ECO 310: Empirical Industrial Organization

Lecture 11: Models of Market Entry
Introduction

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Models of Market Entry: Outline

1. **What is a model of market entry?**
2. **Why do we estimate models of market entry?**
3. **Entry models with homogeneous firms**
4. Entry models with heterogeneous firms

Main References

- Bresnahan and Reiss (JPE, 1991)
- Bresnahan and Reiss (Journal of Econometrics, 1991)
- Tamer (REStud, 2003)
- Seim (RAND, 2006)

1. What is a Model of Market Entry?

Main features of a model of market entry

- (1) The dependent variable is **a firm decision to operate or not in a market**.
  - Entry in a market can be understood in a broad sense
  - e.g., entry in an industry; opening a new store; introducing a new product; adopting a new technology; release of a new movie; participate in an auction, etc.
- (2) There is a **fixed sunk cost** associated with being active in the market;
- (3) The payoff of being active in the market depends on the number (and the characteristics) of other firms active in the market, i.e., the model is a **game**.

Main features of a model of market entry [2]

- Consider a market where there are N firms that potentially may to enter in the market.
- $a_i \in \{0, 1\}$ is a binary variable that represents the decision of firm i of being active in the market ($a_i = 1$) or not ($a_i = 0$).
- Profit of not being in the market is zero.
- Profit of being active is: $V_i(n) - F_i$ where $V_i(.)$ is the variable profit, n is the number of firms active, and F_i is the entry cost.
- The number of active firms, n, is endogenous:

$$n = \sum_{i=1}^{N} a_i$$

Main features of a model of market entry [3]

- Under Nash assumption, every firm takes as given the decision of the other firms and makes a decision that maximizes its own profit.
- The best response of firm i under Nash equilibrium is:

$$a_i = \begin{cases} 1 & \text{if} \quad V_i\left(1 + \sum_{j \neq i} a_j\right) - F_i \geq 0 \\ 0 & \text{if} \quad V_i\left(1 + \sum_{j \neq i} a_j\right) - F_i < 0 \end{cases}$$

where $1 + \sum_{j \neq i} a_j$ represents firm i's Nash-conjecture about the number of active firms.

Example

- Two potential entrants: $N = 2$. With $V_1(n) = V_2(n) = 100 - 20\ n$. And $F_1 = F_2 = 50$.
- $V_i\,(1 + a_j) - F_i = 30 - 20\ a_j$
- Best responses are:

$$a_1 = \begin{cases} 1 & \text{if} \quad 30 - 20\ a_2 \geq 0 \\ 0 & \text{if} \quad 30 - 20\ a_2 < 0 \end{cases} \quad \text{and } a_2 = \begin{cases} 1 & \text{if} \quad 30 - 20\ a_1 \geq 0 \\ 0 & \text{if} \quad 30 - 20\ a_1 < 0 \end{cases}$$

- Payoff Matrix:

	$a_2 = 0$	$a_2 = 1$
$a_1 = 0$	$(0\ ,\ 0)$	$(0\ ,\ 30)$
$a_1 = 1$	$(30\ ,\ 0)$	$(10\ ,\ 10)$

Example [2]

	$a_2 = 0$	$a_2 = 1$
$a_1 = 0$	$(0\ ,\ 0)$	$(0\ ,\ 30)$
$a_1 = 1$	$(30\ ,\ 0)$	$(10\ ,\ 10)$

- With this payoff matrix, the unique Nash equilibrium is $(a_1, a_2) = (1, 1)$. Duopoly.

- Suppose that the fixed cost were larger, $F = 90$. Then, $V_i\,(1 + a_j) - F_i = -10 - 20\ a_j$.

	$a_2 = 0$	$a_2 = 1$
$a_1 = 0$	$(0\ ,\ 0)$	$(0\ ,\ -10)$
$a_1 = 1$	$(-10\ ,\ 0)$	$(-30\ ,\ -30)$

- With this payoff matrix, the unique Nash equilibrium is $(a_1, a_2) = (0, 0)$. No entry.

Example [3]

- Suppose that the fixed cost is not as small as 50 and not as large as 90: $F = 70$. Then, $V_i(1 + a_j) - F_i = 10 - 20\ a_j$.

	$a_2 = 0$	$a_2 = 1$
$a_1 = 0$	$(0\ ,\ 0)$	$(0\ ,\ 10)$
$a_1 = 1$	$(10\ ,\ 0)$	$(-10\ ,\ -10)$

- With this payoff matrix, the model has two Nash equilibria: Monopoly of firm 1: $(a_1, a_2) = (1, 0)$; Monopoly of firm 2: $(a_1, a_2) = (0, 1)$.

Example [4]

- For general value of F:

	$a_2 = 0$	$a_2 = 1$
$a_1 = 0$	$(0\ ,\ 0)$	$(0\ ,\ 80 - F)$
$a_1 = 1$	$(80 - F\ ,\ 0)$	$(60 - F\ ,\ 60 - F)$

- We can see that the model has different predictions about market structure depending on the value of the fixed cost:
  - If $F \leq 60$ —> Duopoly is unique Nash equilibrium
  - If $60 < F \leq 80$ —> Monopoly of 1 or 2 are Nash equilibria
  - If $F > 80$ —> No firm in the market is unique Nash equilibrium
- The observe actions of the potential entrants reveal information about profits, about fixed costs.

Two-stage game

- Where does the variable profit $V_i(n)$ comes from?
- It is useful to see **a model of market entry as part of a two stage game**.
- In a **First stage**, N potential entrants simultaneously choose whether to enter or not in a market.
- In a **Second stage**, entrants compete (e.g., in prices or quantities) and the profits $V_i(n)$ of each firm are determined.
- Example (Exercise): Cournot competition with linear demand $P = A - B\ Q$ and constant MCs, c, implies:

$$V_i(n) = \frac{1}{B}\ \left(\frac{A-c}{n+1}\right)^2$$

2. Why do we estimate Models of Market Entry?

Why do we estimate models of market entry?

- **[1] Explaining market structure.**
  - Why different industries (and different markets within the same industry) have different number of active firms?

- **[2] Identification of entry costs parameters.**
  - These parameters are important in the determination of firms profits, market structure, and market power.
  - Fixed costs do not appear in demand or in Cournot or Bertrand equilibrium conditions, so they cannot be estimated in these type of models.

- **[3] Data on prices and quantities may not be available.**
  - Sometimes all the data we have are firms' entry decisions. These data can reveal information about profits and about the nature of competition.

3. Entry Models with Homogeneous Firms

Market entry with homogeneous firms

- We start with an empirical model of entry in an homogeneous product industry and where all the firms have the same costs.
- There are several reasons why we start with this case.
- 1. This is the simpler empirical model of entry, and where this literature started with the seminal work by Bresnahan & Reiss (JPE, 1990).
- 2. The model with heterogeneous firms typically has multiple equilibria, and this makes the estimation more complicated.
- 3. Sometimes we have very limited information about firms' heterogeneous characteristics.

Market entry with homogeneous firms: Data

- Suppose the researcher has data from M markets in the same industry.
- For instance, the supermarket industry. The M markets are M neighborhoods from different Canadian cities.
- Markets are indexed by m.
- The dataset consists of:

$$\text{Data} = \{\ n_m,\ \ S_m,\ X_m : m = 1, 2, ..., M\}$$

n_m = number of active firms;
S_m = market size;
X_m = other exogenous market characteristics affecting demand or costs.

Market entry with homogeneous firms: Model

- All the potential entrants in a market have the same profit function: - Same costs, and same demand (homogenous product).
- The profit function of a firm in market m is:

$$V_m(n) - F_m$$

where $V_m(n)$ is the variables profit, F_m is the fixed cost, and n is the number of active firms in the market.

- We describe below the specification of $V_m(n)$ and F_m in terms of observable variables and unobservables.
- A key feature is that $V_m(n)$ is a strictly decreasing function of n.

Market entry with homogeneous firms: Model [2]

- Under Nash-equilibrium, we have the following conditions:

$$V_m \left(1 + \textstyle\sum_{j \neq i} a_{jm}\right) - F_m \geq 0 \qquad \text{for firms with } a_{im} = 1$$

$$V_m \left(1 + \textstyle\sum_{j \neq i} a_{jm}\right) - F_m < 0 \qquad \text{for firms with } a_{im} = 0$$

- Then, n_m is an equilibrium iff:

$$V_m \left(n_m\right) - F_m \geq 0 \qquad \text{Active firms are in their best response}$$

$$V_m \left(1 + n_m\right) - F_m < 0 \qquad \text{Inactive firms are in their best response}$$

Market entry with homogeneous firms: Model [3]

- We can write the Nash-equilibrium conditions also as:

$$V_m\left(1+n_m\right) < F_m \leq V_m\left(n_m\right)$$

- The equilibrium conditions imply restrictions on fixed costs and more generally on the parameters in the profit function.
- Using these restrictions and the data, we estimate the parameters in the profit function.

Specification of the variable profit function

- Bresnahan and Reiss (JPE, 1990) do not model explicitly the form of price/quantity competition and consider a flexible model for the variable profit.

$$V_m(n) = S_m \; [X_m^v \; \beta^v - \alpha(n)]$$

- S_m represents market size.
- X_m^v is a vector is observable market characteristics affecting variable profits, e.g., income, prices of variable inputs, and β^v is a vector of parameters.
- The parameters $\alpha(1)$, $\alpha(2)$, ... capture the competitive effect. We expect:

$$\alpha(1) < \alpha(2) < \alpha(3) \; ... \; < \alpha(N)$$

Specification of the fixed cost

- The specification of fixed cost is:

$$F_m = X_m^f \, \beta^f + \delta(n) + \varepsilon_m$$

- X_m^f is a vector is observable market characteristics affecting fixed costs, e.g., prices of fixed inputs, and β^f is a vector of parameters.

- ε_m is unobservable of the researcher; and error term.

- The parameters $\delta(1)$, $\delta(2)$, ... capture possible competition effects in fixed costs, as well as potential collusive motives.

$$\delta(1) < \delta(2) < \delta(3) \; ... \; < \delta(N)$$

Equilibrium conditions

- The total profit function is:

$$V_m(n) - F_m = (S_m\ X_m^v)\beta^v - X_m^f\ \beta^f - S_m\ \alpha(n) - \delta(n) - \varepsilon_m$$

- Equilibrium conditions: $n_m = n$ is an equilibrium:

$$V_m\,(1+n) < F_m \leq V_m\,(n)$$

- or equivalently:

$$\begin{aligned} (S_m\ X_m^v)\beta^v - X_m^f\ \beta^f - S_m\ \alpha(n+1) - \delta(n+1) \\ < \varepsilon_m \leq \\ (S_m\ X_m^v)\beta^v - X_m^f\ \beta^f - S_m\ \alpha(n) - \delta(n) \end{aligned}$$

Equilibrium conditions [2]

- Suppose that ε_m is independent of (S_m, X_m) and *iid* $N(0,1)$.
- Let $P_m(n)$ represent the probability $\Pr(n_m = n \mid S_m, X_m)$:

$$\begin{aligned} P_m(n) &= \Phi\left(S_m\left[X_m^v\beta^v - \alpha(n+1)\right] - X_m^f\beta^f - \delta(n+1)\right) \\ &- \Phi\left(S_m\left[X_m^v\beta^v - \alpha(n)\right] - X_m^f\beta^f - \delta(n)\right) \end{aligned}$$

Estimation of the model parameters

- Let θ be the vector of the parameters of the model. $\theta = \left\{ \beta^v,\ \beta^f,\ \alpha(1),\ ...,\ \alpha(N), \delta(1), ..., \delta(N) \right\}$.
- We estimate these parameters using a Maximum Likelihood estimator (MLE).
- The likelihood function of this model and data is:

$$\begin{aligned}
\mathcal{L}(\theta) &= \prod_{m=1}^{M} \Pr(n_m \mid S_m, X_m; \theta) \\
&= \prod_{m=1}^{M} \begin{bmatrix} \Phi\left(S_m \left[X_m^v \beta^v - \alpha(n+1) \right] - X_m^f \beta^f - \delta(n+1) \right) \\ - \\ \Phi\left(S_m \left[X_m^v \beta^v - \alpha(n) \right] - X_m^f \beta^f - \delta(n) \right) \end{bmatrix}
\end{aligned}$$

- The MLE is the value of θ that maximizes $\mathcal{L}(\theta)$.

Answering empirical questions using estimated model

- **[1] Ratio of Entry costs to Variable profits.**
- We can construct the ration: $\dfrac{F_m}{V_m(1)}$, e.g., in market m, the entry cost is 46% of the variable profit of a monopolist in this market.
- **[2] How strong is competition? How quickly profits decline with n?**
- Define the function ratio:

$$r_m(n) = \frac{(n+1)\ V_m(n+1)}{n\ V_m(n)}$$

- This is the ratio between total variable profits with $n+1$ firms and with n firms, e.g., $r_m(1) = 1.45$ means that total variable profits under duopoly are 45% larger than under monopoly,

Answering empirical questions using estimated model [2]

- Economy theory has several predictions on the ratio $r_m(n) = \frac{(n+1)\ V_m(n+1)}{n\ V_m(n)}$
- [1] It is greater or equal than 1, $r_m(n) \geq 1$;
- [2] As n increases, if firms compete and we converge to the competitive equilibrium, then $r_m(n)$ converges to 1.
- [3] As n increases, if firms collude, then $r_m(n)$ does NOT decline and it does not converge to 1.
- [4] **Contestable markets hypothesis.** It is possible to achieve the competitive outcome even with a small number of firms in the market. For instance, if $r_m(4) = 1$, then market m achieves the competitive outcome with only four active firms.

Bresnahan & Reiss (JPE, 1990): Empirical results

- $M = 202$ local markets (small towns)
- Five industries: dentists, doctors, drug stores, plumbers and tire dealers.
- Main Findings:
  - Entry thresholds converge quite fast after the second entrant.
  - After three or four firms, an additional entrant doesn't affect much competition.

Bresnahan Reiss (JPE 1990)

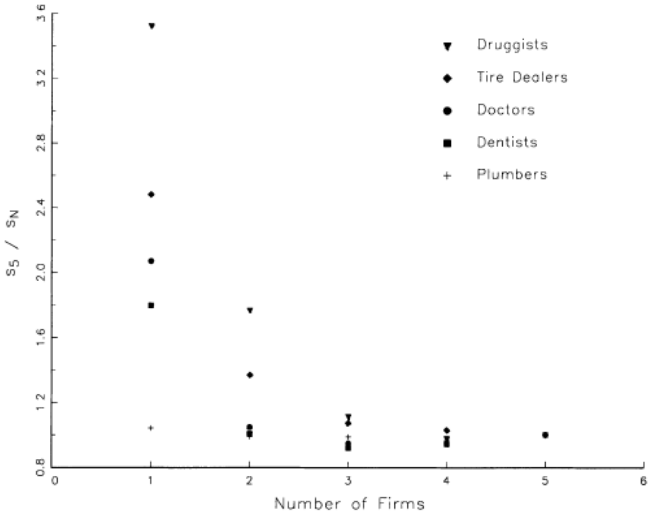

FIG. 4.—Industry ratios of s_5 to s_N by N