INDUSTRIAL ORGANIZATION II (ECO 2901)

University of Toronto. Department of Economics. Spring 2010
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FINAL EXAM

Take Home Exam. Due on Tuesday, April 13 before Midnight

Answer all the questions.

Consider an oligopoly industry characterized by local competition. A researcher has panel data of M local markets over T years, where M is large and T is small. Markets are indexed by m and years are indexed by t. For every market and year, the dataset includes information on: market size, s_{mt}; the number of active firms, n_{mt}; the number of new entrants during the year, en_{mt}; and the number of exiting firms, ex_{mt}. A descriptive analysis of these data reveals the following *stylized facts*.

> (SF.1) There is simultaneous entry and exit at the individual market level. A significant proportion of the observations (m, t) are characterized by $en_{mt} > 0$ and $ex_{mt} > 0$.
> (SF.2) For every cross-section of markets (every period t), there is positive correlation between the number of entrants and the number of exiting firms.
> (SF.3) Conditional on market size s_{mt}, entry is positively correlated (and exit is negatively correlated) with the number of incumbent firms at the beginning of the year. For instance, in a linear regression of en_{mt} on s_{mt} and n_{mt-1} the estimate of the coefficient associated to n_{mt-1} is positive and statistically significant.

Consider the following model of oligopoly competition in a local market. There are N firms that may operate in the market. A firm in this market can be either active or inactive. The profit of an inactive firm is zero. The profit of an active firm in a market with n competitors is:

$$\Pi_{mt}(n) = s_{mt}\left(\theta_0^{VP} - \theta_1^{VP} n\right) - \theta^{FC} - \varepsilon_{imt} - (1 - a_{imt-1})\theta^{EC}$$

θ_0^{VP}, θ_1^{VP}, θ^{FC}, and θ^{EC} are parameters. a_{imt-1} is the binary indicator of the event "firm i was an incumbent at period $t-1$". ε_{imt} is a component of the fixed operating cost that varies over time, across markets, and across firms, and it is private information of firm i. We assume that ε_{imt} is iid over time, markets, and firms, with a $N(0, \sigma_\varepsilon^2)$ distribution. Market size evolves exogenously over time according to a Markov process with transition probability function $f_s(s_{mt+1}|s_{mt})$. Every period t, firms observe market size, the number of active firms in the market at previous period, and their own private fixed cost, and then they decide simultaneously whether to be active in the market or not. Firms are forward-looking and play strategies that depend only on payoff-relevant state variables. The equilibrium in this model is a Markov Perfect Equilibrium (MPE). Given that firms are identical, up to their private information ε_{imt}, we consider only symmetric MPE.

Question 1 (20 points): Describe in detail the structure of a MPE in this model. Derive and explain the following objects in this model:

(1.1) the vector of payoff relevant state variables;
(1.2) the expected one-period profit;
(1.3) the transition probability of the state variables;
(1.4) the dynamic decision problem of an incumbent firm and his best response function;
(1.5) the dynamic decision problem of a potential entrant and his best response function;
(1.6) the best response probability function;
(1.7) the MPE as a fixed point of a mapping in the space of firm's choice probabilities.

Question 2 (10 points): Let x_{mt} be the vector (s_{mt}, n_{mt-1}). Let $P_0(x_{mt})$ be the probability that a potential entrant chooses to enter in the market, and let $P_1(x_{mt})$ be the probability that an incumbent firm decides to stay in the market. Let $P_{en}(en_{mt}|x_{mt})$ and $P_{ex}(en_{mt}|x_{mt})$ be the probability distributions for the number of entrants and the number of exits conditional on x_{mt}, respectively.

(2.1) Write the distribution $P_{en}(.|x_{mt})$ in terms of the probability $P_0(x_{mt})$, and the distribution $P_{ex}(.|x_{mt})$ in terms of the probability $P_1(x_{mt})$;
(2.2) Show that there is a one-to-one relationship between $P_{en}(.|x_{mt})$ and $P_0(x_{mt})$, and between $P_{ex}(.|x_{mt})$ and $P_1(x_{mt})$.
(2.3) Based on the result in (2.2), define a MPE in the model as a fixed point of a mapping in the space of the probability distributions $P_{en}(.|x_{mt})$ and $P_{ex}(.|x_{mt})$.

Question 3 (20 points): Consider the conditional log-likelihood function:

$$l(\theta) = \sum_{m=1}^{M} \log \Pr\left(n_{m2},\ n_{m3},\ ...,\ n_{mT} \mid n_{m1},\ s_{m1},\ s_{m2},\ ...,\ s_{mT}\right)$$

where θ is the vector of structural parameters.

(3.1) Write this log-likelihood function in terms of the probabilities $P_{en}(en_{mt}|x_{mt})$ and $P_{ex}(ex_{mt}|x_{mt})$.
(3.2) Suppose that for every value of θ the model has a unique equilibrium. Describe in detail a method for the estimation of θ in this model.
(3.3) In general, there are values of θ for which the model has multiple equilibria. Describe in detail a two-step method for the estimation of θ. Explain how this method can be extended recursively.

Question 4 (10 points): Explain why this model can explain the empirical evidence in (SF.1) but it cannot explain stylized facts (SF.2) and (SF.3).

Question 5 (20 points): To explain the evidence in (SF.2) consider the following two hypotheses. Hypothesis 1 (Market heterogeneity in the variance of idiosyncratic shocks): Markets are heterogeneous in the dispersion of the private information shocks. For instance, $\varepsilon_{imt} \sim N(0, \sigma_{mt}^2)$ where $\sigma_{mt}^2 = (\lambda s_{mt})^2$. Hypothesis 2 (Creative Destruction): a firm's idiosyncratic shock ε_{imt} has two components, $\varepsilon_{imt} = \varepsilon_{imt}^{(p)} + \varepsilon_{imt}^{(c)}$, where $\varepsilon_{imt}^{(p)}$ is private information of firm i but $\varepsilon_{imt}^{(c)}$ is common knowledge of all the firms.

(5.1) Explain why these hypotheses could explain the evidence in (SF.2).
(5.2) Is it possible to distinguish empirically between the two hypotheses using these data? Explain why/how.
(5.3) Propose a method to estimate the model under hypothesis 1.
(5.4) Propose a method to estimate the model under hypothesis 2.

Question 6 (20 points): To explain the evidence in (SF.3) consider the following two hypotheses. Hypothesis 3 (Market heterogeneity in average fixed costs): The fixed operating cost in market m is $FC_m = \theta^{FC} + \omega_m$, where ω_m is a zero mean random variable that is common knowledge to all the firms. Hypothesis 4 (Uncertainty with "learning-by-being-active" and "learning from others"): The fixed operating cost in market m is $FC_m = \theta^{FC} + \xi_m$, and ξ_m is a zero mean random variable that is unknown to a potential entrant but it is perfectly known by active firms. If a firm enters in market m, it immediately learns the value of ξ_m, i.e., learning-by-being-active. Potential entrants observe whether incumbent firms stay in the market or exit, and they use this information to update their beliefs about the value of ξ_m, i.e., learning from others.

(6.1) Explain why these hypotheses could explain the evidence in (SF.3).
(6.2) Is it possible to distinguish empirically between the two hypotheses using these data? Explain why/how.
(6.3) Propose a method to estimate the model under hypothesis 3. For simplicity, suppose that ω_m can take only two values and it has a known distribution.
(6.4) Propose a method to estimate the model under hypothesis 4. For simplicity, suppose that ξ_m can take only two values and it has a known distribution.