Bresnahan, JIE 87: Competition and Collusion in the American Automobile Industry: 1955 Price War

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Main question: In 1955 quantities of autos sold were higher while prices were lower, relative to 1954 and 1956. Why? Was this due to a price war (i.e. breakdown of collusion)?

Basic idea: use variation in demand (across products) to learn about model of competition. Treat location in characteristics as fixed. Given location, markups will differ depending on ownership of nearby products. Determine which supply model best fits the data.

Essentially, this approach (common now in IO) uses the characteristics of other products as IV.

What are the basic facts to be explained? See table I and II.

Model: Supply side

- $f = 1, \ldots, F$ firms and $j = 1, \ldots, J$ products. Each firm produces some subset, $\mathcal{F}_f$ of the J products.
- Costs of production: $C(x, q) = A(x) + mc(x)q$ where q is the quantity produced, x is the quality of the product. A is the fixed cost and mc is the marginal cost.
- let $mc(x) = \mu \exp(x)$, let M denote total market size and s_j the market share of product j.
- Firm f profits are:

$$\Pi_f = \sum_{j \in \mathcal{F}_f} (p_j - mc_j) M s_j(p) - A_j \tag{1}$$

  assuming (1) existence of a pure-strategy Bertrand-Nash equilibrium in prices and (2) prices that support that equilibrium are strictly positive, the FOC are:

$$s_j(p) + \sum_{k \in \mathcal{F}_f} (p_r - mc_r) \frac{ds_r(p)}{dp_j} = 0 \tag{2}$$

- define $S_{jr} = -\frac{ds_r}{dp_j}$ and let an "ownership" structure be defined as

$$H_{jr} = \begin{cases} 1, & \text{if } \exists f : \{r, j\} \subset \mathcal{F}_f, \\ 0, & \text{otherwise} \end{cases} \tag{3}$$

- Let $\Omega_{jr} = H_{jr} \times S_{jr}$, then FOC become

$$s(p) - \Omega(p - mc) = 0 \tag{4}$$

  which implies the pricing equation

$$p - mc = \Omega^{-1} s(p) \tag{5}$$

Therefore by:

1. assuming a model of conduct, and
2. using estimates of the demand substitution

we are able to

1. measure price markup without using cost data
2. compute these margins under different "ownership" structures

Model: Demand side

- Bresnahan uses a demand model of vertical differentiation – products are differentiated along one dimension, quality.
- Discrete-choice model, where consumers decide to buy one auto or not to buy ($J+1$ options)
- Let
  - ν - measure consumer taste (or willingness-to-pay for quality), where $\nu \sim U[0, V_{\max}]$ with the density δ.
  - x - auto quality
  - y - consumer income
  - p - price of the auto
- The indirect utility of consumer (ν, y) from auto (x, p) is

$$\nu x + y - p \tag{6}$$

  and the indirect utility from not purchasing an auto is

$$\nu\gamma + y - E \tag{7}$$

  where γ and E are parameters to be estimated (along with $V_{\max}$ and δ).

- Consumer ν who buys an auto selects the product j that minimizes $P_j - \nu x_j$. Aggregating across all consumers yields demand for all products

- To determine demand for j, first calculate the ν of the consumer who is indifferent between 2 products, (i, h) where $x_i > x_h$. Consumer ν_{hi} is indifferent between h, i iff

$$P_i - x_i \nu_{hi} = P_h - x_h \nu_{hi} \tag{8}$$

  rearranging terms, we get

$$\nu_{hi} = \frac{P_i - P_h}{x_i - x_h} \tag{9}$$

  All consumers with $\nu < \nu_{hi}$ strictly prefer h, all those with $\nu > \nu_{hi}$ prefer i.

- repeat the above exercise with a product $x_j > x_i$ and compute a ν_{ij}. Then the demand function for auto i is

$$q_i = \delta[\nu_{ij} - \nu_{hi}] = \delta\Big[\frac{P_j - P_i}{x_j - x_i} - \frac{P_i - P_h}{x_i - x_h}\Big] \tag{10}$$

- (see figure 1 in paper)

- Decision to buy or not: Assume consumers with highest willingness-to-pay for quality, $V_{\max}$ always buy some auto. Implication is that they buy highest quality auto, so demand is (assuming products are ordered from lowest to highest in quality

$$q_J - \delta\Big[\nu_{\max} - \frac{P_J - P_{J-1}}{x_J - x_{J-1}}\Big] \tag{11}$$

- The consumers with lowest ν: decide to buy or not buy

$$q_1 = \delta\Big[\frac{P_2 - P_1}{x_2 - x_1} - \frac{P_1 - E}{x_1 - \gamma}\Big] \tag{12}$$

  so the outside option is interpreted as having a lower quality than all new autos (e.g. used car).

- Price derivatives are:

$$\frac{dq_j}{dp_j} = \delta\big[\frac{1}{x_j - x_{j+1}} + \frac{1}{x_{j-1} - x_j}\big] \tag{13}$$

$$\frac{dq_j}{dp_k} = \begin{cases} \delta\big(\frac{1}{|x_j - x_k|}\big), & k \in \{j-1, j+1\} \\ 0, & \text{otherwise} \end{cases} \tag{14}$$

- So conditional on the x's we can estimate demand and compute the implied markups.

- Note that quality is assumed to equal

$$x_j = \sqrt{\beta_0 + \sum_k \beta_k z_{jk}} \tag{15}$$

where z_{jk} is a characteristic of the product j and β's are parameters to be estimated.

Data and Econometrics

Data:

1. prices – list prices

2. sales – quantity produced

3. quality – characteristics

Econometrics

- Let (P^*, Q^*) by the equilibrium prices and quantities predicted by the model (given a vector of parameters)

- assume there is measurement error

$$p_j = P_j^* + \epsilon_j^p \tag{16}$$

$$q_j = Q_j^* + \epsilon_j^q \tag{17}$$

where $(\epsilon_j^p, \epsilon_j^q)$ are iid and mean zero normally distributed shocks with variance (σ_p^2, σ_q^2).

- Then the likelihood function is

$$\Pi_{j=1}^{J} \frac{1}{\sqrt{2\pi\sigma_p^2}} \exp\left[-\frac{(p_j - P_j^*)^2}{2\sigma_p^2}\right] \frac{1}{\sqrt{2\pi\sigma_q^2}} \exp\left[-\frac{(q_j - Q_j^*)^2}{2\sigma_q^2}\right] \tag{18}$$

- Bresnahan estimates 4 models for the years 1954,55,56 separately to answer the question about the price war in 1955

  1. collusion: ownership structure, H is a matrix of 1's.
  2. Nash (multi-product pricing): H is a matrix with blocks of 1's
  3. Products: H is an identity matrix
  4. Hedonic

- Uses a formal test (Cox test) to determine which ownership structure best fits the data and informal tests by comparing estimates across years (recall, structural estimates should be stable, assuming the model is correct).

- See figure 2 (intuition) and tables IV and V (results)

General Comments

- The Cox test requires that one of the alternatives be true. See Voung (Econometrica 1988) for a test that does not require this. An application is Gasmi, Laffont, and Voung (JEMS 1992) which looks at the soft-drink market.

- Test for collusion relies critically on getting the demand estimates right. This vertical differentiation demand model is restrictive in at least 2 ways

  1. very restrictive substitution patterns (see price elasticities). If products aren't neighbors, then no substitution.
  2. no error in quality measures.

- Assumption that characteristics are exogenous (pre-determined). Is this reasonable? We'll see this assumption is used in current models

- Model ignores dynamics on both the supply and demand side.