Lecture 6: Entry

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Slides draw upon lecture materials from Glenn & Sara Ellison (MIT).

Entry with Homogeneous Products

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Question: In general, what is an approach to solving a model like this one with finitely many stages?

We solve by backward induction, resulting in prices $p^*(N)$ and variable profits $\pi_v^*(N)$ if N firms enter. We then find N^* from the first stage.

Entry with Homogeneous Products (cont.)

Stage 2: Firms that chose to enter play some game like Bertrand, Cournot, or price competition with search. Assume firms have variable costs $c(Q)$.

To analyze Stage 1, we need to know the relationship between N and each firm's variable profits (which is determined by equilibrium of Stage 2). A few examples:

- **Bertrand**: $\pi_v^*(N) = \pi^m$ if $N = 1$; otherwise, $\pi_v^*(N) = 0$.
- **Cournot** (symmetric, with linear demand $P(Q) = a - bQ$): $\pi_v^*(N) = \frac{1}{(N+1)^2}\frac{(a-c)^2}{b}$

Entry with Homogeneous Products (cont.)

Pure strategies

Stage 1: We can consider pure or mixed Nash Equilibria (NE).

In a **pure** subgame perfect Nash equilibrium (SPE), we have:

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- **Question**: Suppose there are M potential entrants. Suppose Stage 2 is symmetric Cournot game and $K > 0$. How many PSNE are there? What profits do entrants earn?

Entry with Homogeneous Products (cont.)

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$$N \sim \text{Binomial}(M, \lambda)$$

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If I enter, I earn zero profit if anyone else enters; if I'm the only one who enters, I earn π^m. So expected profit is $(1-\lambda)^{M-1}\pi^m$.

So the unique symmetric mixed strategy equilibrium has

$$\lambda^* = 1 - \left(\frac{K}{\pi^m}\right)^{\frac{1}{M-1}}$$

Entry with Homogeneous Products (cont.)

Observations:

- With lower fixed costs, we get more entry.
- In many models, $N^* \to \infty$ as $K \to 0$.
- Equilibrium profits are a rounding error, so profits are not directly related to factors that increase markups conditional on N.

Efficiency of Entry with Homogeneous Products

We can compare equilibrium entry with multiple benchmarks.

First best: Question: What is first best here?

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Second best: Question: What is second best here?

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Second best: Maximize welfare, taking second-period equilibrium strategies (e.g., $p^*(N)$ or $q^*(N)$) as given. For the Cournot game,

$$N^{2B} = \arg\max_N W(N) \equiv \arg\max_N \int_0^{Nq^*(N)} P(s)ds - Nc\left(q^*(N)\right) - NK$$

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How does this compare to equilibrium number of firms N^*?

Efficiency of Entry with Homogeneous Products (cont.)

Proposition: Suppose $W(N)$ is concave, $\pi_v^*(N)$ is decreasing, and $p^*(N)$ and $q^*(N)$ can be extended to continuous functions with:

- $\frac{\partial}{\partial N}(N \cdot q^*(N)) > 0$
- $\frac{\partial}{\partial N}(q^*(N)) < 0$
- $p^*(N) - c'(q^*(N)) > 0$

Then:

$$N^* \geqslant N^{2B} - 1$$

Efficiency of Entry with Homogeneous Products (cont.)

Proof: Extend $W(N)$ to a differentiable function using $p^*(N)$ and $q^*(N)$. Let $\hat{N}^{2B}$ be the solution to $W'(\hat{N}^{2B}) = 0$.

The second-best number of firms will be $N^{2B} \leqslant \lceil \hat{N}^{2B} \rceil$, assuming $W(N)$ is single-peaked. The first-order condition defining $\hat{N}^{2B}$ gives:

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$$P(Nq^*(N)) \left(q^*(N) + Nq^{*\prime}(N) \right) - c\left(q^*(N)\right) - Nc'\left(q^*(N)\right) q^{*\prime}(N) - K\big|_{N=\hat{N}^{2B}} = 0$$

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$$\pi_v^*(N) + \underbrace{N\left(p^*(N) - c'(q^*(N))\right) q^{*\prime}(N)}_{\equiv \delta < 0} - K\big|_{N=\hat{N}^{2B}} = 0$$

$$\Rightarrow \pi_v^*(\hat{N}^{2B}) = K - \delta > K$$

$$\pi_v^*(\hat{N}^*) = K \text{ and } N^* = \lfloor \hat{N}^* \rfloor$$

$$\Rightarrow N^* \geqslant \lfloor \hat{N}^{2B} \rfloor$$

Efficiency of Entry with Homogeneous Products (cont.)

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Efficiency of Entry with Homogeneous Products (cont.)

Question: Intuition for this (weakly) excessive entry result? Welfare benefits of entry come purely from quantity increases. But the entering firm captures more than this because other firms' quantities decrease so excessive fixed entry costs are incurred. This is referred to as **business stealing**.

1. In numerical examples one often finds that many more firms enter than is socially optimal because most of the marginal entrant's demand is business stealing, e.g. in N firm Cournot with $D(p) = 1 - p$, we have $q^*(N) = \frac{1}{N+1}$. The increase in total output from the Nth firm is just $\frac{N}{N+1} - \frac{N-1}{N} = \frac{1}{N(N+1)}$.

2. We can get one firm too few in Bertrand-like environments and the welfare loss from the slightly insufficient entry can be large. In a pure SPNE of a Bertrand model only one firm enters, so free entry leads to monopoly. If K is not too large, the social planner would prefer to have two firms enter, leading to $p^* = c$.

Welfare Effects of Entry

Beyond the homogeneous goods environment, entry can be too high or too low.

$$W_N = \sum_{i=1}^{N} \pi_v^*(N) + CS(N) - N \cdot K$$

$$W_{N+1} = \sum_{i=1}^{N+1} \pi_v^*(N+1) + CS(N+1) - (N+1) \cdot K$$

The change in welfare from the last entrant is:

$$\Delta W = (\pi_v^*(N+1) - K) + \sum_{i=1}^{N} (\pi_v^*(N+1) - \pi_v^*(N)) + CS(N+1) - CS(N)$$

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Entry is socially optimal iff $\Delta W > 0$. Free entry may differ from this for two reasons:

1. Business stealing can lead to excessive entry.
2. Firms do not internalize gains in consumer surplus. This can lead to insufficient entry.

Our previous theorem implied that with homogeneous goods the second is outweighed by first (except perhaps for leading to one firm too few). On the margin, a reduction in price is just a transfer that increases CS by the same amount by which it reduces profit.

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Consider a Hotelling-like model with mass 1 of consumers who get utility $v - p_j - t \cdot d_{ij}$ from buying at distance d_{ij} arranged around a circle of circumference one.

If N firms enter, they are arranged evenly around the circle. Suppose they have zero marginal cost.

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- We can show that $\pi_v^*(N) = t/N^2$, so $N^* = \sqrt{t/K}$
- $N^{2B} = \sqrt{t/4K} = \frac{1}{2}N^*$
- Intuitively, the extra CS-improving effect from entry exists, but is fairly weak with these preferences; most of the firm's marginal demand is still due to business stealing.
- Things can work out differently with other distributions of idiosyncratic tastes.

Firm Dynamics with Learning

Jovanovic (1982) discusses entry, growth, and exit in a model with learning.

Setup:

- Continuum of small potential entrants with a fixed cost K of entry and liquidation value w.
- Firms have unknown types $\theta_i \sim N(\theta_0, \sigma_\theta^2)$.
- Firm i's period t cost is $c(q_{it})f(\theta_i + \epsilon_{it})$, with N convex and f increasing and bounded.
- Firms don't know their types but get signals every time they produce and update their beliefs.

Firms act as price takers with optimal behavior depending on the mean and variance of their posterior beliefs.

$$q_{it} \in \text{argmax}_q E_{\theta_i} \left[p_t q - c(q) f(\theta_i + \epsilon_{it}) \right]$$

Firm Dynamics with Learning (cont.)

Optimal Behavior:

- Low $E(\theta_i)$ implies high q_{it}.
- Medium $E(\theta_i)$ implies low q_{it}.
- High $E(\theta_i)$ with high uncertainty implies low q_{it}.
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Empirical Predictions:

1. Small firms grow faster and fail more often.
2. Bigger firms have higher profits.
3. Larger firms' profits are more serially correlated.

Other topics related to entry

- Theory: Entry with vertical differentiation
- Theory: Strategic actions (e.g., investment) to deter or accommodate entry.
- Empirical work on excessive entry
- Empirical methods: Use observed entry decisions to infer entry costs (moment inequality methods)

Next time

Start Part 2 of the course