ECO 3901
EMPIRICAL INDUSTRIAL ORGANIZATION

Lecture 4
MARKET ENTRY AND EXIT

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February 10, 2022

Lecture 4: Market Entry and Exit Outline

1. **Introduction to dynamic games of market entry and exit**

2. **A fundamental identification problem**

3. **Dunne et al. (2013) on health services in small towns**

1. Introduction to dynamic games of market entry and exit

Main features of a model of market entry/exit

1. **Decision variable** $a_{it} \in \{0,1\}$: firm's decision to operate in a market.
2. The **endogenous state variable** is $a_{i,t-1}$. If $a_{i,t-1} = 1$, the firm is an **incumbent**. If $a_{i,t-1} = 0$, the firm is a **potential entrant**.
3. **Profit function**:

$$\Pi_{it} = \begin{cases} 0 & \text{if } a_{i,t-1} = 0 \ \& \ a_{it} = 0 \\ \\ \text{Variable Profit}_{it}(\mathbf{a}_{-it}) - \text{Fixed Cost}_{it} - \text{Entry Cost}_{it} & \\ & \text{if } a_{i,t-1} = 0 \ \& \ a_{it} = 1 \\ \\ \text{Scrap Value}_{it} & \text{if } a_{i,t-1} = 1 \ \& \ a_{it} = 0 \\ \\ \text{Variable Profit}_{it}(\mathbf{a}_{-it}) - \text{Fixed Cost}_{it} & \\ & \text{if } a_{i,t-1} = 1 \ \& \ a_{it} = 1 \end{cases}$$

Main features of a model of market entry/exit [2]

4. **Exogenous state variables $\mathbf{z}_t$** Market size affecting Variable Profit; input prices (land price) affecting Fixed Cost and Entry Cost. Follow $f_z(\mathbf{z}_{t+1}|\mathbf{z}_t)$.

5. **Structural parameters**

$$\boldsymbol{\theta} = \{ \ VP_i(.), \ FC_i, \ EC_i, \ SV_i, \ f_z(.) \ : i \in \mathcal{I}\}$$

6. **Main predictions of the model**. The model CCPs are the probabilities of market entry and exit as a function of market structure at previous period.

$$P_i(a_{it} = 1|a_{i,t-1} = 0, \mathbf{a}_{-i,t-1}, \mathbf{z}_t) = \text{Entry probabilities}$$

$$\mathrm{P}_i(a_{it} = 0|a_{i,t-1} = 1, \mathbf{a}_{-i,t-1}, \mathbf{z}_t) = \text{Exit probabilities}$$

Different versions of models of market entry/exit

- In empirical applications, we can distinguish four classes of models based on the combination of **two criteria**.

1. **Structural vs. reduced form variable profit function**

2. **Heterogeneous vs. homogeneous firms**

Structural vs. reduced form variable profit function

- In empirical applications, where the data includes information on prices and quantities at the local market level, it is possible to estimate demand and marginal costs.

- Given these estimates, together with a static equilibrium concept (e.g., Bertrand, Cournot), we can obtain the (static) **equilibrium variable profit functions** $VP_i(\mathbf{a}_{-it}, \mathbf{z}_t)$ for any possible market structure, in the data or not.

- These estimates $\widehat{VP}_i(\mathbf{a}_{-it}, \mathbf{z}_t)$ can be used "as data" in the estimation of the dynamic game.

- An attractive implication is that the other parameters – EC, FC, SV – are identified/estimated in dollar amounts, and not just "up to scale".

Structural vs. reduced form variable profit function [2]

- In many applications, the data DOES NOT include information on prices and quantities at the local market level. Parameters in the variable profit function should be estimated from the market entry/exit game together with EC, FC, and SV.

- In principle, one could consider a structural specification of $\widehat{VP}_i(\mathbf{a}_{-it}, \mathbf{z}_t)$. However, in general, with these data, it is not possible to separately identify demand and marginal cost parameters.

- Following, **Bresnahan & Reiss (1990, 1991, 1994)** the standard approach is using a "quasi" reduced form specification of $\widehat{VP}_i(\mathbf{a}_{-it}, \mathbf{z}_t)$.

Structural vs. reduced form variable profit function [3]

- The following specification is used in different applications:

$$VP_i(\mathbf{a}_{-it}, \mathbf{z}_t) = s_t \left[\mathbf{z}_t' \; \boldsymbol{\theta}_i^{VP} - \sum_{j \neq i} \theta_{ij}^{VP} \; a_{jt} \right]$$

- s_t is a measure of market size.
- $\{\boldsymbol{\theta}_i^{VP} : i \in \mathcal{I}\}$ and $\{\theta_{ij}^{VP} : i, j \in \mathcal{I}, i \neq j\}$ are parameters.
- θ_{ij}^{VP} measures the effect on firm i's profit of market entry by firm j.
- Firm i's monopoly profit $= s_t \left[\mathbf{z}_t' \; \boldsymbol{\theta}_i^{VP} \right]$.
- Profit under i, j duopoly $= s_t \left[\mathbf{z}_t' \; \boldsymbol{\theta}_i^{VP} - \theta_{ij}^{VP} \right]$.

Heterogeneous vs. Homogeneous firms

- Some industries are characterized by multiple geographic/local markets and a **few firms that are potential entrants in every (or most) local markets**.

  - E.g., Airlines, supermarkets.

- For these industries, we observe every firm i making entry/exit decisions in many local markets.

- These data allow for very rich forms of firm heterogeneity. Structural parameters, VP_i, EC_i, FC_i, and SV_i, and CCPs **can vary freely across firms**.

- In these models, a firm's strategy (and CCP) depends on the whole vector $\mathbf{a}_{t-1} = (a_{1,t-1}, a_{2,t-1}, ..., a_{N,t-1})$.

Heterogeneous vs. Homogeneous firms [2]

- Other industries are characterized by "local players". **Every firm is a potential entrant in only one market**.

  - E.g., Dentists, restaurants, Airbnb.

- For these industries, we observe every firm i making entry/exit decisions in only one local market.

- Furthermore, the data includes limited or no information at all about predetermined characteristics of potential entrants (or even who are).

- Applications for these industries and data need to impose homogeneity restrictions on firms' profits.

Heterogeneous vs. Homogeneous firms [3]

- In this context, common restrictions are that:

  (i) All structural parameters in the profit function are homogeneous across firms;

  (ii) Only the number of competitors (n_t) and not their identity ($\mathbf{a}_{-it}$) matters for competition effects.

- For instance,

$$VP(n_t, \mathbf{z}_t) = s_t \left[\mathbf{z}_t' \, \boldsymbol{\theta}_0^{VP} - \theta_1^{VP} \, n_t \right]$$

- In these models, under MPE, a firm's strategy (and CCP) depends on its own incumbency status ($a_{i,t-1}$) and the number of incumbents at previous period (n_{t-1}) but not on the previous incumbency of each competitor ($\mathbf{a}_{-i,t-1}$).

Why do we estimate models of market entry/exit?

1. **Identification of entry and fixed costs**.
   - These parameters are important in the determination of firms profits, market structure, and market power.
   - FC, EC do not appear in demand or in Cournot or Bertrand equilibrium conditions, so they cannot be estimated in those models.

2. **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 competition.

3. **Dealing with endogenous entry/exit in production function and / or demand estimation**.

2. A fundamental identification problem

(based on: Aguirregabiria & Suzuki (QME, 2014)
Kalouptsidi, Souza-Rodrigues, & Scott (QE, 2021))

Model

- Consider the following representation of the profit function:

$$\pi_t = \begin{cases} vp(z_t) \; - \; fc(z_t) \; - \; (1 - a_{t-1}) \; ec(z_t) & \text{if } a_t = 1 \\ \\ sv(z_t) & \text{if } a_t = 1 \end{cases}$$

- where: $vp(.)$ is variable profit; $fc(.)$ is fixed cost; $ec(.)$ is entry cost; $sv(.)$ is scrap value; and z_t are exogenous state variables.

- Suppose that $vp(z_t)$ is known to the researcher, e.g., it has been estimated using data from prices and quantities.

- Our purpose is the estimation of functions $fc(.)$, $ec(.)$, and $sv(.)$.

Identification problem

- The data to identify these functions consists of $vp(z_t)$, and the CCPs $P(1|0, z_t)$ (entry of potential entrants) and $P(1|1, z_t)$ (staying of incumbents).
- These two CCPs are not sufficient to identify the three structrural parameters/functions, even if we assume that these functions do not depend on z_t.
- No plausible exclusion restrictions.
- Standard approach is restricting one of these three functions to be zero: either $fc(z_t) = 0$; or $ec(z_t) = 0$; or $sv(z_t) = 0$.

Identification problem [2]

- In general, these restrictions are not correct. In this context, two relevant questions are:

1. What are the implications of these "normalizations" (restrictions) on the estimates of the other functions? Do they still have an economic interpretation?

2. What are the implications of these "normalizations" (restrictions) on counterfactual experiments using the estimated model? Are counterfactual CCPs correct?

Interpretation of estimates depending on the normalization

Table 1 Interpretation of estimated structural functions under various "normalizations"

Normalization	Estimated Functions		
	$\widehat{sv}(\mathbf{z}^c)$	$\widehat{fc}(\mathbf{z}^c)$	$\widehat{ec}(\mathbf{z}^c)$
$\widehat{sv}(\mathbf{z}^c)=0$	0	$fc(z^c)+sv(z^c)$ $-\beta E[sv(z^c_{t+1})\|z_t=z]$	$ec(z^c)-sv(z^c)$
$\widehat{fc}(\mathbf{z}^c)=0$	$sv(z^c)$ $+\sum_{r=0}^{\infty}\beta^r E[fc(z^c_{t+r})\|z_t=z]$	0	$ec(z^c)$ $+\sum_{r=0}^{\infty}\beta^r E[fc(z^c_{t+r})\|z_t=z]$
$\widehat{ec}(\mathbf{z}^c)=0$	$sv(z^c)-ec(z^c)$	$fc(z^c)+ec(z^c)$ $-\beta E[ec(z^c_{t+1})\|z_t=z]$	0

Implications of "normalizations" on counterfactual experiments

- Suppose that we are interested in using the estimated structural model to study the effects on firms' behavior (CCPs) of a counterfactual change in the structural parameters $\boldsymbol{\theta}$.

- **Example**: A change in entry cost from the factual $ec(z_t)$ to a counterfactual $ec^*(z_t)$.

- Let $\boldsymbol{\theta}^0 \equiv (vp^0, fc^0, ec^0, sv^0, \beta^0, f_z^0)$ be the true "factual" parameters.

- Let $\boldsymbol{\theta}^*$ be counterfactual values of the structural parameters.

- And let $\Delta_\theta \equiv \boldsymbol{\theta}^* - \boldsymbol{\theta}^0$ be the perturbations that define the counterfactual experiment:

$$\Delta_\theta \equiv \boldsymbol{\theta}^* - \boldsymbol{\theta}^0 = \left(\Delta_{vp}, \ \Delta_{fc}, \ \Delta_{ec}, \ \Delta_{sv}, \ \Delta_{\beta}, \ \Delta_{f_z} \right)$$

Implications of "normalizations" on counterfactuals [2]

- Let $\widehat{\boldsymbol{\theta}}$ be the identified parameters under the normalizations.
- The true vector of counterfactual CCPs is $\mathbf{P}(\boldsymbol{\theta}^0 + \Delta_\theta)$.
- Instead, based on the restrictions, we obtain $\mathbf{P}(\widehat{\boldsymbol{\theta}} + \Delta_\theta)$.
- Is the interpretation of the counterfactual experiment under the normalization correct? That is,

$$\text{Is } \mathbf{P}(\widehat{\boldsymbol{\theta}} + \Delta_\theta) = \mathbf{P}(\boldsymbol{\theta}^0 + \Delta_\theta),$$

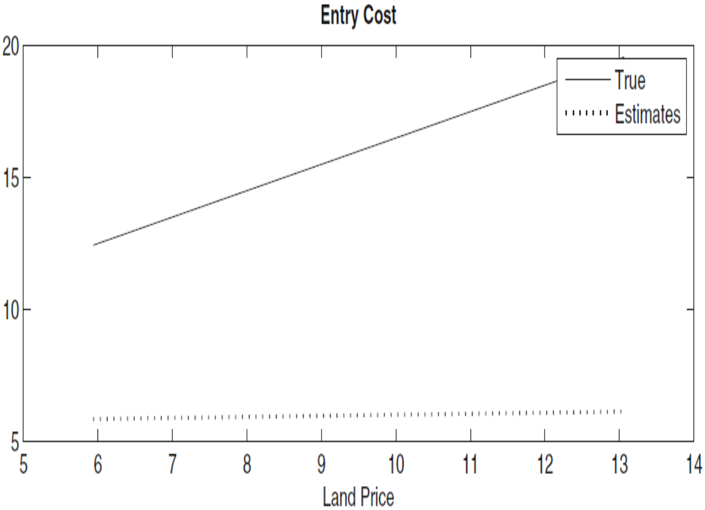
such that the normalization restrictions are innocuous for counterfactual experiments?

Implications of "normalizations" on counterfactuals [3]

- The answer to this question depends on the type of counterfactual.
- If Δ_θ is known to the researcher (i.e., it does not depend on true $\boldsymbol{\theta}^0$), $\Delta_\beta = 0$, and $\Delta_{f_z} = 0$, then the normalization restrictions are innocuous for these counterfactuals.
- Otherwise, the normalization introduces a bias such that $\mathbf{P}(\widehat{\boldsymbol{\theta}} + \Delta_\theta) \neq \mathbf{P}(\boldsymbol{\theta}^0 + \Delta_\theta)$.
- Aguirregabiria & Suzuki (QME, 2014) and Kalouptsidi, Souza-Rodrigues, & Scott (QE, 2021)) present very straightforward counterfactuals with $\Delta_{f_z} \neq 0$ where the biases are very large and they imply wrong signs in the effects on probabilites of entry and exit.

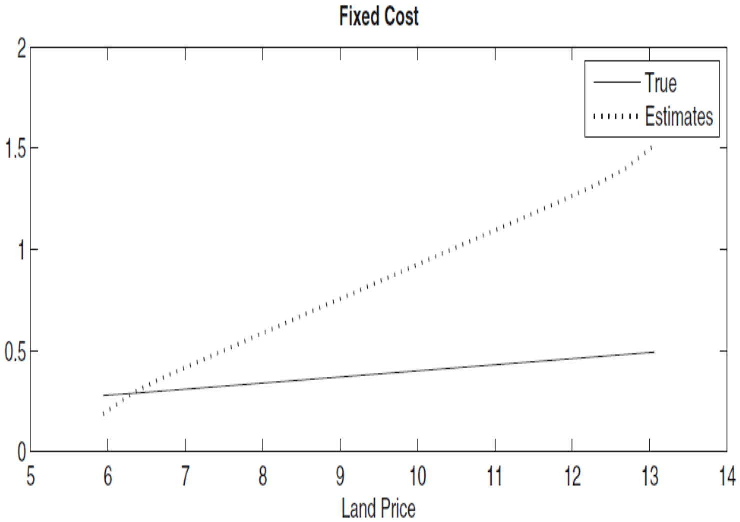
Example: True and Estimated Entry Cost

$ec^0(z) = 6.5 + z; sv^0(z) = 0.9 + 0.96z; fc^0(z) = 0.1 + 0.03z$

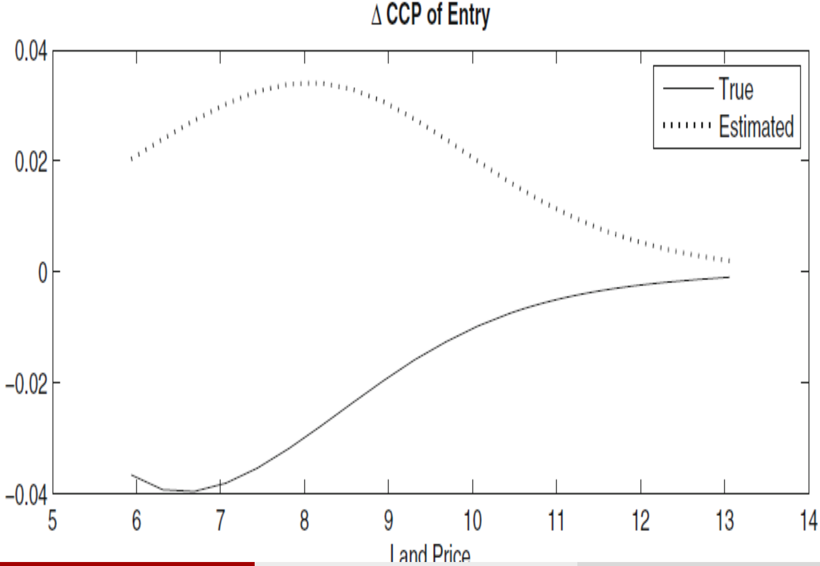


Example: True and Estimated Fixed Cost

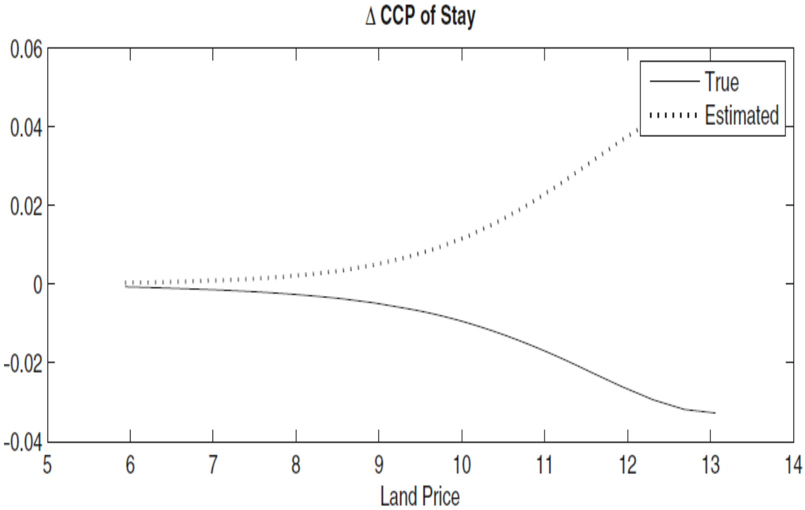
$ec^0(z) = 6.5 + z; sv^0(z) = 0.9 + 0.96z; fc^0(z) = 0.1 + 0.03z$



Example: Counterfactual – increase in mean value of z



Example: Counterfactual – increase in mean value of z [2]



Explaining the large biases in this example

- This bias is generated by the difference between the estimated and true structural cost functions.
- Imposing a zero scrap value restriction leads to an overestimation of fixed cost and an underestimation of entry cost.
- In addition, fixed cost estimates under this restriction depend on the land price, while both entry cost and scrap value do not.
- The "estimated counterfactual" is capturing two effects: the true counterfactual; and a spurious effect that consists of a much smaller *ec* that depends very weakly on land price.

Examples of normalizations and counterfactuals in applications

Table 2 Counterfactual experiments in recent empirical studies

Type of Counterfactuals	Normalization Assumption sv = 0	fc = 0	ec = 0	No normalization
Change in β				
Change in transition f_z	Collard-Wexler (2013) Das et al. (2007)			Kalouptsidi (forthcoming)
Change in profit	Aguirregabiria and Ho (2012) Bollinger (forthcoming) Collard-Wexler (2011) Dunne et al. (2013) Igami (2013) Kryukov (2010) Barwick and Pathak (2012) Lin (2012) Suzuki (2013) Varela (2013)	Ryan (2012) Santos (2013) Sweeting (2013)		

2. Dunne et al. (2013) on health services in small towns

Motivation

- This paper is motivated by the policy problem of **low supply of health care providers in small towns**.
- They study two health service industries: **dentists** and **chiropractors**.
- They are interested in different subsidies to encourage supply in under-served geographic areas.
- They are interested in two types of subsidy programs: **subsidies on entry costs**; and **subsidies on fixed operating costs**.
- Which is the subsidy program that **maximizes number of active professionals per dollar spent**?

Model

- It is the type of industry data where we need to impose restrictions of homogeneous profits across firms.
- Professionals in a local market are homogeneous, expect for i.i.d. private information shocks in fixed cost (ε_{it}^{FC}) and in entry cost (ε_{it}^{EC})
- At period t, firms are (endogenously) different depending on whether they are potential entrants ($a_{i,t-1} = 0$) or incumbents ($a_{i,t-1} = 1$).
- The vector of common knowledge state variables $\mathbf{x}_t$ consists of the number of incumbent firms at previous period, n_{t-1}, and a vector of exogenous profit-shifters, $\mathbf{z}_t$,

  $\mathbf{z}_{mt}$ = population, average real wage to employees in the industry, real per-capita income, county-level medical benefits, and infant mortality rate.

Model [2]

- There is one-period time-to-build in entry decisions.

- The variable profit of an active firm, $VP(n_{t-1}, \mathbf{z}_t)$, is modeled as a reduced form: a linear-in-parameters function of state variables.

$$VP_{mt} = \theta_0 + \sum_{n=0}^{5} \theta_n \ 1\{n_{m,t-1} = n\} + \theta_6 \ n_{m,t-1} + \theta_7 \ n_{m,t-1}^2 + h(\mathbf{z}_{mt}, \boldsymbol{\theta}_z)$$

- The authors argue that balance sheet data from the US Census Bureau provides good measures of VP_{mt} in the geographic markets included in their sample.

- Given they observe variable profits, they estimate the parameters in the profit function $VP(n_{t-1}, \mathbf{z}_t)$ as a linear regression model.

Model [3]

- In addition to the variable profit, there are fixed costs, $\theta^{FC} + \varepsilon_{it}^{FC}$, paid by any incumbent firm, and entry costs, $\theta^{EC} + \varepsilon_{it}^{EC}$, paid by potential entrants that choose to enter in the market.

- The authors assume that ε_{it}^{FC} is i.i.d. Expontential, and ε_{it}^{EC} is i.i.d. chi-square.

Data

- Following Bresnahan & Reiss (1990), thet consider isolated geographic markets in the US which are observed at five points in time, 1982, 1987, 1992, 1997, and 2002.
- $M = 639$ for dentists, and $M = 410$ for chiropractors.
- These markets are all relatively small, with populations that vary between 2,500 and 50,000 people.
- 59 of these markets are designated "Health Professional Shortage Areas" (HPSA).

Estimation

- After estimating the variable profit function, the parameters in FC and EC are estimated from the dynamic game using a two-step CCP method, ala Hotz-Miller.

- To control for market unobserved heterogeneity, they include as a state variable the market fixed effect ω_m estimated in the VP function.

- Vector $\mathbf{z}_t$ contains 5 state variables. This implies a substantial computational cost in the estimation and counterfactual experiments. To deal with this issue, they assume that these state variables can be aggregated in only 1 which is the index $h(\mathbf{z}_{mt}, \widehat{\theta}_z)$ in the VP function.

Empirical Results

- Profits decline quickly with n for dentists, but competition effects are very weak for chiropractors.
- Estimates of FC and EC are reasonable and imply also reasonable estimates of present values.
- Counterfactuals show that the two subsidy policies are substantially different in terms of their costs per retained firm.
- FC subsidies are more costly (per retained firm) than EC subsidies. Targeting the subsidy to potential entrants is far more cost effective.
- The reason is that FC subsidies generate a larger proportion of infra-marginal firms (who get the subsidy) which would not exit without subsidy.