Industrial Dynamics: evolution as a model of equilibrium and Sutton's bounds approach

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Outline

1. Jovanovic, 1982
2. Ericson and Pakes, 1995
3. Sutton's Bounds approach

Introduction

- Previous lectures
  - Stylized facts in micro-economics
  - S-C-P a first paradigm in which to investigate some facts
- There have been attempts to account for a number of stylized facts in a framework of equilibrium.
- Jovanovic (1982) Selection and the evolution of industry
- Ericson and Pakes (1995) Markov-Perfect Industry Dynamics: A framework for empirical work

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Jovanovic (1982)

- From which stylized facts does it depart?
  - Smaller firms have higher and more variable growth rates (Mansfield, 1962).
  - (relatedly) Smaller (younger) firms have higher probability to fail than larger firms.
  - Firm size distribution is skewed to the right (Gibrat's law).
- Main intuition
  - At entry all firms look alike
  - Firms discover (learn) their productivity over time, staying in the industry
  - Over time only "good" firms survive (selection effect)
  - "Bad" firms decline in size and then exit (selection effect)

Overview of the model I

- Small industry to which factors are supplied at constant price;
- Homogeneous product; time path of demand is deterministic and known;
- Costs are random and *different* among firms (source of firms' heterogeneity);
- Distribution of firms' cost is known, but no firm knows its own;
- All firms share the same prior beliefs about their own cost;
- Prior beliefs are update as evidence comes in;

Overview of the model II

- If firm's draw of cost is low $\Rightarrow$ high probability of survival;
- Number of firms is always infinite;
- Firms - and potential entrants - know the entire equilibrium price sequence and based on it, make entry, production and exit decisions;
- A one time entry cost is bore at the time of entry;
- At equilibrium, NPV of entry cannot be positive, for if it were there would be entry.

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Implications of the model

- Exit rate decreases with age;
- Surviving firms are larger than exiting firms;
- Successful firms grow faster:
  - If a firm learns that it has a lower cost than expected, it increases production;
  - Alternative (standard) explanation would rely on credit constraint and internally financed growth
- The sequences of output tend to diverge
  - Entrants are smaller and homogenous
  - FSD tend to be more disperse over time: Gini index increases over time.
- Variance of growth rates larger for smaller than bigger firms
  - (passive) learning process. Over time firms get finer perception of their "true" productivity

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Ericson and Pakes, 1995

- Ericson and Pakes (EP) framework is designed to capture the evolution of industry with heterogeneous firms.
- As before, at every period every firm decides whether to stay in the market or exit.
- And now, if it stays it has to decide how much to invest.
- Time is discrete, infinite horizon.
- Dynamics of the model are generated by stochastic outcomes of firm's investment (and the outcome of an exogenous process reflecting improvements made by competition outside the industry).

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The model I

- Technology is open to all firms. The only distinction among firms is their "success" in exploiting its (efficiency).
  - $\omega \in \mathbb{Z}$ is such level of efficiency
  - Higher ω indicates that the firm is in a stronger position
- Industry structure at any point in time: $s = \{s_\omega\}_{\omega \in \mathbb{Z}} \in \mathbb{Z}^+$
  - where s provides the number of firms at each possible ω state
- The state (ω, s) changes a result of the outcomes of the firm's own investment (and market environment in general)
- The firm's level of investment $x_t \in \mathbb{R}^+$ is chosen to max. expected present value of profits
- (stochastic feature) Higher investment today is no guarantee of more favorable state tomorrow, but it provides a more favorable distribution.

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Model II

- Incumbent
  - If it stays in the market: makes investment decision (previous slide)
  - Assess the exit option based on a scrap value, ϕ_i. Scrap value is drawn from a distribution at the beginning of every period.
  - Scrap value is known before decision of stay/exit and is *private* information.
- Entrant
  - Potential entrant i, incurs in a setup cost ϕ_i^e (*private information*) and chooses initial investment x_i^e
- Payoffs and strategies are symmetric and anonymous
  - This allows to dramatically reduce the dimensionality of the problem

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The Model III

- Incumbent's problem: intertemporal max. problem to determine exit/investment decisions.
- $V(\omega_i, \omega_{-i}, \phi)$ is the expected net present value of all future cash flows to incumbent i, when industry structure is ω, and the firm has drawn scrap value ϕ
    - $V(\omega_i, \omega_{-i}, \phi) = \pi(\omega_i, \omega_{-i}) +$ $\max\left\{\phi, \max_{x_i} -x_i + \beta E\left[V(\omega_i^{'}, \omega_{-i}^{'}, \phi^{'}) | \omega_i, \omega_{-i}, x_i\right]\right\}$
    - β common discount operator
    - E expected operator

The Model IV

- Entrant's problem
  - $V^e(\omega, \phi^e) = \max \left\{ 0, max_{x_i^e} - \phi^e - x_i^e + \beta E\left[.\right] \right\}$
  - where $E[.]$ describes the same expectation as before.

The Equilibrium

- A Markov Perfect Equilibrium is a set of functions such that:
- The policy functions solve the incumbent and entrants problems given beliefs
- The perceived aggregate transition probabilities are consistent with the optimal response of all agents.
- Equilibrium exists and is unique (refer to the paper)

Sutton's Bounds approach

- Research questions: What determines market structure?
  - Firm size distribution
  - Concentration levels
- Moves from some weakness of recent past game theoretic approach to IO.
- He stresses that many outcomes in economic data are driven by a number of factors, some of which are difficult to measure, proxy or control for in empirical work.
- It is not a problem of game theoretic methods, per se, because such problems arise whether we choose to model the industry in a game theoretic fashion or otherwise.

- Some examples:
  - To model the firm entry in an industry: One can adopt ‘simultaneous’ vs ‘sequential’ entry
  - For post entry competition, we can use Cournot (Nash equilibrium in quantities) or Bertrand (NE in prices)
- Yet - Sutton argues - when we get to empirical work, we have no way of measuring, proxing or controlling for such distinctions.
- Two responses have emerged in the literature:
- ‘single industry approach’
  - Focus on the modeling of a single market, where high degree of information is available, and ‘customize’ the form of the model to the market under investigation.
- ‘bounds approach’
  - “the aim is to build the theory to focus the attention on those predictions which are robust across a range of model specifications which are deemed ‘reasonable’, in the sense that we cannot discriminate a priori in favor of one rather than another on empirical grounds.”

- A radical feature of the ‘bounds approach’ is that it involves a departure from the standard notion of a ‘fully specified model’ with a unique equilibrium outcome.
- Different members of the set of admissible models will generate different equilibrium outcomes, and the aim in this approach is to specify bounds on the set of observable outcomes: in the space of outcomes, the theory specifies a region, rather than a point.

Some more references

- Einav and Levin, “Empirical Industrial Organization: A progress report”, J. Econ. Persp. 24, 2010
- Ericson and Pakes “Markov-Perfect Industry Dynamics: A framework for empirical work”, Review of Ec St, 62, 1995.
- Fisher “Games economist play: A noncooperative view” Rand Journal, 20, 1989.
- Jovanovic “Selection and the Evolution of Industry”, Econometrica, 50, 1982.
- Pelzman “The Handbook of industrial organization: A review article” JPE, 99, 1991.
- Sutton, “Technology and Market Structure: theory and history” MIT press, 1998.
- Sutton, “Market Structure: Theory and Evidence”, Handbook of IO, 2007