Search markets: Hong-Shum paper

Caltech

Ec106

Why are prices for the same item so different across stores?

Can search models explain price dispersion?

Modus operandi: estimate search costs which are consistent with observed price distributions, and see if they are reasonable.

Concept: mixed strategy.

Two search models:

Consider two search models:

Nonsequential search model: consumer commits to searching n stores before buying (from lowest-cost store). "Batch" search strategy.

Sequential search model: consumer decides after each search whether to buy at current store, or continue searching.

Main assumptions:

- Infinite number ("continuum") of firms and consumers
- Observed price distribution F_p is equilibrium mixed strategy on the part of firms, with bounds $\underline{p}, \bar{p}$.
- r: constant per-unit cost (wholesale cost), identical across firms
- Firms sell homogeneous products
- Each consumer buys one unit of the good
- Consumer i incurs cost c_i to search one store; drawn independently from search cost distribution F_c
- First store is "free"
- q_k: probability that consumer searches k stores before buying

Consumers in nonsequential model

- Consumer with search cost c who searches n stores incurs total cost

$$\begin{aligned} & c * (n-1) + E[\min(p_1, \dots, p_n)] \\ =& c * (n-1) + \int_{\underline{p}}^{\bar{p}} p \cdot n(1-F_p(p))^{n-1} f_p(p) dp. \end{aligned} \quad (1)$$

- This is decreasing in c. Search strategies characterized by cutoff-points, where consumer indifferent between n and $n+1$ must have cost

$$c_n = E[\min(p_1, \dots, p_n)] - E[\min(p_1, \dots, p_{n+1})].$$

  and $c_1 > c_2 > c_3 > \cdots$.
- Similarly, define $\tilde{q}_n = F_c(c_{n-1}) - F_c(c_n)$ (fraction of consumers searching n stores). Graph.

Firms in nonsequential model

- Firm's profit from charging p is:

$$\Pi(p) = (p - r)\left[\sum_{k=1}^{\infty} \tilde{q}_k \cdot k \cdot (1 - F_p(p))^{k-1}\right], \quad \forall p \in [\underline{p}, \bar{p}]$$

- For mixed strategy, firms must be indifferent btw all p:

$$(\bar{p} - r)\tilde{q}_1 = (p - r)\left[\sum_{k=1}^{\infty} \tilde{q}_k \cdot k \cdot (1 - F_p(p))^{k-1}\right], \quad \forall p \in [\underline{p}, \bar{p}) \quad (2)$$

Estimating search costs

- Observe data $P_n \equiv (p_1, \ldots p_n)$. Sorted in increasing order.
- Empirical price distribution $\hat{F}_p = Freq(p \leq \tilde{p}) = \frac{1}{n}\sum_i \mathbf{1}(p_i \leq \tilde{p})$..
- Take $\underline{p} = p_1$ and $\bar{p} = p_n$
- Consumer cutpoints $c_1, c_2, \ldots$ can be estimated directly by simulating from observed prices P_n. This are "absissae" of search cost CDF.
- Corresponding "ordinates" recovered from firms' indifference condition. Assume that consumers search at most K $(< N - 1)$ stores. Then can solve for $\tilde{q}_1, \ \ldots \ , \ \tilde{q}_K$ from

$$(\bar{p}-r)\tilde{q}_1 = (p_i-r)\left[\sum_{k=1}^{K-1} \tilde{q}_k \cdot k \cdot (1 - \hat{F}_p(p_i))^{k-1}\right], \quad \forall p_i, i = 1, \ldots, n-1$$

$n - 1$ equations with K unknowns.

Nonsequential model: results

- Figure 3
- Table 1
- Table 2

Sequential model

- Consumer decides after each search whether to accept lowest price to date, or continue searching.
- Optimal "reservation price" policy: accept first price which falls below some optimally chosen reservation price.
- NB: "no recall"

Consumers in sequential model

- Heterogeneity in search costs leads to heterogeneity in reservation prices
- For consumer with search cost c_i, let $z^*(c_i)$ denote price z which satisfies the following indifference condition

$$c_i = \int_0^z (z - p) f(p) dp = \int_0^z F(p) dp.$$

Now, for consumer i, her reservation price is:

$$p_i^* = \min(z^*(c_i), \bar{p}).$$

- Let G denote CDF of reservation prices, ie. $G(\tilde{p}) = P(p^* \leq \tilde{p})$.

Firms in sequential search model

- Again, firms will be indifferent between all prices
- Let $D(p)$ denote the demand (number of people buying) from a store charging price p. Indifference condition is:

$$(\bar{p} - r)D(\bar{p}) = (p - r)D(p) \Leftrightarrow$$
$$(\bar{p} - r) * (1 - G(\bar{p})) = (p - r) * (1 - G(p))$$

for each $p \in [\underline{p}, \bar{p})$.

Estimation: sequential model

- Observe prices $p_1, \ldots, p_n$ (order in increasing order, so $\bar{p} = p_n$).
- Indifference conditions, evaluated at each price, are:

$$(\bar{p} - r) * (1 - G(\bar{p})) = (p_i - r) * (1 - G(p_i)), \quad i = 1, \ldots, n-1$$

- This gives $n - 1$ equations, but $n + 1$ unknowns: $G(p_i)$ for $i = 1, \ldots, n$ as well as r.
- Define $\alpha = 1 - G(\bar{p})$: percentage of people who don't search.
- Assume that search distribution is Gamma distribution. (Eq. (13) in paper).
- Estimate model parameters $(\delta_1, \delta_2, \alpha, r)$ by *maximum likelihood* (Eq. 9)

Results: sequential search model

- Figure 3
- Table 2
- Table 3