Targeting with Consumer Search: an Economic Analysis of Keywords Advertising

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Introduction

Search engines make most of their profits through advertising.
Google: revenue of $22 billion in 2008
How does advertising on search engines work?
Introduction

- Choice of keywords
- **Bidding**: Generalized second price auction
- Sorting of ads according to bid and quality score
- Per-click payment
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Keyword advertising $\implies$ better targeting of consumers by announcers (intent-related)

Questions:

- How does keyword advertising affect the strategic interactions between firms?
- Is the targeting technology welfare improving?
- What are the incentives of the search engine to manipulate the mechanism?
Introduction

Basic ingredients of the model
Firms will choose
- Price of the good
- Set of keywords

Demand’s characteristics
- Heterogenous tastes
- Search costs
Introduction

Preview of the results:

- Targeting is welfare improving;
- The search engine will either improve or deteriorate the matching quality.
The model

Product space and preferences

- Heterogenous product space (à la Salop): unit circle, continuum of firms, \( c = 0 \), continuum of consumers.

- Utility \( u = v(d) - p \), with \( v'(.) < 0 \).

Information frictions

- Consumers cannot observe the price nor the position on the circle directly.
- Search cost \( s \) to learn price and position.
Timing

- Search engine sets advertising per-click fee $a$.
- Firm $i$ sets price $p_i$ and keywords $K_i = [i - D; i + D]$
- Consumers enter keyword $k = \text{ideal product}$.
- Sequential search among $\{i/k \in K_i\}$: optimal stopping rule
I look for symmetric Perfect Bayesian Equilibria.

- Firms maximize their profits given other firms’ strategies and consumers’ stopping rule.

- Consumers choose the optimal stopping rule given firm’s strategies.

- Search engine maximizes its profit w.r.t. a
Optimal search process 1

Consumers expect firms to play $\sigma^* = (p^*, D^*)$.

Expected value of a click

$$\int_{0^*}^{D^*} \frac{v(x) - p^*}{D^*} dx$$

Expected improvement after first offer at distance $d$:

$$I(d) \equiv \int_{0}^{d} \frac{v(x) - v(d)}{D^*} dx$$
If firms set $p = p^*$, reservation distance $R^*$ such that

$$I(R^*) = s$$

If a consumer faces $p \neq p^*$, he buys iff

$$d \leq R(p, \sigma^*)$$

where $R(p, \sigma^*)$ is such that

$$v(R(p, \sigma^*)) - p = v(R^*) - p^*$$
Properties of stopping rule

Consumer’s strategy: buy at price $p$ iff $d \leq R(p, \sigma^*)$

\[
\frac{\partial R(p, \sigma^*)}{\partial p} < 0
\]

\[
\frac{\partial R(p, \sigma^*)}{\partial p^*} > 0
\]

outside-option effects:

\[
\frac{\partial R(p, \sigma^*)}{\partial D^*} > 0
\]

\[
\frac{\partial R(p, \sigma^*)}{\partial s} > 0
\]
Firms’ strategy

Advertising strategy: Firm $x$ targets consumer $y$ iff

$$pPr(y \text{ buys } x's \text{ product} | y \text{ clicks on } x's \text{ link}) - a \geq 0$$

Lemmas 1 and 2: In a symmetric equilibrium, $D = R(p, p, D)$: no additional search.
Intuition of the proof

Profit: $\pi(p) \propto (p - a)(R(p, \sigma^*))$
Existence and unicity of equilibrium

If

1. For any $p$, $R(p, p, 1/2) < 1/2$.
2. $\psi : x \mapsto v'(x) + xv''(x)$ satisfies the single crossing property.
3. $\forall x \in [0; 1/2], xv''(x) + 2v'(x) \leq 0$

Then there exists a unique symmetric PBE.

The SE chooses $a$ s.t. $E[v(d)|d \leq D^*] - p(a) - s = 0$. 
Effects of search costs

Holding $a$ constant, price rises with search cost. However, a rise in $s$ leads the SE to lower $a$. 
A benchmark: Wolinsky 1983

In his model, firms cannot target consumers.

- Targeting reduces search costs.
- Targeting improves the quality of matches.
- Welfare unambiguously rises with targeting.
- Ambiguous effect on the price.
Strategic search engine

Search engines are strategic intermediaries. Examples:

- Maps;
- Weighting of bids according to a quality score;
- Broad match technology.
Strategic search engine

SE chooses both $D$ and $a$, while firms choose $p$.

Suppose that SE set $D = 0$: perfect matching.

The only equilibrium is the “monopoly”’’ price $p = v(0)$.

$$EU = v(0) - p - s = -s < 0$$
Strategic search engine

Suppose SE chooses $D$ and firms choose $p$. 

![Graph showing strategic choices and p(D)]
Intuitions

In order to sell to a consumer, 2 constraints:

- $\text{utility} \geq 0$ (IR);
- $\text{utility} \geq \text{outside option}$ (OO);

For $D$ small, (IR) $\Rightarrow$ (OO).

For $D$ large, (OO) $\Rightarrow$ (IR).
Optimal matching accuracy

SE wants to implement a high price.

Here, the outcome is constrained efficient.
Optimal matching accuracy

But the outcome may also be inefficient: $b > 1$. 

![Diagram showing $p(D)$ and $u(D)$ with $D^*$ and $D_{max}$]
Related literature


- Iyer, Soberman and Villas-Boas (2005), Esteban, Gil and Hernandez (2001): Ability to target $\implies$ Differentiation $\implies$ Market power.

- Grossman and Shapiro (1984): targeting $\implies$ better information $\implies$ price drops.

- Two-sided markets; Baye and Morgan (2004), Hagiu and Jullien (2009), White (2008)
Conclusion

“Methodological” contribution:
▶ model with search and targeted advertising

Results:
▶ Targeting is welfare improving
▶ Potential scope for manipulation, efficient or inefficient.