

# 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

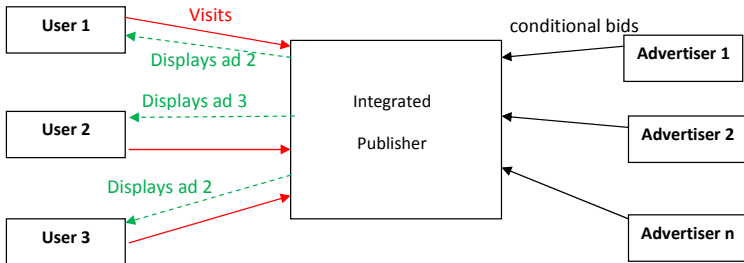
### 1. Ability to gather information about users:

- ▶ Cookies
- ▶ IP address
- ▶ Social network

### 2. Ability to tailor interactions

- ▶ Simultaneous auctions
- ▶ Display different ads to different users

# Overview of the model



# 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.

# Consumer

The consumer's valuation for product  $i$  is

$$v_i = \begin{cases} 1 & \text{with prob } 1 - q_i \\ \hookrightarrow \mathcal{U}([1, 1 + V]) & \text{with prob } q_i \end{cases}$$

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

$\mathbf{q} = (q_1, \dots, q_n)$  : *interim-type*

$\mathbf{v} = (v_1, \dots, v_n)$  : *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

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



# 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.

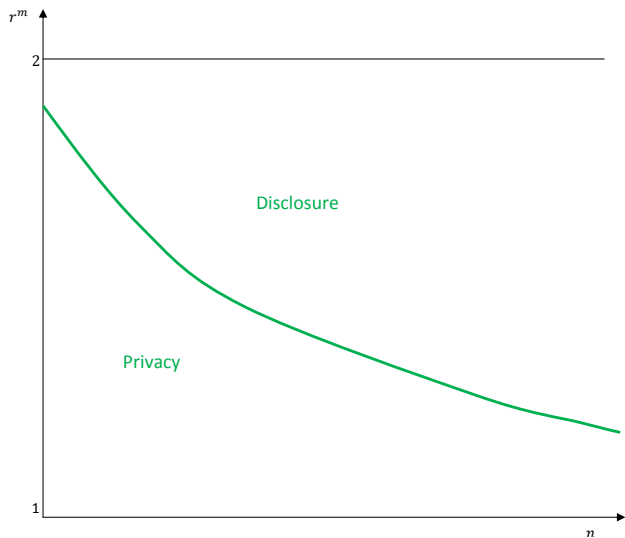
The publisher's expected profit is  $\Pi_{Disclosure} = E[q_{n-1:n}]r^m$ .

Consumer's expected surplus is

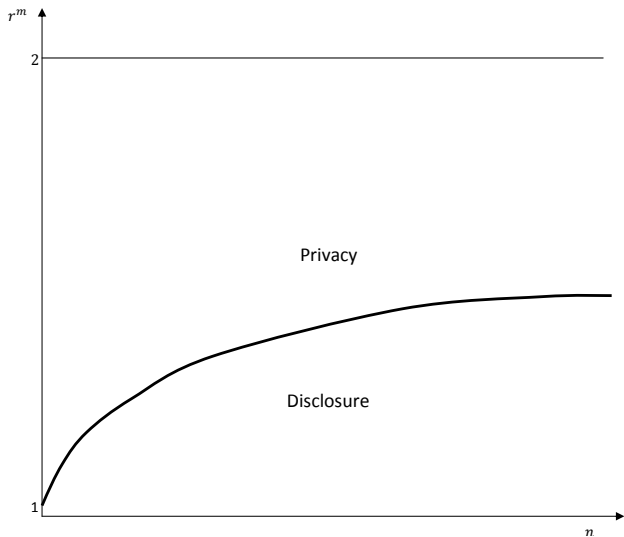
$$CS_{Disclosure} = E[q_{n:n}] \int_{p^m}^{1+V} x - p^m \frac{dx}{V} = \frac{n}{n+1} \frac{r^m}{2}$$

Under disclosure, consumer's surplus and publisher's profit increase with  $n$ .

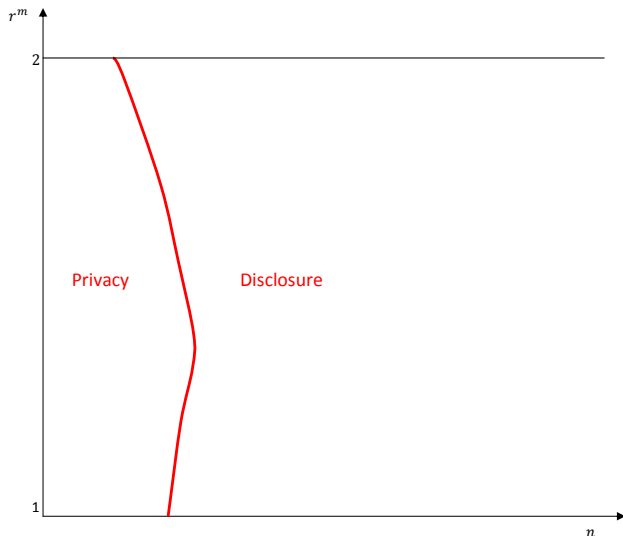
# Publisher: Disclosure or Privacy?



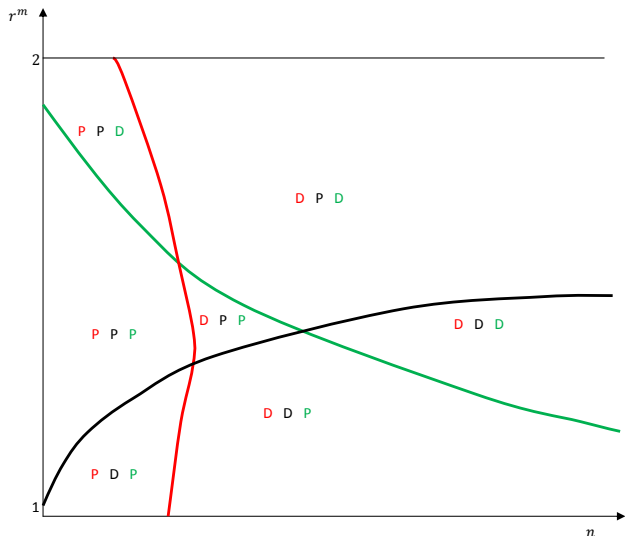
# Consumers: Disclosure or Privacy?



# Total welfare: Disclosure or Privacy?



# Summary



# 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

- ▶ In auctions: Ganuza (2004), Ganuza and Penalva (2010), Milgrom and Webber (1982).
- ▶ In IO: Lewis and Sappington (1994), Johnson and Myatt (2006).

## Economics of privacy

- ▶ Taylor (2004), Aquisti and Varian (2005)
- ▶ Calzolari and Pavan (2006), Hermalin and Katz (2006)

## Targeted advertising

- ▶ Iyer, Soberman and Villas-Boas (2005)
- ▶ de Cornière (2010)

# Future research

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

