

Consumer Price Search and Platform Design in Internet Commerce

Dinerstein et.al. (2014)

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Background

- No definitive study measuring online mark-ups
- Ways of structuring online search affect price competition and consumer purchase patterns

Overview

- Note: this subsection is not well-organized.

Literatures Review I

- Search frictions and price competition
 - Theoretical: Stigler (1961)
 - Empirical: Hortacsu and Syverson (2003); Hong and Shum (2006); Hortacsu et al. (2012)
- Online Price dispersion
 - Bailey (1998); Smith and Brynjolfsson (2001); Baye, Morgan, and Scholten (2004); Einav et al. (forthcoming)
- Price elasticity estimation
 - Ellison and Ellison (2009); Einav et al. (2014)

Literatures Review II

- Limited consumer search
 - Malmendier and Lee (2011)
- Consumer search across different websites
 - Ellison and Ellison (2014)
- Two-sided matching
 - Fradkin (2014); Horton (2014)

Two Dimensions of Consumer Online Search

- Guide consumers toward relevant products
 - User query
 - Advertising
 - Recommendations
- "Price search": Help consumers to find attractive prices (focused by this paper)

Different Approaches for Search Problems

- Identifying relevant goods: SKUs or catalog numbers
- Presenting information
 - Ordered by listing date: Craigslist
 - Ordered by price: Amazon
 - Between two approaches: Google Shopping

Trade-offs of Different Approaches to Search Design

- Ordered by listing date
 - Advantages: more difficult for buyers to find the lowest prices
 - Disadvantages: provide opportunities for sellers less professional in categorizing products
- Ordered by prices
 - Advantages: promote price competition
 - Disadvantages: provide sellers with incentives to "obfuscate"

Redesign of eBay's Search Processes ??

- Before: Best Match
 - Not for individual users
 - Not consider price explicitly
 - Difficulty for filtering unrelated goods
- After: two-stage design
 - Search pages with relevant product models
 - Product pages with top-rated seller presented together, ranked by the lowest posted price+shipping (but never seen)

Data Source

- Time horizon
 - Before: traditional Best Match
 - After: new product page as default
- Category
 - Most commonly transacted (to avoid changes during the sample period with half a year)

Table 1

General Patterns

- Average number of listings: 16-41
- Variation in prices (measured by 75th price/25th price)
- Extreme prices: dramatic
- Consumer purchase goods with 25-40th price percentile at most

Comparison between Two Periods

- Variation in decreases of transacted prices
- Variation in decreases of post prices (reflected)

Consumer Search Patterns

- Consumers buy cheaper items ??
- Shares of top-rated sellers increase
- Low-prices top-rated sellers promoted

Figure 3

Consideration Set

- Data: Halo Reach
- Changes:
 - Size increases
 - Clicks decreases

Utility Function

$$u_{ij} = \alpha_0 + \alpha_1 p_j + \alpha_2 TRS_j + \alpha_3 p_j TRS_j + \varepsilon_{ij}$$

- i: consumer
- j: product
- p: price
- TRS: top-rated seller
 - TRS = 1: $u_{ij} = (\alpha_0 + \alpha_2) + (\alpha_1 + \alpha_3)p_j + \varepsilon_{ij}$
 - TRS = 0: $u_{ij} = \alpha_0 + \alpha_1 p_j + \varepsilon_{ij}$
- ε : logit error, Type I extreme value

Consideration Set

- Consumers choose utility-maximizing option in their consideration set $J_i \subseteq \mathbf{J}$
 - Consideration set: J_i
 - Set of all available offerings \mathbf{J}
- Outside goods: $u_{i0} = \varepsilon_{i0}$

Demand Parameter Estimation

- Browsing data → Consideration set and resulting choices ???
- Assumption: the consideration set includes all the listings on the page seen by the consumer following his last search query
 - Before: listings page
 - After: product page
- Demand estimation: multinomial logit choice probabilities

Sample Weight

- Question: which sellers make it into the consideration set?
- Sample weight
(Wallenius' non-central hypergeometric distribution):

$$w_j = \exp\left[-\gamma\left(\frac{p_j - \min_{k \in J}(p_k)}{\text{std}_{k \in J}(p_k)}\right)\right]$$

- Before: $\gamma = 0$, price did not factor directly into search ranking
- After: $\gamma > 0$, price plays a predominant role

Wallenius' Non-central Hypergeometric Distribution

- Hypergeometric distribution:
 - the probability of k successes in n draws without replacement from a finite population of size N that contains exactly K successes
- Non-central hypergeometric distribution: unequal weight for each success ??
 - Wallenius: Competition between successes
 - Fisher: Simultaneously or independently of each other

Nash Equilibrium

$$\max_{p_j} (p_j - c_j) D_j(p_j)$$

- $D_j(p_j)$: probability of a given buyer selects j 's product, given the set of offerings \mathbf{J} ??

$$D_j(p_j) = \sum_{J: j \in J \subseteq \mathbf{J}} \left[\frac{\exp(\alpha_0 + \alpha_1 p_j + \alpha_2 TRS_j + \alpha_3 p_j TRS_j)}{1 + \sum_{k \in J} \exp(\alpha_0 + \alpha_1 p_k + \alpha_2 TRS_k + \alpha_3 p_k TRS_k)} \right] Pr(J|\mathbf{J})$$

- p_j : sellers do not change prices often in practice in the short run

Price Incentive of Sellers I

- $D_j(p_j) = A_j(p_j)Q_j(p_j)$
 - A_j : probability that the listing enters the consideration set given p_j and \mathbf{J}
 - Q_j : probability that the consumer purchases item j conditional on being in the listing set
- Optimal price:

$$\frac{p_j}{c_j} = \left(1 + \frac{1}{\eta_D}\right)^{-1} = \left(1 + \frac{1}{\eta_A + \eta_Q}\right)^{-1}$$

- η_D, η_A, η_Q : respective price elasticities

Price Incentive of Sellers II

• $\gamma > 0$

\nearrow $\eta_A < 0 \quad (\gamma \uparrow \rightarrow \eta_A)$

\searrow $\eta_Q < 0$

Stahl's (1989) Search Model

- Two types of consumers:
 - who (optimally) sample a single offer completely at random
 - who sample all the offers
- $L \in \{1, |\mathbf{J}|\}$ and $\gamma = 0$??
- ??

Directions to Be Extend

- Heterogeneity among sellers or consumers
 - Seller: distinguish between price-elastic searchers and price-inelastic "convenience" shoppers ??
- Search rank
 - Less dramatic
 - Harder to interpret

Estimation Sample

- Product: single, well-defined - popular Microsoft Xbox 360 video game, Halo Reach
 - A large number of units transact on eBay
 - Relatively stable supply and demand during the observation period



Demand Parameters: Methods

- Standard logit demand with individual-level data and observed individual-specific consideration sets
- Maximum likelihood, restricting attention only to consumer data from the **before** period

Demand Parameters: Results

- Top-rated sellers(TRS): \$10 discount (of an average price of less than \$40) - very large(no advantage for the before period)
- Price elasticity: -10 (-13 for TRS)
- Profit margin(profit/revenue): 10%

Consideration Set Model: Methods

- Estimate distribution of L_i (the number of items sampled by a consumer)
 - directly from the browsing data
 - separately for the before and after periods
- Estimate the sampling parameter γ

Consideration Set Model: Results

- Distribution of L_i : Figure 3
 - Sample parameter γ
 - Before: 0
 - After : 0.81
- ?? - a ten percent reduction in the posted price would, on average, make the listing 29% more likely to be part of a consumer's consideration set

Seller Costs: Methods

$$c_j = p_j + \frac{D_j(p_j)}{D'_j(p_j)}$$

- Demand parameters + consideration set model $\rightarrow D_j$
- First order condition: $D_j \rightarrow D'_j$
- Back out the cost c_j

Mathematical Note: Proof

$$f(p_j) = (p_j - c_j)D_j(p_j)$$

First order condition:

$$\begin{aligned}\frac{df}{dp_j} &= D_j(p_j) + (p_j - c_j)D'_j(p_j) \\ &= 0\end{aligned}$$

Therefore,

$$c_j = p_j + \frac{D_j(p_j)}{D'_j(p_j)}$$

Seller Costs: Results

- Figure 4
- High dispersion of seller costs

Methods

- Assumption: consumer choice behavior and sell cost distribution remain unchanged
- Method: combine our demand and cost estimates from the before period with estimates of the consideration set process from the after period
- Goal: calculate equilibrium prices and expected sales with the post-redesign search process

Results

- Demand is more responsive to seller prices
 - Demand becomes more elastic
 - Seller margin falls by 20%

Factors Contributed to the Shift of Seller Incentives

- Increase in the size of consideration set
- Price became an important factor in entering the consideration set
- Increase in the number of available listings

Evaluate the Importance Three Factors I

- Methods
 - Separately impose three effects
 - Calculate new price equilibrium → equilibrium margins and purchase rates
- Results
 - Increase in γ - large effect
 - Increase in listings - small effect
 - Increase in consideration set size - small effect

Evaluate the Importance Three Factors II

- Question
 - Whether the model's predictions for the after period are similar to the outcomes we actually observe
- Comparison
 - Distribution of seller prices: match quite well (Figure 6)
 - Consumer purchase rate: reasonably close (Table 3)

Reasons for High Degree of Price Dispersion

- Dispersion in costs
- Search frictions
- Perceived seller differentiation

Discussion and Extensions



Experiment Design

- Method:
 - Users were randomly assigned to be shown either product page or Best Match results in response to a search query if the product page existed
 - After being shown initial results, users could browse to the other type of listing
- Goal: test whether conditional on both types of results being available, it was better to start users with relevance results

Phenomena

- The experiment did succeed in steering users toward particular results
- Best Match group had a higher purchase rate
- The Best Match group also had **slightly** higher average transacted prices

Data

- Observations: All purchases from the experimental user sessions → Select product pages that were visited at least 1,000 times in the experiment
- Entities: 4,250 different products, and 30,696 different listings that had purchases
- Period: July 25, 2012 to August 30, 2012

Measuring Product Homogeneity

- Relevance ranking might have been particularly effective for differentiated products
- → Need a proxy for each product's level of homogeneity
- → The fraction of product listings with the most common title on the product code
- → Group products depend on whether their top listing share is in the top quartile (less heterogeneous), middle half, or bottom quartile (more heterogeneous) ??

Results

- The Best Match treatment looks best for the more heterogeneous products
 - Purchases under the product page
 - Average percentage effect on sales
- Price search problem is just one dimension of the broader platform problem when there are a large variety of products, many of which are heterogeneous and may involve richer consumer search processes

Conclusion

- Explore search frictions in online commerce, and the role of search design in reducing them
- Price search and price competition and homogenous products
- Develop from theory literatures
- Explain price dispersion, seller margins and the effects of changes in the search ranking

Shortcomings

- Price just one of the dimensions along which consumers are searching
- Orienting a platform toward price search may not work as well for heterogeneous products

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