Industrial Organization II (ECO 2901)

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Problem Set #1

Due of Friday, February 28, 2014

TOTAL NUMBER OF POINTS: 200

The three problems in this set deal with models of demand and price competition in differentiated product industries as in Berry (1994) and Berry, Levinsohn, and Pakes (1995).

PROBLEM 1 [100 points]. Competition upstream (manufacturers) and downstream (retailers), and retailers assortment decisions.

There are J brands or product varieties, indexed by $j \in \{1, 2, ..., J\}$. There are F manufacturing firms in the industry that we index by $f \in \{1, 2, ..., F\}$. Manufacturer f produces a subset $\mathcal{J}_f$ of the products, such that the subsets $\{\mathcal{J}_1, \mathcal{J}_2, ..., \mathcal{J}_F\}$ represent a partition of the set $\{1, 2, ..., J\}$. Manufacturers do not sell their products directly to consumers but to retail firms. There is a retail market with L retail firms, indexed by $\ell \in \{1, 2, ..., L\}$, where retailers sell these products to consumers. Retailer ℓ sells an assortment of products $\boldsymbol{a}_\ell \equiv \{a_{1\ell}, a_{2\ell}, ..., a_{J\ell}\}$, where $a_{j\ell} \in \{0, 1\}$ is the indicator of the event "retailer ℓ sells product j". \

The profit of manufacturer f is:

$$\Pi_f = \sum_{j \in \mathcal{J}_f} \left[\sum_{\ell=1}^{L} (w_{j\ell} - c_j) \ q_{j\ell} \right]$$

where: $w_{j\ell}$ is the wholesale price or manufacturer price of product j for retailer ℓ; c_j is the unit cost of producing j; and $q_{j\ell}$ is the quantity of product j purchased by retailer ℓ. The profit of retailer ℓ is:

$$\pi_\ell = \sum_{j=1}^{J} a_{j\ell} \left[(p_{j\ell} - w_{j\ell} - r_\ell - \tau_j) \ q_{j\ell} - K_\ell \right]$$

where: $p_{j\ell}$ is the consumer price of product j charge by retailer ℓ; r_ℓ is the per-unit management cost or retailing cost of retailer retailer ℓ; τ_j is the transportation cost from the production site of product j to the retail market; and K_ℓ is a fixed cost per-product for the retailer.

There are H consumers in the market. Each consumer buys at most one unit of the differentiated product, and has to decide the variety to purchase and the store, (j, ℓ). The demand system is described by the following equations:

$$q_{j\ell} = H \ s_{j\ell} = H \frac{a_{j\ell} \ \exp\left\{\beta_j + \gamma_\ell - \alpha \ p_{j\ell}\right\}}{1 + \sum_{\ell'=1}^{L} \sum_{i=1}^{J} a_{i\ell'} \ \exp\left\{\beta_i + \gamma_{\ell'} - \alpha \ p_{i\ell'}\right\}}$$

where α, β's, and γ's are parameters. α represents the marginal utility of money. And β_j and γ_ℓ represents consumers' average valuation of product j and store ℓ, respectively. Given this demand system, and taking as given wholesale prices $\{w_{j\ell}\}$, retail firms compete in prices a la Nash-Bertrand. Given the equilibrium in the retail market, manufacturers compete in prices a la Nash-Bertrand. In the simpler version of the model, we assume that product assortments $\boldsymbol{a}_\ell$ are exogenously given. Later, we relax this assumption and consider also retailers' competition in product assortment.

Consider a version of the model where $K_\ell = 0$ and retailers' product assortments $\{\boldsymbol{a}_\ell\}$ are exogenously given.

Question 1.1 [5 points] Derive the system of best response equations that characterizes the Nash-Bertrand equilibrium in the retail market.

Question 1.2 [5 points] Define and describe the demand functions $q_{j\ell} = d_{j\ell}(\mathbf{w})$ from retailers to manufacturers, where $\mathbf{w} = \{w_{j\ell} : j = 1, 2, ..., J,\ \ell = 1, 2, ..., L\}$.

Question 1.3 [5 points] Given the demand systems $q_{j\ell} = d_{j\ell}(\mathbf{w})$, derive the system of best response equations that characterizes the Nash-Bertrand equilibrium in the manufacturer market.

Question 1.4 [5 points] Suppose that manufacturers cannot price discriminate retailers such that $w_{j\ell} = w_j$ for any retailer j. Derive the system of best response equations that characterizes the Nash-Bertrand equilibrium in the manufacturer market without price discrimination.

Question 1.5 [5 points] In the context of this model, explain what is the double marginalization problem.

Now, consider the model where $K_\ell > 0$ and retailers' choose endogenously their product assortments $\boldsymbol{a}_\ell$. Suppose that retailers play a two-stage game where they first choose their product assortments $\{a_\ell\}$, and then they compete in prices taking these assortments as given. The second stage of this game is simply the Nash-Bertrand game in Question 1.1 above. Let $VP_\ell(\boldsymbol{a}_\ell, \boldsymbol{a}_{-\ell})$ be the Nash-Bertrand equilibrium **variable profit** for retailer ℓ provided that he has assortment $\boldsymbol{a}_\ell$ and the other retailers in the market have assortments $\boldsymbol{a}_{-\ell} = \{\boldsymbol{a}_{\ell'} : \ell' \neq \ell\}$. In the first stage of the game (assortment choice), retailers compete a la Nash.

Question 1.6 [5 points] Describe the Nash equilibrium of assortment choice.

Question 1.7 [10 points] Consider a simplified version of the model with: two manufacturers ($F = 2$); two products ($J = 2$) where $j = 1$ is produced by firm 1, and $j = 2$ is produced by firm 2; and two retail firms, $\ell = 1$ and $\ell = 2$. Retailer 1's assortment is fixed and it consists of only product 1, i.e., $a_{11} = 1$ and $a_{21} = 0$. Retailer 2's assortment is endogenous and it is based on the profit maximization of this retailer. (a) Describe in detail the equilibrium in this model. (b) Provide conditions under which retailer 2 decides to sell only product 2. (c) Is it possible to have an equilibrium where both retailers sell only product 1? Explain.

Consider the simplified model in Question 1.7. There are M separate retail markets, that we index by m, where M is large. The two retailers are active in all these markets (we ignore here market entry decisions). Competition between retailers occurs at the local market level. However, competition between manufacturers takes place at the national level such that wholesale prices $\{w_{11}, w_{12}, w_{22}\}$ are the same at every local market m. The variables τ_{1m} and τ_{2m} represent the unit transportation costs from the production sites of products 1 and 2, respectively, to local market m. In each local market, consumer demand follows the structure described above but with two new features: (1) market size H_m varies exogenously across markets; and (2) consumer average willingness to pay for product-retailer (j, ℓ) in market m is equal to $\beta_j + \gamma_\ell + \xi_{j\ell m}$ where β's and γ's are the parameters that we have described above, and $\xi_{j\ell m}$ is a random variable that is unobservable to the researcher and it is i.i.d. across markets with zero mean.

Suppose that the researcher has data from this industry. The dataset includes the following information for each local market m: (a) the assortment choice of firm 2, $(a_{12m}, a_{22m}) \in \{(1, 0),\ (0, 1),\ (1, 1)\}$; (b) retail prices and quantities, $(p_{j\ell m}, q_{j\ell m})$, for every active product-retailer (j, ℓ); (c) market size H_m; and (d) unit transportation costs τ_{1m} and τ_{2m}. The dataset includes also wholesale prices and quantities at the national level, $\{w_{j\ell},\, Q_{j\ell} : (j,\ell) = (1,1),\, (1,2),\, (2,2)\}$ where $Q_{j\ell} \equiv \sum_{m=1}^{M} q_{j\ell m}$.

The researcher is interested in estimating the vector of structural parameters of the model, θ, that includes: the average quality of the two products $\{\beta_1,\, \beta_2\}$; the average quality of the two retailers $\{\gamma_1,\, \gamma_2\}$; the demand-price sensitivity parameter α; the unit retail costs $\{r_1, r_2\}$; the fixed cost of retailer 2, K_2; and the unit manufacturing costs $\{c_1,\, c_2\}$.

Question 1.8 [5 points] Write the consumer demand system as a linear regression-like system of equations.

Question 1.9 [10 points] Discuss the endogeneity problems associated to the estimation of parameters $\{\beta_1,\, \beta_2,\, \gamma_1,\, \gamma_2\}$ in this system of linear regression equations. In particular, explain the endogeneity (selection) problem related to the assortment choice of retailer 2.

Question 1.10 [10 points] Propose a method to estimate consistently the demand parameters $\{\beta_1,\, \beta_2,\, \gamma_1,\, \gamma_2\}$ in this model. Explain the necessary condition for identification, and the different steps in the implementation of this method.

Question 1.11 [10 points] Given consistent estimates of $\{\beta_1,\, \beta_2,\, \gamma_1,\, \gamma_2\}$, consider the estimation of the unit retail costs $\{r_1, r_2\}$ from the optimal pricing equations. (a) Write the expression for these equations. (b) Is there a selection problem in the estimation of this equation? Why/why not? (c) Propose a method to estimate consistently the parameters $\{r_1, r_2\}$.

Question 1.12 [10 points] Given consistent estimates of $\{\beta_1,\, \beta_2,\, \gamma_1,\, \gamma_2,\, r_1,\, r_2\}$, consider the estimation of the fixed cost K_2 from the optimal assortment decision of retailer 2, $(a_{12m}, a_{22m}) \in \{(1,0),\, (0,1),\, (1,1)\}$. (a) Write the discrete choice econometric model for this estimation. (b) Propose a method to estimate consistently the parameter K_2 in this model.

Question 1.13 [5 points] Given consistent estimates of $\{\beta_1,\, \beta_2,\, \gamma_1,\, \gamma_2,\, r_1,\, r_2,\, K_2\}$, consider the estimation of the unit production cost parameters $\{c_1, c_2\}$ from the best response pricing decisions of manufacturers. Explain how to obtain consistent estimates of these parameters.

Question 1.14 [10 points] The model has been estimated with data from an industry where manufacturing firms can price discriminate retailers. Suppose that the researcher is interested in the following empirical question: what would be the level of prices, market shares, firms' profits, and consumer welfare in the different local markets if price discrimination were illegal? Describe a counterfactual experiment that answers this empirical question. Explain how to implement this experiment to obtain counterfactual values of all the endogenous variables.

PROBLEM 2 [20 points]. Conjectural variations with differentiated product.

We have an industry with J manufacturing firms where each firm produces a variety of a differentiated product. Suppose that firms compete in prices but firms' beliefs about other firms actions do not correspond to the Nash axiom. Instead, any firm j beliefs that for any $k \neq j$, $\dfrac{\partial p_k}{\partial p_j} = \theta$, where θ is a conjectural variation parameter.

Question 2.1 [5 points] Describe an equilibrium of this model under the conjectural variation assumption of $\dfrac{\partial p_k}{\partial p_j} = \theta$.

Suppose that the industry is such that J is large. The researcher has data on $\{q_j, p_j, X_j : j = 1, 2, ..., J\}$. The researcher has estimated the demand system such that the market share function $\sigma_j(\mathbf{p}, \mathbf{X}, \widehat{\boldsymbol{\xi}}, \widehat{\boldsymbol{\beta}})$ are known, where $\widehat{\boldsymbol{\xi}}$ and $\widehat{\boldsymbol{\beta}}$ represent consistent estimates of unobserved product characteristics and demand parameters, respectively. The marginal cost for product j is $MC_j = X_j\gamma + \omega_j$, where γ is a vector of parameters and ω_j represents the effect of unobserved characteristics on marginal costs.

Question 2.2 [5 points] Present a regression-like equation for the estimation of the parameters γ and θ. Explain the problems for the estimation of these parameters.

Question 2.3 [10 points] Propose a method for the consistent estimation of γ and θ. Explain the necessary conditions for identification/consistency.

PROBLEM 3 [80 points].

The STATA datafile `eco2901_problemset_01_2014_airlines_data.dta` contains data of the US airline industry in 2004. A market is a *route* or directional city-pair, e.g., round-trip Boston to Chicago. A product is the combination of route (m), airline (f), and the indicator of stop flight or nonstop flight. For instance, a round-trip Boston to Chicago, non-stop, with American Airlines is an example of product. Products compete with each other at the market (route) level. Therefore, the set of products in market m consists of all the airlines with service in that route either with nonstop or with stop flights. The dataset contains $2,950$ routes, 4 quarters, and 11 airlines (where the airline "Others" is a combination of multiple small airlines). The following table includes the list of variables in the dataset and a brief description.

Variable name		**Description**
`route_city`	:	Route: Origin city to Destination City
`route_id`	:	Route: Identification number
`airline`	:	Airline: Name (Code)
`direct`	:	Dummy of Non-stop flights
`quarter`	:	Quarter of year 2004
`pop04_origin`	:	Population Origin city, 2004 (in thousands)
`pop04_dest`	:	Population Destination city, 2004 (in thousands)
`price`	:	Average price: route, airline, stop/nonstop, quarter (in dollars)
`passengers`	:	Number of passengers: route, airline, stop/nonstop, quarter
`avg_miles`	:	Average miles flown for route, airline, stop/nonstop, quarter
`HUB_origin`	:	Hub size of airline at origin (in million passengers)
`HUB_dest`	:	Hub size of airline at destination (in million passengers)

In all the models of demand that we estimate below, we include time-dummies and the following vector of product characteristics:

{ `price, direct dummy, avg_miles, HUB_origin, HUB_dest, airline dummies` }

In some estimations we also include market (route) fixed effects. For the construction of market shares, we use as measure of market size (total number of consumers) the average population in the origin and destination cities, in number of people, i.e., `1000*(pop04_origin + pop04_dest)/2`.

Question 3.1 [20 points]: Estimate a Standard Logit model of demand: (a) by OLS without route fixed effects; (b) by OLS with route fixed effects. Interpret the results. What is the average consumer willingness to pay (in dollars) for a nonstop flight (relative to a stop flight), ceteris paribus? What is the average consumer willingness to pay for hub size at the origin airport (in dollars per million people)? What is the average consumer willingness to pay for Continental relative to American Airlines, ceteris paribus? Based on the estimated model, obtain the average elasticity of demand for Southwest products. Compare it with the average elasticity of demand for American Airline products.

Question 3.2 [20 points]: Consider a Nested Logit model where the first nest consists of the choice between groups "Stop", "Nonstop", and "Outside alternative", and the second nest consists in the choice of airline. Estimate this Nested Logit model of demand: (a) by OLS without route fixed effects; (b) by OLS with route fixed effects. Interpret the results. Answer the same questions as in Question 3.1.

Question 3.3 [20 points]: Consider the Nested Logit model in Question 3.2. Propose and implement an IV estimator that deals with the potential endogeneity of prices. Justify your choice of instruments, e.g., BLP, or Hausman-Nevo, or Arellano-Bond, ... Interpret the results. Compare them with the ones from Question 3.2.

Question 3.4 [20 points]: Given your favorite estimation of the demand system, calculate price-cost margins for every observation in the sample. Use these price cost margins to estimate a marginal cost function in terms of all the product characteristics, except price. Assume constant marginal costs. Include also route fixed effects. Interpret the results.