry literature confronts multiple equilibrium problem head-on, and focuses on estimation methods when there are multiple equilibria.

References

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