Market Structure and Multiple Equilibria in Airline Markets

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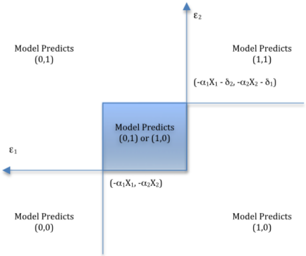
Introduction

Research Question:

How to estimate the payoff functions in entry games where there are multiple equilibria?



Novelty

- general forms of heterogeneity across players
- no assumptions on equilibrium selection mechanism

An Empirical Model of Market Structure

$$\begin{aligned} \pi_{im} &= S'_m\alpha_i + Z'_{im}\beta_i + W'_{im}\gamma_i + \sum_{j\neq i}\delta^i_j y_{jm} + \sum_{j\neq i} Z'_{jm}\phi^i_j y_{jm} + \epsilon_{im} \\ y_{im} &= 1[\pi_{im} \geq 0] \end{aligned}$$

- S_m: market characteristics
- Z_{im}: firm characteristics that enter into π_{jm}, $\forall j$
- W_{im}: firm characteristics that enter into π_{im} only (crucial for identification)
- y_{jm}: entry decision of firm j
- δ^i_j: **fixed competitive effects**
- ϕ^i_j: **variable competitive effects**

Estimation

Conditional moment inequality

$$\boldsymbol{H}_1(\boldsymbol{\theta}, \boldsymbol{X}) \leq Pr(\boldsymbol{y}|\boldsymbol{X}) \leq \boldsymbol{H}_2(\boldsymbol{\theta}, \boldsymbol{X})$$

Objective function

$$Q_n(\boldsymbol{\theta}) = \frac{1}{n}\sum_{i=1}^{n}[\|(P_n(X_i) - H_1(X_i, \theta))_-\| + \|(P_n(X_i) - H_2(X_i, \theta))_+\|]$$

Hausdorff-consistent set estimator

$$\hat{\Theta}_I = \{\theta \in \Theta | nQ_n(\theta) \leq \nu_n\}$$

where $\nu_n \to \infty$ and $\nu_n/n \to 0$

Market Structure in the U.S. Airline Industry

no variable competitive effects, $\phi_j^i = 0$

column 2: $\delta_j^i = \delta_j, \ \forall i$

TABLE III

EMPIRICAL RESULTS[a]

	Berry (1992)	Heterogeneous Interaction	Heterogeneous Control	Firm-to-Firm Interaction
Competitive fixed effect	[−14.151, −10.581]			
AA		[−10.914, −8.822]	[−9.510, −8.460]	
DL		[−10.037, −8.631]	[−9.138, −8.279]	
UA		[−10.101, −4.938]	[−9.951, −5.285]	
MA		[−11.489, −9.414]	[−9.539, −8.713]	
LCC		[−19.623, −14.578]	[−19.385, −13.833]	
WN		[−12.912, −10.969]	[−10.751, −9.29]	
LAR on LAR				
LAR: AA, DL, UA, MA				[−9.086, −8.389]
LAR on LCC				[−20.929, −14.321]
LAR on WN				[−10.294, −9.025]
LCC on LAR				[−22.842, −9.547]
WN on LAR				[−9.093, −7.887]
LCC on WN				[−13.738, −7.848]
WN on LCC				[−15.950, −11.608]
Airport presence	[3.052, 5.087]	[11.262, 14.296]	[10.925, 12.541]	[9.215, 10.436]
Cost	[−0.714, 0.024]	[−1.197, −0.333]	[−1.036, −0.373]	[−1.060, −0.508]
Wright	[−20.526, −8.612]	[−14.738, −12.556]	[−12.211, −10.503]	[−12.092, −10.602]
Dallas	[−6.890, −1.087]	[−1.186, 0.421]	[−1.014, 0.324]	[−0.975, 0.224]
Market size	[0.972, 2.247]	[0.532, 1.245]	[0.372, 0.960]	[0.044, 0.310]
WN			[0.358, 0.958]	
LCC			[0.215, 1.509]	

(*Continues*)

Algorithm

- **Step 1: First Stage Estimation of Choice Probabilities**

$$P_n^{(y')}(x) = \frac{\sum_i 1[y_i = y']1[x_i = x]}{\sum_i 1[x_i = x]}$$

Comments:
need to discretize the continuous Xs, but the cells of Xs increases exponentially with the dimension of Xs (quartiles-$4^{18} \approx 6.8 \times 10^{10}$).

Algorithm

- **Step 2: Take random draws of ϵ and simulate for $\boldsymbol{H}_1(\theta, \boldsymbol{X})$ and $\boldsymbol{H}_2(\theta, \boldsymbol{X})$**
  For each ϵ,
  - if y_j is a unique equilibrium, add 1 to both H_1 and H_2 for y_j
  - if y_j is one of the multiple equilibria, add 1 to only to H_2.

Comments:
strong assumption: $\epsilon_{im} = u_{im} + u_m + u_m^o + u_m^d$ are independently (relaxed in Section 5.2) and normally distributed

Algorithm

- **Step 3: Minimize the objective function**

$$Q_n(\boldsymbol{\theta}) = \frac{1}{n}\sum_{i=1}^{n}[\|(P_n(X_i) - H_1(X_i, \theta))_-\| + \|(P_n(X_i) - H_2(X_i, \theta))_+\|]$$

Comments:
Because of δ_j^i and ϕ_j^i dimension of θ increases with the number of firms, k. It might be a problem when k is large but n is small.

Algorithm

- **Step 4: Construct the confidence region C_n such that** $lim_{n\to\infty} P(\theta_I \in C_n) \geq \alpha$

$$C_n(c) = \{\theta \in \Theta : n * Q_n(\theta) \leq n * min_t Qn(t)) + c\}$$

Comments:

This is a multi-dimensional confidence region. To get the confidence intervals, one also need to project the confidence region onto each covariates, which is computationally complicated.

One more general comments

Reduced form profit function

$$\pi_{im} = S'_m \alpha_i + Z'_{im}\beta_i + W'_{im}\gamma_i + \sum_{j \neq i} \delta^i_j y_{jm} + \sum_{j \neq i} Z'_{jm}\phi^i_j y_{jm} + \epsilon_{im}$$

Results from Numerical Exercise

Only take the entry decisions of AA and DL as endogenous

$$\pi_{AA,m} = Z'_{AA,m}\beta_i + W'_{AA,m}\gamma_i + \delta_{DL} y_{DL,m} + \sum_{j \neq i} \mu_j y_{jm} + \epsilon_{AA,m}$$

- $argmin_t nQ_n(t)$

			fixed competitive effects					
constant	market presence	cost	AA	DL	UA	MA	LCC	WN
28.22	-0.30	0.02	-29.18	-29.50	-11.75	0.07	-17.38	0.86

- threshold c=385.4871
- still working on projecting the confidence region onto each covariate.