Online Advertising and Privacy

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Introduction

Online advertising industry: $100 billion, and growing.

Three main types

▶ Search advertising (43%)
▶ Classified advertising (24%)
▶ Display advertising (33%)

Main actors in display advertising

▶ Large publishers (Facebook, Google, etc.)
▶ Advertising networks, Ad Exchanges
Introduction

Factors enhancing efficiency of display advertising

1. Ability to gather information about users:
   ▶ Cookies
   ▶ IP address
   ▶ Social network

2. Ability to tailor interactions
   ▶ Simultaneous auctions
   ▶ Display different ads to different users
Overview of the model

User 1

User 2

User 3

Integrated Publisher

Visits

Displays ad 2

Displays ad 3

Displays ad 2

conditional bids

Advertiser 1

Advertiser 2

Advertiser n
Economic questions

Questions

▶ When is it profitable for the publisher to disclose consumers’ data?
▶ Do consumers and firms prefer privacy or disclosure?

Potential policy implications

▶ OFT market study (May 2010) “Online Targeting of Advertising and Prices”
▶ The FTC is contemplating a new online privacy mechanism: “Do not track” button (December 2010)
The main tradeoffs

**Publisher** (see, e.g., Ganuza (2004))

- Under **Privacy**: symmetric bidders, no rent.

- Under **Disclosure**: increases dispersion of willingness to pay, positive informational rent.
The main tradeoffs

Advertisers

- Under **Privacy**: “weak” demand by consumers, low price, zero profit.

- Under **Disclosure**: “strong” demand, high price, positive profit.
The main tradeoffs

Consumers

- Under **Privacy**: bad match with advertisers, low price of the good.

- Under **Disclosure**: good match, high price.
The model

Players:

▶ One consumer.

▶ \( n \) differentiated firms.

▶ One publisher auctioning one slot.
The consumer’s valuation for product $i$ is
\[ v_i = \begin{cases} 
1 & \text{with prob } 1 - q_i \\
\mathcal{U}([1, 1 + V]) & \text{with prob } q_i 
\end{cases} \]

Ex ante, the $q_i$’s are i.i.d uniform on $[0; 1]$.

$q = (q_1, \ldots, q_n) : \text{interim-type}$

$v = (v_1, \ldots, v_n) : \text{type}$
Information structure

The publisher has information, but cannot infer the $q_i$’s. Firms could.

Under **Privacy**, the publisher does not let firms learn the information.

Under **Disclosure**, it lets firms learn the information. Each firm $i$ then observes $q_i \equiv P[v_i > 1]$. 
Timing of the game

1. The publisher chooses either Disclosure or Privacy.

2. Firms choose a price, and a bidding function $b_i(q_i)$.

3. Under Disclosure, firms learn $q_i$.

4. The publisher runs a second-price auction, without reserve price.

5. The winning firm’s advertisement is displayed to the consumer.

6. The consumer buys one unit if and only if $p_i \leq v_i$. 
Firms’ pricing decision

Suppose that firm $i$ faces a consumer of type $q_i$.

Its gross revenue, if it sets a price $p_i$, is

$$p_i P[v_i \geq p_i] = \begin{cases} 
1 & \text{if } p_i = 1 \\
q_i p_i \left(\frac{1+V-p_i}{V}\right) & \text{if } p_i > 1
\end{cases}$$

The second expression is maximized by setting

$$p_i = \frac{1 + V}{2} \equiv p^m$$

and the revenue is

$$q_i \frac{(1 + V)^2}{4V} \equiv q_i r^m$$
Firms’ pricing decision

The optimal price is thus

\[ p_i(q_i) = \begin{cases} 
1 & \text{if } q_i \leq 1/r^m \\
p^m & \text{if } q_i \geq 1/r^m 
\end{cases} \]

A firm which faces a consumer with a high \( q_i \) wants to charge a high price.
A firm which faces a consumer with a low \( q_i \) wants to charge a low price.

**Assumption:** \( r^m \in [1; 2] \).
Equilibrium under Privacy

If the publisher opts for Privacy, each firm expects $q_i = \frac{1}{2}$.

Since $r^m \leq 2$, it is optimal for firms to choose $p_i = 1$, and $b_i = 1$.

The winner of the auction is picked randomly, and the publisher’s profit is $\Pi_{Privacy} = 1$.

Consumer’s surplus is $CS_{Privacy}(V, n)$, with $\frac{\partial CS_{Privacy}}{\partial V} > 0$ and $\frac{\partial CS_{Privacy}}{\partial n} = 0$.

Firms’ profit is zero.
Equilibrium under Disclosure

We look for an equilibrium in which all firms charge the high price $p^m$ and bid $b_i(q_i) = q_i r^m$.

Firms have to choose their price prior to learning $q_i$. So, if a firm wins the auction, the expected value of $q_i$ is $E[q_{n:n}]$.

Firms’ expected profit under this strategy profile is

$$\pi = \frac{1}{n} (E[q_{n:n}] - E[q_{n-1:n}]) \cdot r^m = \frac{r^m}{n(n + 1)}$$
Equilibrium under Disclosure

Is there a profitable deviation by a firm?

The only potential deviation is $p_i = 1 = b_i(q_i)$.

This deviation is not profitable if and only if $(r^m)^n > n + 1$.

If the condition does not hold, or if $E[q_{n:n}] < 1/r^m$, the unique equilibrium is an asymmetric one with:

- One firm playing $p_j = b_j = 1$ and
- $n - 1$ firms playing $p_i = p^m$ and $b_i(q_i) = q_i r^m$. 
Equilibrium under Disclosure

We focus on the symmetric equilibrium.

The publisher’s expected profit is $\Pi_{\text{Disclosure}} = E[q_{n-1:n}]r^m$. 

Consumer’s expected surplus is

$$CS_{\text{Disclosure}} = E[q_{n:n}] \int_{p^m}^{1+V} x - p^m \frac{dx}{V} = \frac{n}{n+1} \frac{r^m}{2}$$

Under disclosure, consumer’s surplus and publisher’s profit increase with $n$. 
Publisher: Disclosure or Privacy?
Consumers: Disclosure or Privacy?

![Graph showing the relationship between Disclosure and Privacy]

- Disclosure vs. Privacy
- Graph with axes labeled $n$ and $r^m$
Total welfare: Disclosure or Privacy?
Summary

\begin{figure}
\begin{center}
\begin{tikzpicture}
  \draw[->] (0,0) -- (6,0) node[right] {$n$};
  \draw[->] (0,0) -- (0,4) node[above] {$r^m$};
  \draw[red, thick] (0,4) -- (1,3) node[below] {P P D};
  \draw[green, thick] (0,4) -- (2,1) node[below] {P P P};
  \draw[black, thick] (0,1) -- (3,2) node[below] {D P P};
  \draw[black, thick] (0,2) -- (4,3) node[below] {D P D};
  \draw[black, thick] (4,3) -- (5,4) node[below] {D D D};
  \draw[black, thick] (1,3) -- (2,4) node[below] {D D P};
  \draw[black, thick] (2,1) -- (3,2) node[below] {D D P};
\end{tikzpicture}
\end{center}
\end{figure}
Extensions (in the paper)

- Partial disclosure
- Customized pricing
- Other media
Extension: Customized Pricing

Firms can charge $p(q_i)$.

Two results

1. The publisher always chooses to disclose information.

2. Firms are worse-off than without customized prices.
   - Better surplus extraction power (+)
   - The first and the second highest bids become closer (-)
Extension: partial disclosure

3 technologies

1. Truth or noise
2. Symmetric partition
   In both cases, partial disclosure is never optimal.
3. Pooling at the top: partial revelation optimal.
Related literature

Information disclosure


Economics of privacy


Targeted advertising

▶ de Cornière (2010)
Future research

- Mass and niche advertisers
- Competition between publishers
- Costly content
- Not integrated publisher member of an ad network