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 $p, \bar{p}$.
- $r$: 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

$$c \times (n - 1) + E[\min(p_1, \ldots, p_n)]$$

$$= c \times (n - 1) + \int_{\tilde{p}} \bar{p} \cdot n(1 - F_p(p))^{n-1} f_p(p) dp. \quad (1)$$

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

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

and $c_1 > c_2 > c_3 > \ldots$.

- 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 $\hat{F}_p = \text{Freq}(p \leq \tilde{p}) = \frac{1}{n} \sum_i 1(p_i \leq \tilde{p})$.
- Take $p = p_1$ 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. $G(\bar{p}) = P(p^* \leq \bar{p})$. 
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:

$$ (\bar{p} - r)D(\bar{p}) = (p - r)D(p) \iff (\bar{p} - r) \times (1 - G(\bar{p})) = (p - r) \times (1 - G(p)) $$

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

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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:

\[
(\bar{p} - r) \times (1 - G(\bar{p})) = (p_i - r) \times (1 - G(p_i)), \quad i = 1, \ldots, n - 1
\]

- 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