Information Revelation and Consumer Privacy

Rossella Argenziano[1] Alessandro Bonatti[2] Gonzalo Cisternas[2]

[1]University of Essex

[2]MIT Sloan

Ninth bi-annual Postal Economics Conference

March 31st, 2016

Introduction

Wide collection and diffusion of personal data in online markets.

- Sources: recorded purchases, browser cookies, social media.
- Uses: customized search results, web content, targeted advertising, promotional offers.

Consumers have partial control over available information.

Introduction

Wide collection and diffusion of personal data in online markets.

- Sources: recorded purchases, browser cookies, social media.
- Uses: customized search results, web content, targeted advertising, promotional offers.

Consumers have partial control over available information.

This paper: game-theoretical analysis of information revelation with rational consumer.

- Consumer has no intrinsic value of privacy.
- Understands information collection mechanism and its payoff consequences.

Research Questions

1. What determines the amount of information revealed by consumers?
2. What are the implications of information collection (vs. privacy regulation) for consumers' welfare?
3. How do these answers depend on the *source* of the information and on its *intended use*?

Just the first step...

Model: Sources of Information

Two-period model.

Consumers' preferences are private information.

In the first period, each consumer interacts with heterogeneous firms: **sellers** and **websites** (non-merchant content providers).

Each interaction generates information of **endogenous precision**.

Consumer can **distort first period behavior to affect beliefs** about his preferences in second period interactions.

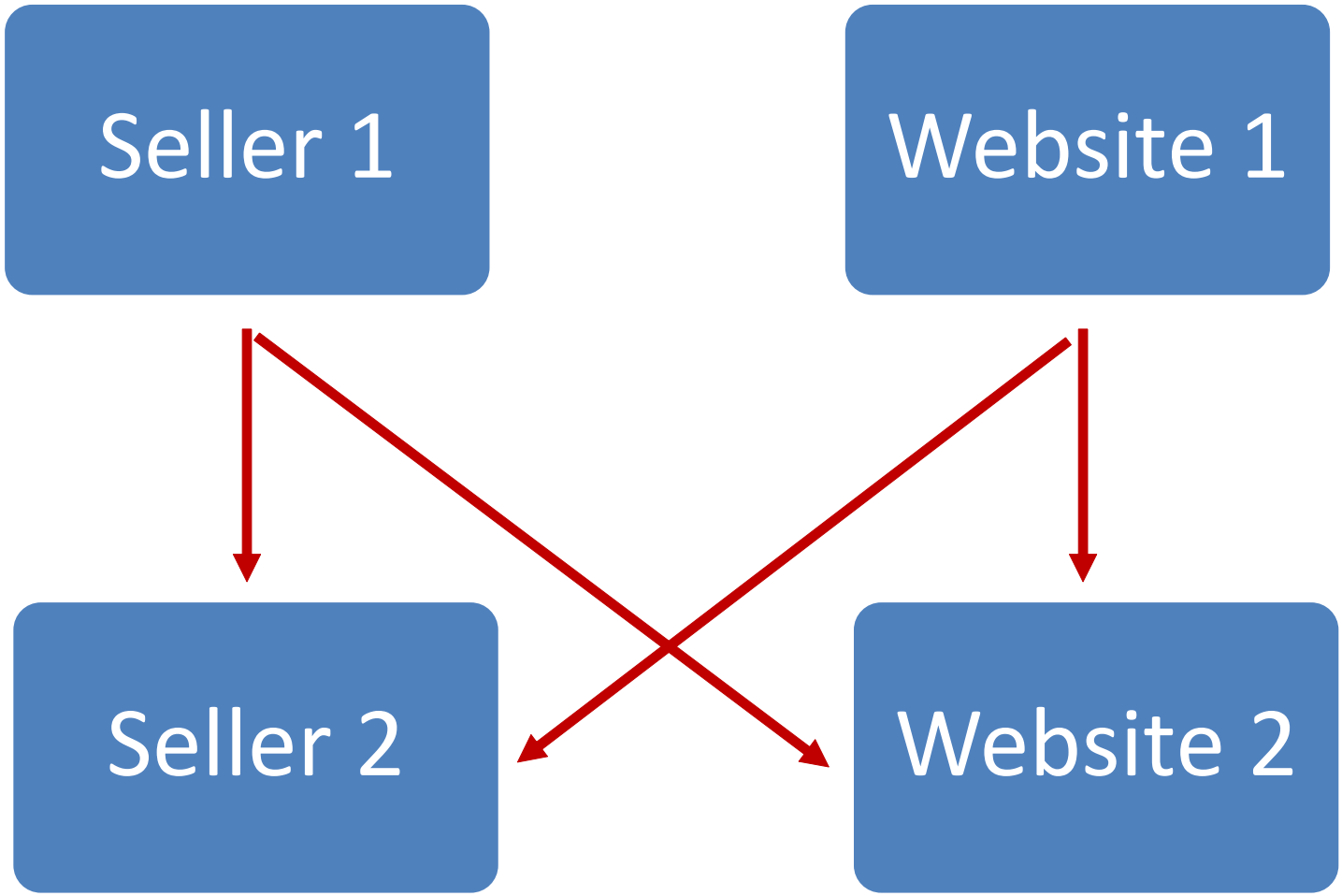
This distortion has **non-trivial welfare effects**

Model: Uses of Information

Simplify second period interactions to two types:

1. Browsing a (different) website:
   - **Aligned interests**: Website wants to match content to tastes.
   - Precise information is good for the consumer.
2. Buying from a (different) seller:
   - **Conflict**: Seller wants to match prices to willingness to pay.
   - Precise information is bad for the consumer.

Signals



Model

Consumer meets two short-lived firms in each period $t = 1, 2$.
Think of them as different firms

- Each **Seller** offers a single product at a unit **price** p_t.
  Wants to maximize profits
  Consumer chooses **quantity** q_t (intensity of interaction).

- Each **Website** offers tailored **content** w_t (e.g., news stories).
  Wants to match content to consumer's type
  Consumer chooses which **page** z_t to access (e.g., read).

Consumer has **type** (θ_q, θ_z) =(taste for product, taste for news).
Correlated "vertical" and "horizontal" and components.
Today: perfectly correlated $\theta_q = \theta_z = \theta$.

Model: Payoffs

Consumer has type (θ_q, θ_z) =(taste for product, taste for news).

Correlated "vertical" and "horizontal" and components.

Today: perfectly correlated $\theta_q = \theta_z = \theta$.

Model: Payoffs

Consumer has type (θ_q, θ_z) =(taste for product, taste for news).

Correlated "vertical" and "horizontal" and components.

Today: perfectly correlated $\theta_q = \theta_z = \theta$.

Linear-quadratic *flow* utility function

$$U(\theta, q, z; p, w) = (\theta - p)\, q - q^2/2 - (\theta - z)^2 - (w - z)^2 .$$

Sellers maximize profits

$$\Pi(p, q) = p \cdot q.$$

Websites want to match content to consumer's type

$$L(\theta, w) = -(w - \theta)^2 .$$

Model: Information

Prior distribution of consumer's type

$$\theta \sim N\left(\theta_0, 1/\tau_0\right).$$

Consumer's actions at $t = 1$ **recorded** with noise.

1. Browsing history
$$s_z \sim N\left(z, 1/\tau_z\right).$$
2. Purchase history
$$s_q \sim N\left(q, 1/\tau_q\right).$$

Firms at $t = 2$ observe (part of) the consumer's record.

Information set of firm $j \in \{W, S\}$

$$\mathcal{I}_j \subseteq \{s_q, s_z\}.$$

Consumer's Problem

Period 2:

Given the payoff structure, the consumer wants

- Seller to under-estimate willingness to pay θ
- Website to learn horizontal preferences θ.

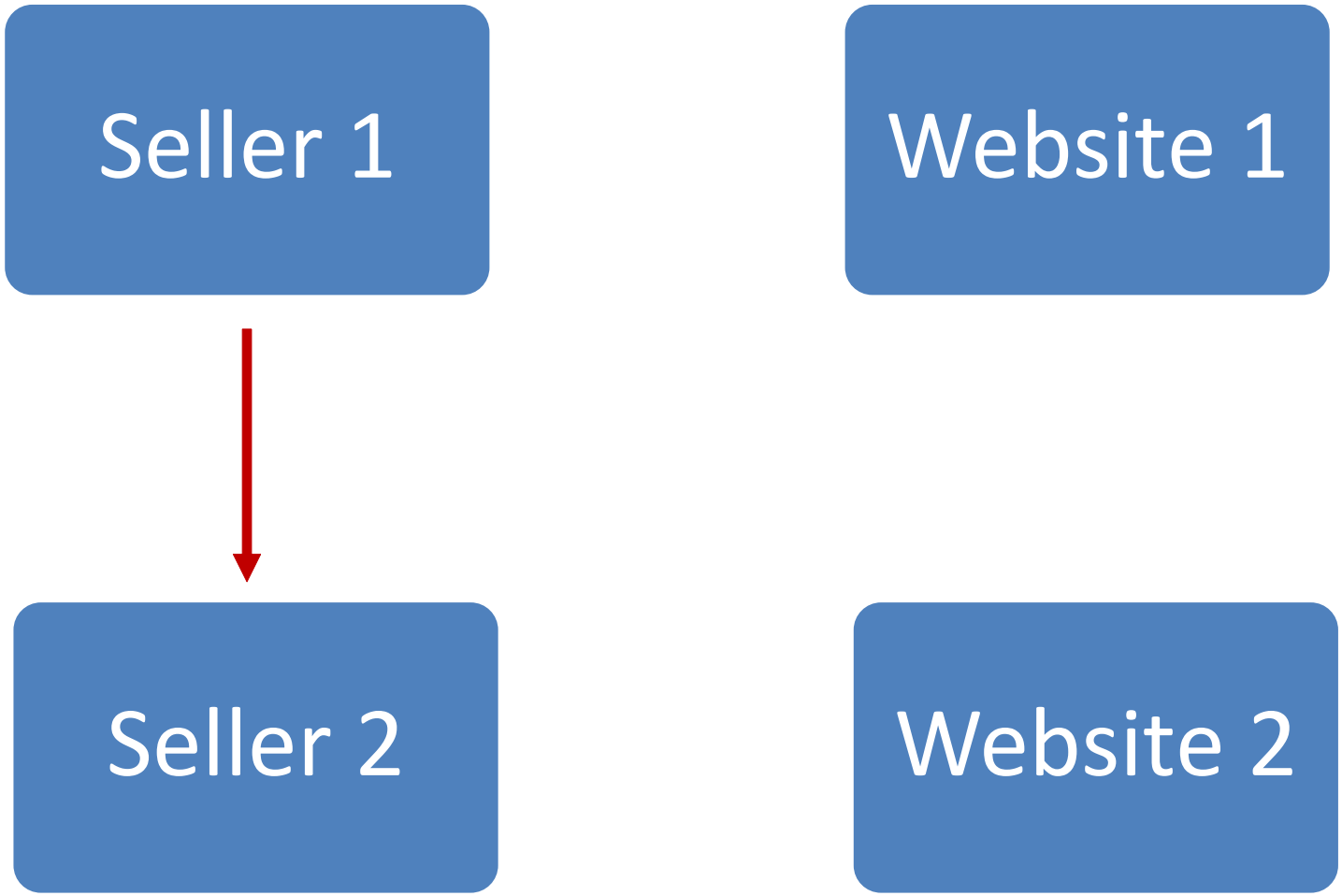
Period 1:

Trades off period-1 flow utility vs. manipulating period-2 firms' beliefs**.**

Value of manipulating depends on type θ and information sets $\mathcal{I}_j$.

Today: Private vs. Public Purchase Signal

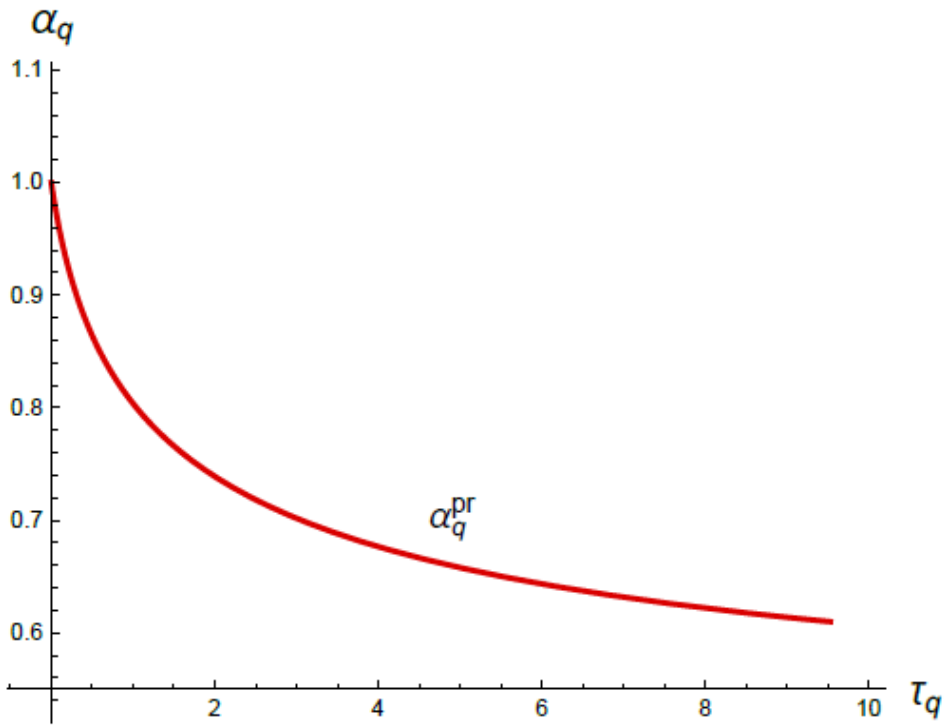
Private Purchase Signal



Period 1 Distortion as a Function of Precision

(Private Purchase Signal)

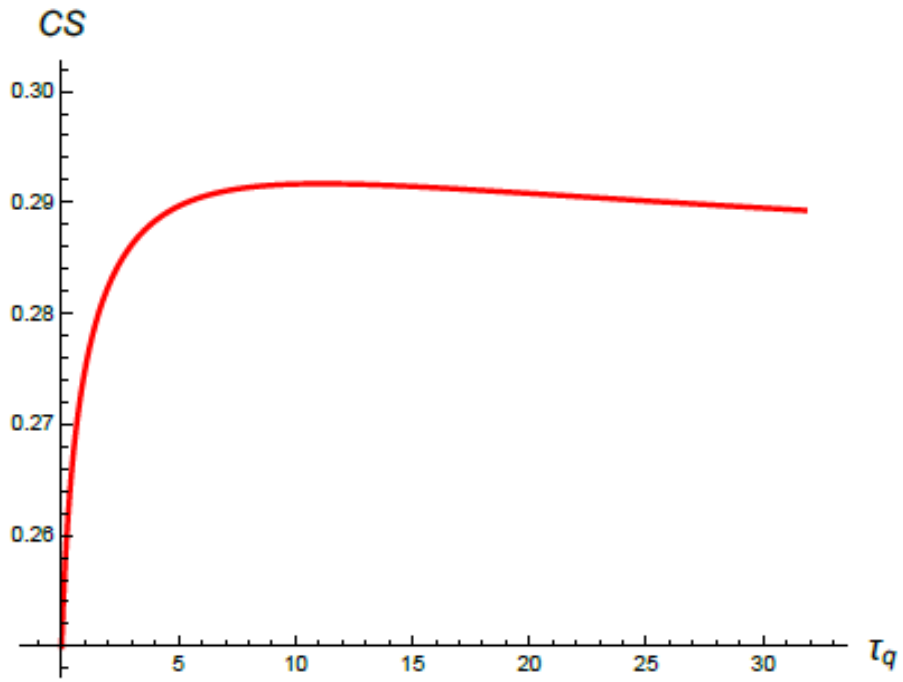
- Equilibrium quantity at $t = 1$ is a linear function of type.
- Higher coefficient = more information revelation.
- Coefficient is distorted down.
- Equilibrium price at $t = 1$ also decreases in signal precision.



Ex-Ante Consumer Surplus as a Function of Precision

(Private Purchase Signal)

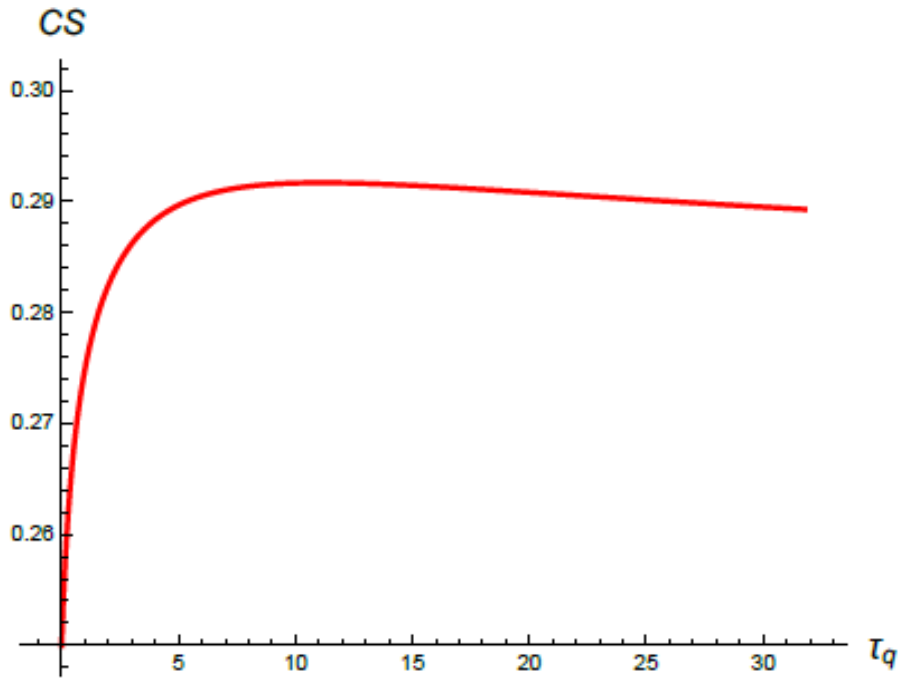
The distortion can benefit the consumer.



Ex-Ante Consumer Surplus as a Function of Precision

(Private Purchase Signal)

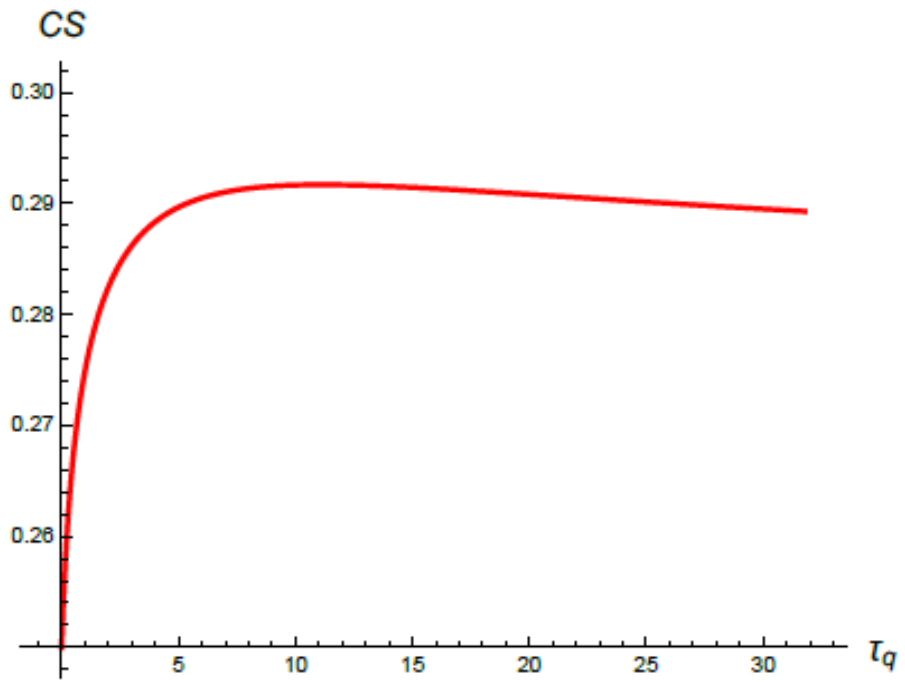
Period 2: As signal precision increases, precision of second period belief increases and consumer suffers higher price.



Ex-Ante Consumer Surplus as a Function of Precision

(Private Purchase Signal)

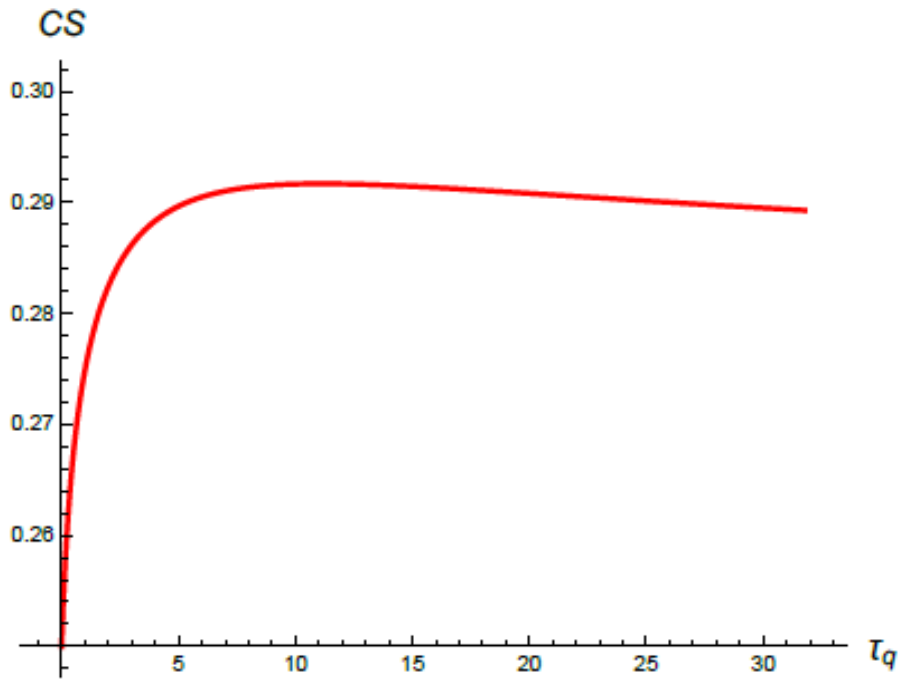
Period 1: As signal precision increases, demand is distorted down.
Seller 1 anticipates consumer's concern over second-period price.
Expects lower demand, charges lower price.
Consumer buys fewer units at a lower price.



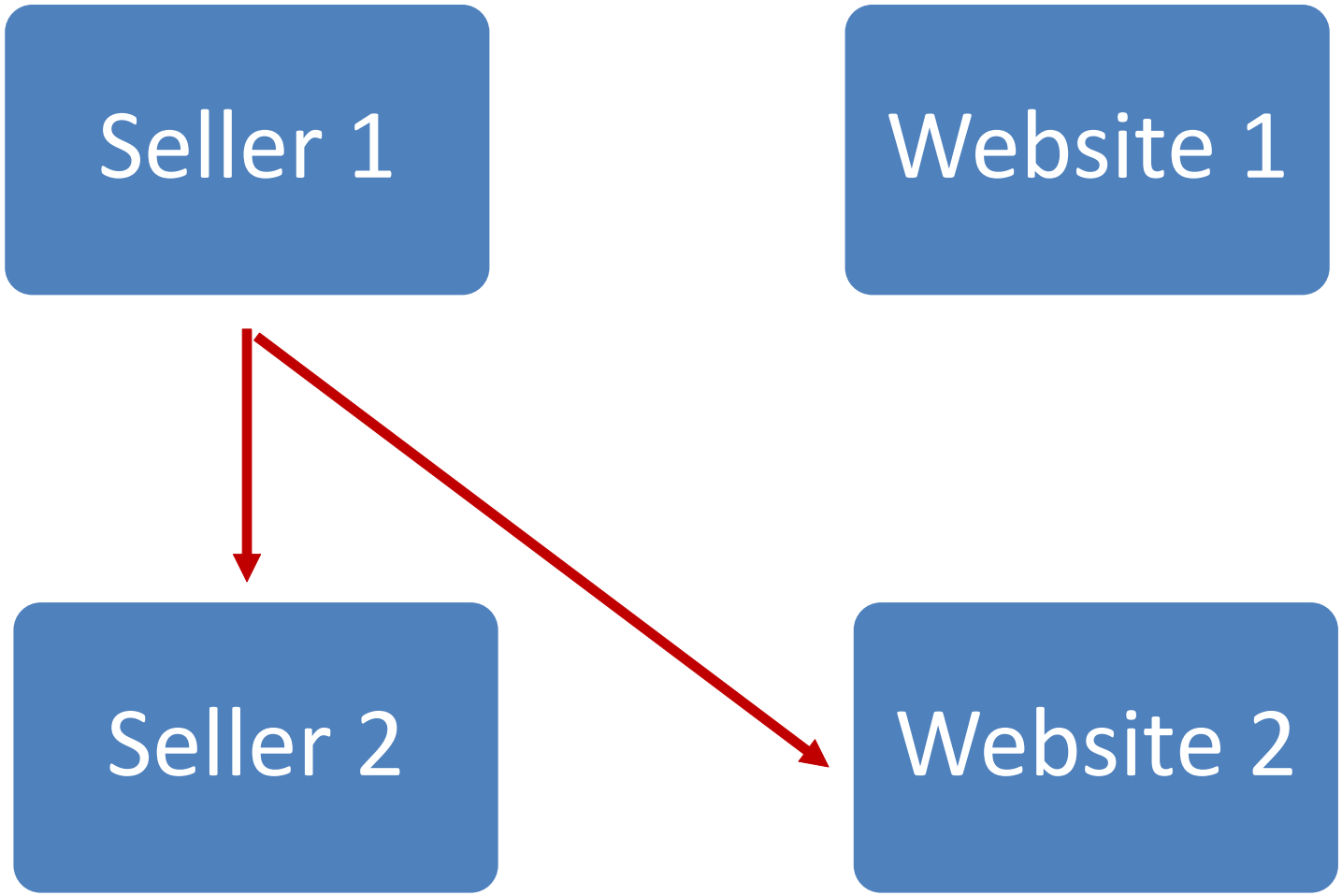
Ex-Ante Consumer Surplus as a Function of Precision

(Private Purchase Signal)

Overall, period-1 payoff can increase and offset period-2 loss.

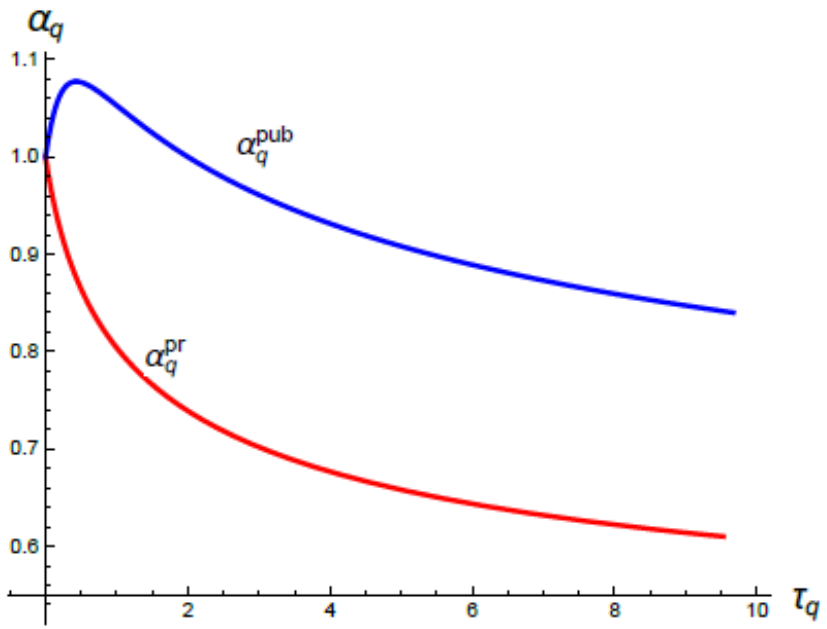


Public Purchase Signal

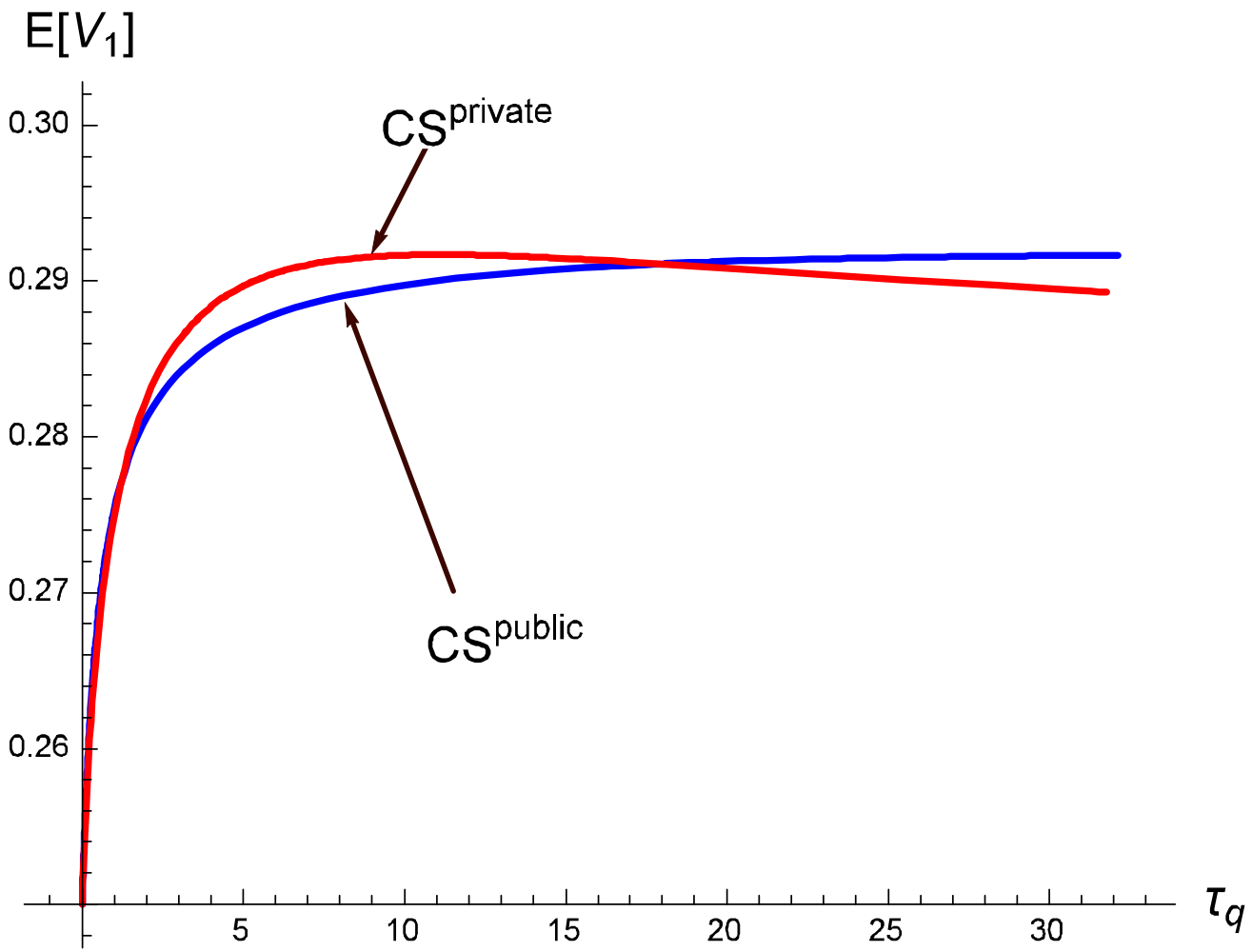


Public vs. Private Purchase Signal: Period 1 Distortion

More information revelation (to get better match with period-2 website)

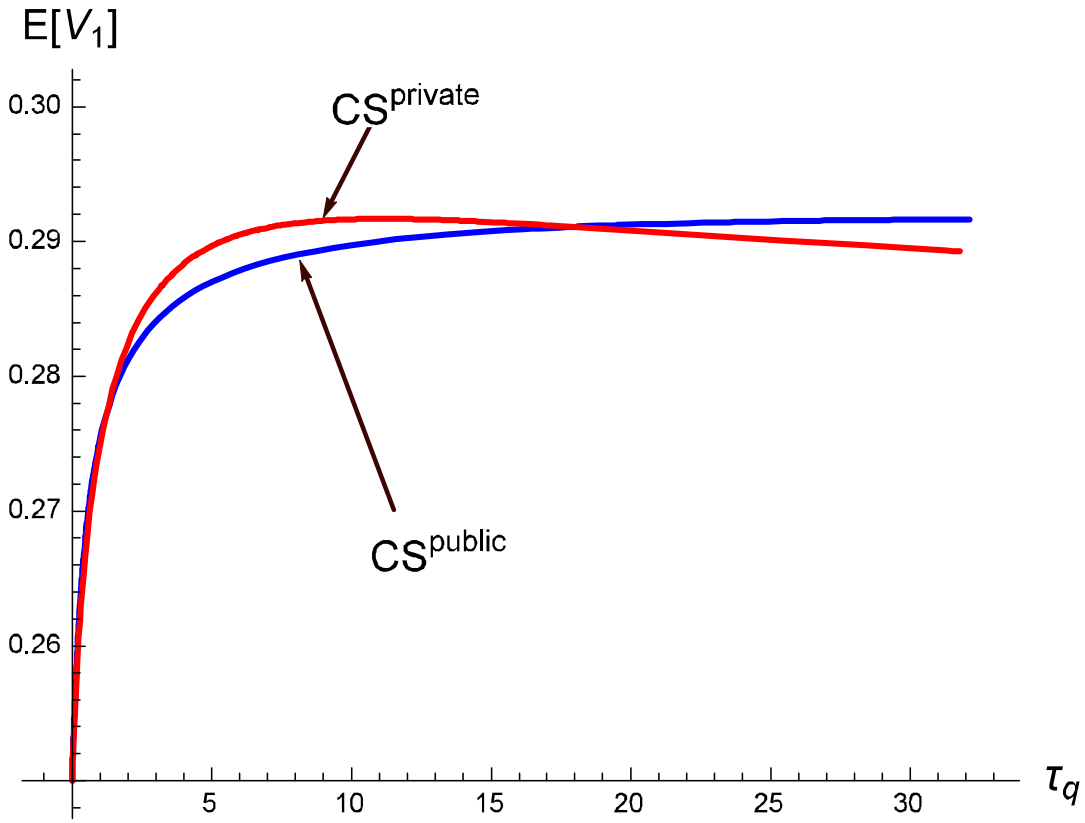


Public vs. Private Purchase Signal: Ex-Ante Surplus Comparison



Public vs. Private Purchase Signal: Payoff Comparison

Period-2: Higher payoff from browsing, lower payoff from purchase
Period-1: Possibly higher payoff from purchase
The period-1 payoff impact of the distortion is non-monotonic.



Model: Discussion

What is the source of conflict between consumers and firms?

Model: Discussion

What is the source of conflict between consumers and firms?

Here: firms customize prices based on purchase histories.

Richer model: firms sell multiple goods; searching is costly.

Customized search results steer high-value consumers to high-markup products.

Model: Discussion

What is the source of conflict between consumers and firms?

Here: firms customize prices based on purchase histories.

Richer model: firms sell multiple goods; searching is costly.

Customized search results steer high-value consumers to high-markup products.

Here: separate roles (players) for conflict and alignment.

Reality: additional product-quality dimension.