

Consumers' search

Industrial Organization

Bernard Caillaud

Master APE - Paris School of Economics

October 20, 2016

Consumers' inertia as a source of market power

We have seen how firms' market power rests on differentiation, real or perceived, possibly incorporating quality. We have seen how market power can be used to prevent or deter entry, or to engage in sophisticated pricing and price discrimination.

In the next 2 sessions, we will come back on the sources of market power and investigate how they can be related to imperfection in the formation of demand.

- Imperfect information about products and prices (reminiscent of models of advertising): consumers search for the best alternative
- Frictions on consumers' side: consumers cannot perfectly react to changes in market environment
- Non-fully rational consumers' behavior: behavioral models

Today's sessions about **consumers' search**

- Consumers must search information about prices and products that meet their needs
- They find it too costly to become perfectly informed: search is never exhaustive, even on the Internet.
- This incomplete search constitutes a source of market power to firms
- Reduction of search costs: Internet allows consumers to quickly and easily locate best deals and extends competition to sellers that can be geographically far from consumers
- How does it affect firms' market power? Is the online economy more competitive than the off-line economy?

Search costs are associated with price dispersion: otherwise, why search ! Classical questions, dating back to Stigler (1961):

- Evidence about price dispersion, i.e. deviation from the so-called "law of one price"
- Do markets that account for large share of consumers' budget, that are more repetitive, that involve more experience buyers, exhibit less price dispersion ?
- Has the emergence of the Internet reduce price dispersion ?

The Diamond Paradox

Starting point: the consequences of even small search costs are potentially severe!

- N symmetric firms with zero costs compete in prices
- Unit mass of consumers, with unit-demand and valuation v for the product
- Consumers incur a search cost $s > 0$ per visited firm beyond the first firm (e.g. their neighbor firm ?)

If all firms charge $p = v$, i.e. the monopoly price, it is not worth searching and no consumer gets informed about another price quote than his initial one

If consumers do not engage in search, there is de facto no competition and firms can charge the monopoly price.

The Diamond Paradox

Diamond paradox

If all consumers have positive search costs and products are homogeneous, in equilibrium oligopolistic firms set the monopoly price and consumers do not search.

Comparison with Bertrand equilibrium: introducing even a small friction on the demand side yields a substantive qualitative change in the price equilibrium.

If the first price quote is also costly to obtain,... **the market entirely collapses**, consumers do not participate as they do not expect any surplus from any firm in equilibrium !

The Diamond Paradox

Yet, as for the Bertrand paradox, the Diamond paradox is extreme and unrealistic: people search, that's how Google makes so much money !

Additional meaningful ingredient to build more relevant models: introduce a source of uncertainty for firms, of unobserved dispersion among consumers:

- Search models in homogeneous goods: heterogeneity in search costs, some consumers having no search cost at all / being perfectly informed
- Search models in differentiated goods: heterogeneity in consumers' match value for the products available

Varian's clearinghouse models

Focus on an *homogeneous* good market: consumers search for price quotes.

- Sequential search models: after one observation, consumer decides whether to buy or to continue shopping around. Allows to economize on search costs
- Non-sequential search models: consumer chooses *ex ante* how many price quotes to observe. Allows quick purchase if search-step implies delay

Clearinghouse models: non-sequential search with exogenous number of price quotes if the consumer decides to search at all, e.g. search gives access to the exhaustive price lists of all active firms.

Examples: newspapers that display prices at different stores for the same product, online price comparison websites

Model by Varian (1980).

- N symmetric firms, with zero cost, simultaneously choose their price
- Unit mass of consumers with unit demand each and valuation v for the good
- First price quote is free (see before)
- A fraction I of informed consumers: observe all prices by visiting the clearinghouse and then buy from the cheapest firm
- A fraction $U = 1 - I$ of uninformed consumers: observe only one price quote randomly (uniform on active firms) and buy at this price if it is smaller than v

Varian's clearinghouse models

Firm i 's profit:

$$\begin{aligned}\Pi_i(p_i, p_{-i}) &= p_i \frac{U}{N} && \text{if } p_i > \min_j p_j \\ &= p_i \left(\frac{U}{N} + I \right) && \text{if } p_i < \min_{j \neq i} p_j\end{aligned}$$

A symmetric price equilibrium exists only in mixed strategies:

- Surplus appropriation effect: firms want to charge $p = v$ to extract maximal surplus from uninformed
- Business stealing effect: If all do charge $p = v$, a slight undercut makes a firm gain all informed, jump in profit
- Business stealing does not lead all the way down to Bertrand, as at some point, a firm is better off specializing on its uninformed at monopoly price

Varian's clearinghouse models

- Firms randomize prices on $[\underline{p}, v]$ such that:

$$\underline{p} \left(\frac{U}{N} + I \right) = v \frac{U}{N}$$

- There cannot exist mass points: at such a point, the logic of undercutting would prevail, inducing a jump in profits
- In symmetric ms equilibrium, indifference within the support yields, for all p in $[\underline{p}, v]$:

$$p \left(\frac{U}{N} + I[1 - F(p)]^{N-1} \right) = v \frac{U}{N}$$

- Hence: $F(p) = 1 - \left(\frac{U}{IN} \left(\frac{v}{p} - 1 \right) \right)^{1/N-1}$

Firms randomize: sometimes low prices to attract informed consumers, sometimes high prices to extract surplus from captive uninformed consumers: interpretation as "sales"

Effect of the proportion of informed consumers: As I increases, the expected price paid by both informed ($\mathbb{E}[p_{min}]$) and uninformed ($\mathbb{E}[p]$) decrease

Intuition: business stealing effects becomes more pronounced and the cost of foregone revenues on uninformed becomes smaller (less uninformed consumers), so both firms' price distribution shift to lower prices (FOSD).

Effect of number of firms: As N increases, the expected price paid by informed ($\mathbb{E}[p_{min}]$) decreases, the expected price paid by uninformed ($\mathbb{E}[p]$) increases

Intuition: one additional firm implies smaller revenues from uninformed consumers but also lower chances to have the smallest price hence to get the informed: overall, firms charge higher prices (FOSD) but informed consumers get one more draw and therefore can obtain a smaller price in expectation

Imposing a price floor or ceiling: It may decrease consumers' incentives to search

Intuition: price dispersion is reduced, hence smaller gains from search (smaller expected price reduction). This can lead to counter-intuitive effects:

- A price cap imposed by a regulator may make all consumers pay a higher price
- A wholesaler may impose RPM on its retailers to reduce consumers' search and therefore increase industry profits

Search behavior has to be consistent with firms' pricing strategy.

Value of price information contained in the clearinghouse is $VOI = \mathbb{E}[p] - \mathbb{E}[p_{min}]$, the price reduction brought about by search in expected terms

- VOI as a function of I is non-monotonic: no point in searching when no one searches (monopoly price anyway) or when every consumer searches (competitive price): high value of information when search intensity is intermediate
- Suppose s distributed according to a cdf $G(\cdot)$ on $[0, \bar{s}]$ with mass point $G(0) > 0$ at $s = 0$. In equilibrium $VOI(I) = \tilde{s}$ with $I = G(\tilde{s})$

Preference interpretation: loyal consumers vs switchers (used in marketing literature a lot)

- Uninformed = loyal, who have strong preference for this product
- Informed = indifferent between products

Bounded rationality interpretation:

- Uninformed = bounded rational consumer whose search behavior is not optimal
- Informed = Fully rational consumer

Stahl's sequential search model

Stahl (1989) uses the same type of model as Varian but assumed that consumers search sequentially.

The sequential search protocol may be more realistic in several situations; it also allows potentially to save on search costs if you get a good early draw.

A proportion I of consumers have zero search costs and so observe all prices and buy from the cheapest firm. A proportion $U = 1 - I$ of consumers must incur a search cost s (known) to observe one price quote (except the first one) and search sequentially with perfect recall.

Consumers' behavior:

- Anticipate price distribution $F(.)$ on $[\underline{p}, v]$ followed by firms
- After observing a price p_0 , a consumer compares the expected gains from extra search are $GS(p_0) = \int_{\underline{p}}^{p_0} (p_0 - p) dF(p)$ with her search cost s
- If $I = 1$, all consumers are informed, Bertrand emerges: all firms charge their zero marginal cost, no gain from search !
- In equilibrium, it must be that consumers with search cost do not search and the maximum price that can be charged on them is $r = \min\{v; GS^{-1}(s)\}$ (reservation price for non-shoppers).

Firms' behavior, for a given equilibrium search intensity characterized by I , is similar to the one characterized in the non-sequential model of Varian, with r instead of v .

Reservation price for non-shoppers r is an increasing function of N : consumers become less choosy when there are more firms in the market.

Intuition: As N increases, there is more competition which induces firms to charge lower prices; but the probability of being the lowest price store also decreases, which induces firms to charge higher prices. Overall, the second effect dominates !

Price dispersion in the data

Baye-Morgan-Sholten (2004) on detailed information on prices for 1000 items (on comparison sites): significant and persistent price dispersion: coef of variation (std var / mean) about 9%

Dispersed prices may come from product heterogeneity/differentiation models or costly consumer search models: if product characteristics do not change, product differentiation models predict no change in prices while consumer search models predict temporal price dispersion since firms use mixed strategies to avoid consumers' learning the lowest price firm.

Empirical strategy: look whether firms vary their relative position in the cross sectional distribution of prices over time

Issue of "clean" prices: use panel data and regress prices on fixed effects for firms, time and location, so that the obtained residuals are the prices of a homogeneous good (Lach, 2002)

Price dispersion in the data

On gasoline markets, Lach - Moraga-Gonzales (2009): transition of quartils at one week interval

		t+7			
		q ₁	q ₂	q ₃	q ₄
t	q ₁	33	22	22	22
	q ₂	27	27	27	18
	q ₃	32	23	28	17
	q ₄	27	22	31	20

Price dispersion in the data

On gasoline market also, Chandra-Tappata (2011): rank reversal between firm i and j over T_{ij} days:

$$r_{ij} = \frac{1}{T_{ij}} \sum_{t=1}^{T_{ij}} \mathbf{1}_{\{p_{it} > p_{jt}\}}$$

More than 90 % of the pairs of stations have positive rank reversals

Average rank reversal is around 0.15

Assuming optimal search by consumers and pricing according to equilibrium mixed strategy, the distribution of search costs can be recovered from data on prices.

Few empirical studies on consumers' search costs:

- Hong-Shum (2006): online markets for books, they find s around USD 2.5, with about half consumers who never search beyond first sampled brand
- Moraga-Gonzales - Wildenbeest (2008): online markets for computer memory chips, they find 3 groups of consumers: consumers who do not search (but for the first quote), consumers who compare 2 or 3 prices and consumers who collect information about all prices, with associated search costs.

In an homogeneous good market, the only motive a consumer has to search is to find a better price. But consumers also search for a product they like !

Introduce **heterogeneity / differentiation across products**: consumers have no information about the existing products

- Products cannot be distinguished ex ante, search has to be random
- Or search may be guided by a platform: e.g. order in a list proposed by a search engine, accessibility and location of products in a supermarket

Random sequential search

Very influential model due to Wolinsky (1986) and further developed by Anderson - Renault (1999)

- N symmetric firms with zero cost simultaneously choose their price
- Unit mass of consumers with unit demand and

$$u_{mi}(p_i) = \epsilon_{mi} - p_i$$

ϵ_{mi} uniformly iid on $[0, 1]$: match value consumer m - product i

- Consumer incurs search cost $s > 0$ to learn the price and match value for a product sold by any firm (sequential with perfect recall)

Random sequential search

Consumer's stopping rule:

- Suppose she expects all (remaining) firms charge the same price p^*
- Then given the best observed match a and the price p^* , she compares s with the incremental benefit from one additional search:

$$\int_a^1 (\epsilon - a) d\epsilon = s$$

- Defines the critical match value at which she stops (LHS decreasing in a): $a = 1 - \sqrt{2s}$
- Facing a best observed product (ϵ, p) (when one firm deviates) that yields surplus $\epsilon - p$, she stops if this is larger than her reservation surplus:

$$\epsilon - p \geq a - p^*$$

Random sequential search

Assume that N is infinite.

So, a firm that deviates to p faces a demand proportional to $1 - a + p^* - p$ (probability that the match value be larger than the reservation surplus corrected for the price difference)

In equilibrium (with N infinite), the deviating firm's profits should be maximized at $p = p^*$; this yields: $p^* = \sqrt{2s}$

- Consumer finds optimal to search whenever $a > p^*$, i.e. for low enough search costs ($s < 1/8$). If not, the market collapses (Diamond)
- This limit price increases with the search cost, from the perfectly competitive price when no search cost.

Random sequential search

But there is only a finite number of firms !

Expecting uniform price p_0 , consumer participates only if $p_0 \leq a$; she buys if she finds $\epsilon_i - p \geq a - p_0$; if not, after visiting all the firms, she buys the highest $\epsilon_i - p$ if non-negative.

A firm charging a price p , others charging p_0 , faces a demand:
 $d(p; p_0) = h_0(1 - a + p_0 - p) + r_0$

- First term = fresh demand. $h_0 \equiv \frac{1}{n} \sum_{k=0}^{n-1} a^k = \frac{1-a^n}{n(1-a)}$; consumer visits the firm after k unsatisfactory others and then buys from the firm immediately if $\epsilon - p \geq a - p_0$
- Second term = returning demand (less elastic); consumer comes back after all unsatisfactory visits.

$$r_0 \equiv Prob\{\max_{j \neq i} \{0, \epsilon_j - p_0\} < \epsilon_i - p < a - p_0\} = \int_{p_0}^a \epsilon^{n-1} d\epsilon$$

Random sequential search

In (symmetric) equilibrium, a firm maximizes its profit $pd(p; p_0)$ at $p = p_0$, so that:

$$p_0 = 1 - a + \frac{r_0(p_0)}{h_0} \Leftrightarrow \frac{1 - p_0^n}{p_0} = \frac{1 - a^n}{1 - a}$$

- Unique $p_0 \in [1 - a, 1/2]$, the market is active
- The equilibrium price increases in the search cost and decreases in the number of firms
- When the number of firms goes to ∞ , the equilibrium price goes to p^*

Guided search: the example of prominence

Extend the previous model to allow one product to be displayed more prominently than others: then, it is assumed that consumers start search by this product and, if not satisfied, they continue by randomly searching among the others.

Examples: links displayed on a search engine, products displayed at entrance of supermarket,...

Armstrong-Vickers-Zhou (2009)

Guided search: the example of prominence

Effect on prices: $p_{Prominent} \leq p_0 \leq p_{Non-prominent}$

Intuition: If all prices close together, the prominent firm's demand is mostly "fresh", the Non-prominent firms' demand is mostly of returning type; and returning demand is less elastic than fresh demand, hence the price ranking.

Role of search cost:

- s very small, consumers sample all firms before purchase, hence prominence has no impact
- s close to $1/8$ (i.e. a close to $1/2$), prices converge to monopoly price $1/2$:

Guided search: the example of prominence

Effect on output: Total output is lower when one firm is made prominent, as the price increase for non-prominent firms dominates the price decrease of the prominent firm.

Effect on number of searches: Average number of searches is smaller when one firm is made prominent, as consumers start searching by the lowest price firm (drawback: lower average match value)

Effect on welfare: Welfare is reduced when one firm is made prominent, as there is dispersion of prices for a given total output, plus total output decreases.

Other models of guided search

Prices may be observable freely while consumers have to search to discover the match value of products: hence, search may be ordered by the observed prices (i.e. increasing prices if ex ante symmetric products).

Zhang (2009): average price charged by firms increases when the search cost decreases (higher s , second visit less likely, hence more important to be the 1st visited, hence lower prices)

Obfuscation: when a firm makes price structure and/or product attributes more difficult to evaluate for consumers (increase of search cost)

Soften price competition (Wilson, 2010, Ellison-Wolinsky, 2012) and helps filter consumers to ensure that only genuinely interested consumers visit the firm

- Armstrong, M., J. Vickers and J. Zhou (2009), Rand JE, 40(2), 209-233
- Belleflamme - Peitz, Ch.7
- Stahl, D. (1989), AER 79, 700-712.
- *Varian, H. (1980), AER 70, 651-659
- *Wolinsky, A. (1986), QJE 101(3), 493-512