Intermediation and Competition in Search Markets: An Empirical Case Study

Author: Tobias Salz
Presenter: Renjie Zhong
Econ 220B Presentation

2/4/2025

Motivation and Background

search friction: increase sellers' market power and allow them to raise prices

in a market (heterogeneous search friction), intermediary can improve consumer welfare by separation:

1. exposure to a more efficient search technology: reducing expenses for buyers with high cost
2. search externality: consumer with low cost in the search markest

empirical case: NYC waste market

1. the market supports a large number of suppliers in geographic area
2. brokers procure contracts through a request for proposals, which is akin to a first-price auction

key identification difficulty: the equilibrium number of price inquiries & the search cost are unobserved consumer j with search cost $\kappa_j \sim_{iid} \mathcal{H}(\cdot)$ (cont dist) and waste quantity q

carter i with customer-specific service cost $c_{ij} \sim_{iid} \mathcal{G}(\cdot)$ (cont dist)

broker $b \in \{1, ..., B\}$ with frequency f_b, price $\mathrm{E}(p^B|b)$ and fees ϕ

timing:

1. the customer privately draws search cost κ and carters draw service cost c.
2. customers decide delegate search to a broker / search $m(\kappa) \in \{1, ..., M\}$ carters
3. carters submit price quotes in a first price auction / the search market nonsequentially

consumer's problem: indifference threshold $\bar{\kappa}$: $q\mathbb{E}\left[p^B\right]\phi = q\mathbb{E}\left[p^{1:m(\bar{\kappa})}\right] + m(\bar{\kappa})\bar{\kappa}$

$$\min_m q\mathbb{E}\left[p^{1:m}\right] + m\kappa = \min_{m\in\{1,\ldots,M\}} \int_0^{\bar{p}} mpq(1-\mathcal{F}(p))^{m-1} f(p)dp + m\kappa$$

Lemma 1. Optimal Searching

There are marginal types $0 = \kappa_M \leq \kappa_{M-1} < \cdots < \kappa_2 < \kappa_1 < \bar{\kappa} \leq \infty$ such that every type $\kappa \in [\kappa_{m-1}, \kappa_m]$ samples m firms, and every type larger than $\bar{\kappa}$ delegates search to an intermediary.

notation: $\widetilde{\mathcal{G}} = 1 - \mathcal{G}$, and search market size $w_m = \mathcal{H}(\kappa_m \mid \kappa < \bar{\kappa}) - \mathcal{H}(\kappa_{m-1} \mid \kappa < \bar{\kappa})$.

carters's problem:

1. broker b first-price auction with N_b participants: $\max_p (p - c) \cdot \widetilde{\mathcal{G}}(\beta_b^{-1}(p))^{N_b - 1} \Rightarrow \beta_b$
2. nonsequential market $\Longleftrightarrow$ first-price procurement auction with ambiguous number of competitors

$$\max_p (p - c) \cdot \left[\sum_{m=1}^{M} w_m \cdot \widetilde{\mathcal{G}}(\beta_S^{-1}(p))^{m-1}\right] \Rightarrow \beta_s$$

equilibrium: $\{\beta_b(\cdot), \beta_s(\cdot), w_m\}$ such that

bidding strategy $\Rightarrow$ price distribution $\Rightarrow$ optimality of search behavior $\Rightarrow$ optimality of bidding strategy

identification (Athey and Haile, 2002) = observation dist uniquely pins down the model and latent dist

price dist in search market $\mathcal{F}^o(p) = \sum_m w_m \cdot \left(1 - \left[1 - \mathcal{G}(\beta_S^{-1}(p))\right]^m\right)$ is affected by a combination of search cost and service cost $\Rightarrow$ nonidentification

$+$ As1 regularity (same $\mathcal{G}$ in both markets and Lip-cont virtual value)$+$ As2 existence and uniqueness of equil $\Rightarrow$ search weights w_m and cutoff types κ_m are identified from winning bids p

Estimation

restrict a more homogeneous set of contracts, no dynamic considerations, same industry (retail busi)

restrictions on the dist of unobservables: $\mathcal{G}(\cdot \mid x) = \mathcal{N}_{[0,\infty)}(m^c(x), \sigma^c)$ and $\mathcal{H}(\cdot) = \mathcal{N}_{[0,\infty)}(\mu^s, \sigma^s)$,where $m(x) = \mu^c + \sum_{k=1}^{4} \gamma_k^{c,Boro} 1\{\text{Contract in borough } k\} + \gamma^q q + \gamma^r 1\{\text{Contract specifies recyclables}\}$

the linear relative attractiveness of brokers: $q\mathbb{E}\left[p^B \mid x\right]\Phi(x) - \psi q = q\mathbb{E}\left[p^{1:m(\bar{\kappa})} \mid x\right] + m(\bar{\kappa}(x))\bar{\kappa}(x)$

estimate $\theta = \{\mu^s, \mu^c, \sigma^s, \sigma^c, \gamma^{s,Boro}, \gamma^r, \gamma^q, \psi\}$ to min d(data moments, model-simulated moments)

discretize q and repeatedly solve the equil for each set of conditioning variables in different cells A_x

$g_{1:m}$ refers to the lowest-order statistic of carter costs out of m draws

simulation procedure:

1. search market: $\Upsilon_s(\theta, x) = \sum_{m=1}^{M} w_m(x) \cdot \int \beta_s(c \mid x) \cdot g_{1:m}(c \mid x; \theta)\, dc \approx K^{-1} \cdot \sum_{k=1}^{K} p_{s_k}(\theta, x)$

   randomly draw from the multinomial dis with weights w_m and then a corresponding number of cost draws from $\mathcal{G}(\cdot|\theta)$, the lowest of which is mapped to a price via $\beta_s(\cdot \mid x; \mathbf{w})$

2. broker: $\Upsilon_B(\theta, x) = \sum_b f_b \cdot \int \beta_b(c) \cdot g_{1:N_b}(c \mid x; \theta)\, dc \approx K^{-1} \cdot \sum_{k=1}^{K} p_{s_k}^{b}(\theta, x)$

   N_b cost draws and mapping the lowest cost draw to a price via $\beta_b(\cdot, N_b)$

construct moments: $m(\theta, x) = [m_{1,B}(\theta, x), m_{1,S}(\theta, x), m_{2,B}(\theta, x), m_{2,S}(\theta, x), m_f(\theta, x)]$

1. $m_{1,S}(\theta, x) = N_x^{-1} \cdot \sum_{i \in A_x} p_i - K^{-1} \cdot \sum_{k=1}^{K} p_{s_k}(\theta, x)$
2. $m_{2,S}(\theta, x) = (N_x^{-1} \sum_{i \in A_x} (p_i - N_x^{-1} \sum_{i \in A_x} p_i)^2)^{0.5} - (K^{-1} \sum_{k=1}^{K} (p_{s_k}(\theta, x) - K^{-1} \sum_{k=1}^{K} p_{s_k}(\theta, x))^2)^{0.5}$
3. $m_f(\theta, x) = N_x^{-1} \sum_{i \in A_x} 1\{\text{brokered}\}_i - (1 - \mathcal{H}(\bar{\kappa}(x)))N_x$

optimize the moment: $\hat{\theta}_{MSM} = \arg\min_\theta \mathbf{m}(\theta)' \cdot \Omega \cdot \mathbf{m}(\theta)$

weight: the inverse of the observed variance of each moment

Algorithm 1: Estimation of Model

Result: Estimate of θ

while $\mathbf{m}(\theta)' \cdot \hat{\Omega} \cdot \mathbf{m}(\theta) >$ outer tolerance **do**

1. Initialize weight vector w_0 with $1/M$ in each entry;
2. **while** $d(w^k, w^{k-1}) = \|w^k - w^{k-1}\| >$ inner tolerance **do**
   - 2.1 Recompute the broker bidding functions $\beta_b^k(\cdot \mid \theta)\ \forall\ b$;
   - 2.2 Use w^k to recompute the bidding function $\beta_s^k(\cdot \mid w^k; \theta)$;
   - 2.3 Use $\beta_s^k(\cdot \mid w^k; \theta)$ to compute expected prices $\mathbb{E}[p^{1:m}]$ for each m;
   - 2.4 Recompute $\kappa_m = \mathbb{E}[p^{1:m}] - \mathbb{E}[p^{1:m+1}]\ \forall m \in 1, \ldots, M$ as well as $\bar{\kappa}$;
   - 2.5 Form new weights $w_m^{k+1} = \mathcal{H}(\kappa_m \mid \kappa < \bar{\kappa}) - \mathcal{H}(\kappa_{m-1} \mid \kappa < \bar{\kappa})\ \forall m$;

   end
3. Use the equilibrium objects to simulate $\{p_s, ..., p_s\}$ and $\{p_s^b, ..., p_s^b\}$, compute the average and the standard deviation of simulated prices, compute fraction of brokered contracts $(1 - \mathcal{H}(\bar{\kappa})) \cdot N$;
4. Construct moments for the objective function.

end

1. rule out the Diamond paradox (Diamond 1971)
2. no tricky cases: the set of equilibria with a nondegenerate price distribution is not a singleton
3. no mulptile equil in practice, robustness

Results and Counterfactuals

TABLE 4
Model Parameter Estimates

Parameter	Estimate	SE	95% CI
Supply:			
Carter cost ($):			
Mean	9.969	.24	9.776–10.023
SD	2.96	.157	2.81–3.105
Cost efficiencies (×1,000):			
Quantity	−2.456	1.709	−4.62 to .259
Recyclables	−.152	7.048	−1.589 to 19.8
Cost shifter:			
Bronx	−.235	.031	−.3 to −.214
Brooklyn	−.002	.007	−.003 to .022
Manhattan	−.32	.033	−.398 to −.276
Demand:			
Search cost ($):			
Mean	79.718	5.298	77.302–95.007
SD	62.352	4.903	58.929–73.238
Quantity broker shift	−.309	.015	−.333 to −.284

Note.—The table shows the parameter estimates along with bootstrapped standard errors and 95% confidence intervals (CIs), based on 400 bootstrap iterations. The borough cost shifters are relative to Queens.

TABLE 7
Counterfactual Overview

	Change in Buyer Expenses			Carter		Welfare (Total Cost)	
	Not Brokered	Brokered	All	Margin	Profits	Lower Bound	Upper Bound
Δ absolute ($)	64.0	445.0	127.0	.046	−11.1	4.28	12.61
SE	(11.0)	(157.0)	(32.0)	(.0271)	(10.0)	(1.1)	(3.07)
95% CI	47.7–80.2	265.0–759.3	88.3–189.0	.002–.088	−28.7 to 1.4	3.28–6.78	9.63–18.77
Δ percent	2.52	11.7	4.6	1.95	−1.8	4.41	14.22
SE	(.57)	(1.96)	(1.19)	(1.14)	(1.53)	(1.2)	(4.03)
95% CI	1.84–3.52	8.9–15.42	3.17–6.95	.1–3.81	−4.53 to .25	3.35–7.19	10.58–22.77

Note.—The table shows expected search cost per inquiry, number of inquiries, and total expenses for search. Search cost changes are computed under the assumption that brokers' total variable profits are equal to their fixed cost, which provides a lower bound on the change. Bootstrapped standard errors (in parentheses) and confidence intervals (CIs) are based on 400 iterations.