Costly Search and Design

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NASM, June 2009
Introduction

- Firm design choices
  - product design
  - marketing/information

- Competition and search
  - falling search costs affect the nature of demand
  - changing the kinds of goods provided

- Prevalence and coexistence of very different design strategies
  - broad designs (lowest common denominator) and niche (very specialized)
Implications/Preview

- Search costs affect pricing but also product variety
  - holding variety fixed, lower search costs lead to lower prices
  - what kind of products (how niche/specialized)?

- Externalities in design choice
  - profits and prices can be non-monotonic in search costs
Superstars and the Long-Tail of the Internet

- Long tail
  - Anderson (2004,6); Brynjolfsson, Hu and Smith (2006)
  - demand side effects and long tail; Brynjolfsson, Hu and Simester (2007)

- Superstars
  - Elberse and Oberholzer-Gee (2006); Goldmanis, Hortacsu, Onsel and Syversson (2009)

- Model delivers coexistence of long-tail and superstar effects
Model Preview

- Product design and competition
  - Each firm chooses price and a distribution of matches from a family
  - More or less dispersed: broad vs nichey
  - Johnson and Myatt (2006)

- Costly sequential search (a la Diamond 1971)
  - Differentiated products
    - visit to a new firm provides a new “match” as well as a new price quote; Wolinsky (1986), Bakos (1997), Anderson and Renault (1999)
    - no modelling of spatial differentiation: new firm then independent draw from distribution of matches
Model

- Continuum of firms of measure 1
- Continuum of consumers of measure $m$
- Consumer $l$ when consuming good from firm $i$ at price $p_i$ gains utility (not including any search costs)

$$u_{li}(p_i) = -p_i + \varepsilon_{li}$$

where $\varepsilon_{li}$ is the value of the match
- The cost of visiting an additional firm is $c > 0$
- The utility of consumer $l$ is given by

$$u_{li}(p_i) = -k c,$$

if she buys product $i$ at price $p_i$ after visiting $k$ firms
Firm Strategy

- A firm’s strategy: choose a price $p$ and a design $s \in [B, N]$ where $\varepsilon_{li}$ is an independent draw from $F_s(.)$
  - $F_s(.)$ has support on some interval $(\theta_s, \bar{\theta}_s)$ is continuously differentiable and the distribution has logconcave densities $f_s(\theta)$
  - There is a family of rotation points $\theta^\dagger_s$ such that $\frac{\partial F_s(\theta)}{\partial s} < 0$ for $\theta > \theta^\dagger_s$ and $\frac{\partial F_s(\theta)}{\partial s} > 0$ for $\theta < \theta^\dagger_s$; further $\theta^\dagger_s$ is increasing in $s$
Demand rotations

- **single rotation point**
- **differing rotation points**
Consumer Strategy

- Consumer strategy: choose whether or not to continue search, choose whether or not to buy
  - Note with continuum firms, never revisit a previous firm
Equilibrium

We look for Symmetric Nash Equilibrium

- Firms mix in choice of price and product design
  \[ \sigma \in \Delta(\mathbb{R} \times [B, N]) \]
- Consumer strategy determined by some threshold \( U \) such that continue search if anticipate that doing so yields \( U \) or more in expected net utility
- Note that there is always a trivial (and uninteresting) class of equilibria with no consumers and high prices
Firm's problem

- Firm $i$ faces a consumer $l$ who will buy as long as $-p_i + \varepsilon_{li} > U$
- Define $p_s(U)$ as the firm's optimal price when choosing some design $s$ and faces consumer with stopping rule $U$

$$p_s(U) = \arg \max p_s(1 - F_s(p_s + U)) = \frac{1 - F_s(p_s(U) + U)}{f_s(p_s(U) + U)}$$

- Logconcavity ensures that $p_s(U)$ is uniquely-defined and is continuous and monotonic (non-increasing) in $U$
Firm’s problem

- Then, trivially, profits can be written as

\[ p_s(U) \frac{m}{\rho} (1 - F_s(p_s(U) + U)), \]

- \( \frac{m}{\rho} \) is the mass of consumers who visit where \( \rho \) is the probability that a consumer buys from any given store.
- Firm problem then reduces to choosing \( s \) to maximize profits

**Lemma**

*Equilibrium prices and designs do not vary with \( m \).*

**Corollary**

*Endogenizing \( m \) (through free entry and zero profit condition with a fixed cost of entry) would lead to identical prices, designs and consumer surplus.*
Design Choice (Preliminary Result)

Proposition

Firms choose extremal designs, that is either \( s = H \) or \( s = L \).

Proof.

Recall design chosen to optimize

\[
\frac{m}{\pi \sigma} p_d (U_{\sigma})(1 - F_d (p_d (U_{\sigma}) + U_{\sigma})) \quad \text{or equivalently} \quad p (1 - F_d (p + U_{\sigma}))
\]

with respect to both \( p \) and \( d \): affine transforms of demand rotations are still rotations, and the firm is a monopolist on this residual demand curve so that Proposition 1 of Johnson and Myatt (2006) can be applied.
optimal price is above the point of rotation: more “nichey” design

optimal price is below the point of rotation: more “broad” design
Summary

- For very high $c$ no trade possible
- For $c$ high enough all broad equilibrium and decreasing prices in this region as $c$ falls
- For $c$ low enough all niche equilibrium and decreasing prices in this region as $c$ falls
- Intermediate $c$ then mixed strategy
  - unique if $c_B > c_N$
  - *increasing* prices in this region as $c$ falls if $c_B > c_N$

Corollary

*Prices and profits can be non-monotonic in search costs.*
Comparative Statics

- **All niche**
  - As $c$ increases
  - Prices increase
  - Profits increase
  - CS falls
  - Sales constant

- **Mixed**
  - As $c$ increases
  - Ave prices decrease
  - Profits decrease
  - More broad firms
  - Fewer niche firms
  - CS constant
  - lower sales for niche firms
  - lower sales for broad firms

- **All broad**
  - As $c$ increases
  - Prices increase
  - Profits increase
  - CS falls
  - Sales constant

- **No trade:**
  - “Diamond paradox” intuition
  - lower sales for niche firms
  - lower sales for broad firms
Comparative Statics II

- prices and profits non-monotonic
- surplus monotonic
- In intermediate region
  - both types of firm have higher sales
  - overall sales constant (from set-up of model)
  - more niche firms
  - long-tail effects (niche firms have higher sales)
  - superstar effects (broad firms have higher sales)
  - coexistence of “superstar” and “long tail” effects
Related Literature

- **Search models (design exogenous)**
  - Diamond (1971); Wolinsky (1986); Bakos (97); Anderson and Renault (1999)

- **Product design and demand rotations (monopoly models)**
  - Johnson and Myatt (2006); Lewis and Sappington (1994); Bar-Isaac, Caruana and Cuñat (2009)

- **Search and product design**
  - Kuksov (2004): two firms, consumers know the varieties available but not location, different designs come with different costs associated
  - Cachon, Terwiesch and Xu (forthcoming) focus specifically on multi-product firms, where consumers search costlessly within a firm but at some cost between firms and “design” = product range.
Long tail and superstar effects
  - Anderson (2004,6), Brynjolfsson, Hu and Smith (2006)
  - demand side effects and long tail; Brynjolfsson, Hu and Simester (2007)
  - superstars; Elberse and Oberholzer-Gee (2006), Goldmanis, Hortacsu, Onsel and Syversson (2009)
Conclusions

- Search costs affect product design
- Different design-styles can coexist in equilibrium
- Prices, profits and consumer surplus may be non-monotonic in search costs
  - lower search cost induce lower prices fixing design
  - but lower search cost can induce more niche designs which in turn soften price competition
Extensions and further notes

- Endogenous firm entry
- Endogenous consumer entry
- Coordinated industry behaviour (industry-sponsored websites etc)
- Prominence and search order
- Search on price and product attributes separately
- Targeted search and advertising
- Ex-ante firm heterogeneity: “superstar” effects