Search and Price Discrimination Online

Eeva Mauring

U Bergen, U Vienna, and CEPR

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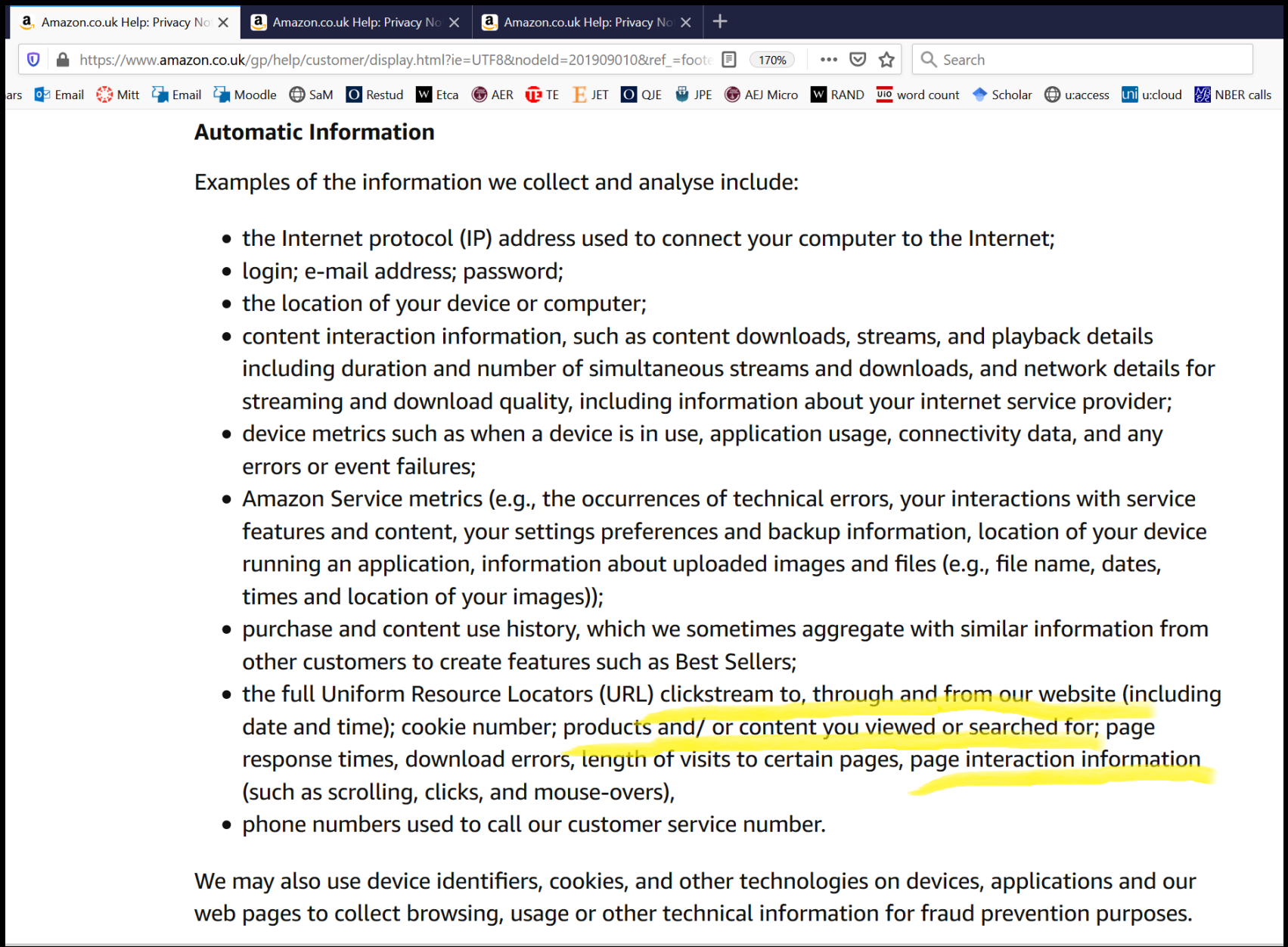
Motivation

- Online markets are increasingly important.
- Information collection online is costly for consumers (De los Santos et al., 2012, Honka, 2014).
- Firms can track consumer behaviour more easily online.
- Collect information that is suggestive of search type
  - pages visited on website.
  - time spent looking at pages.
  - where comes and where goes.
  - scrolling, clicks and mouseovers.

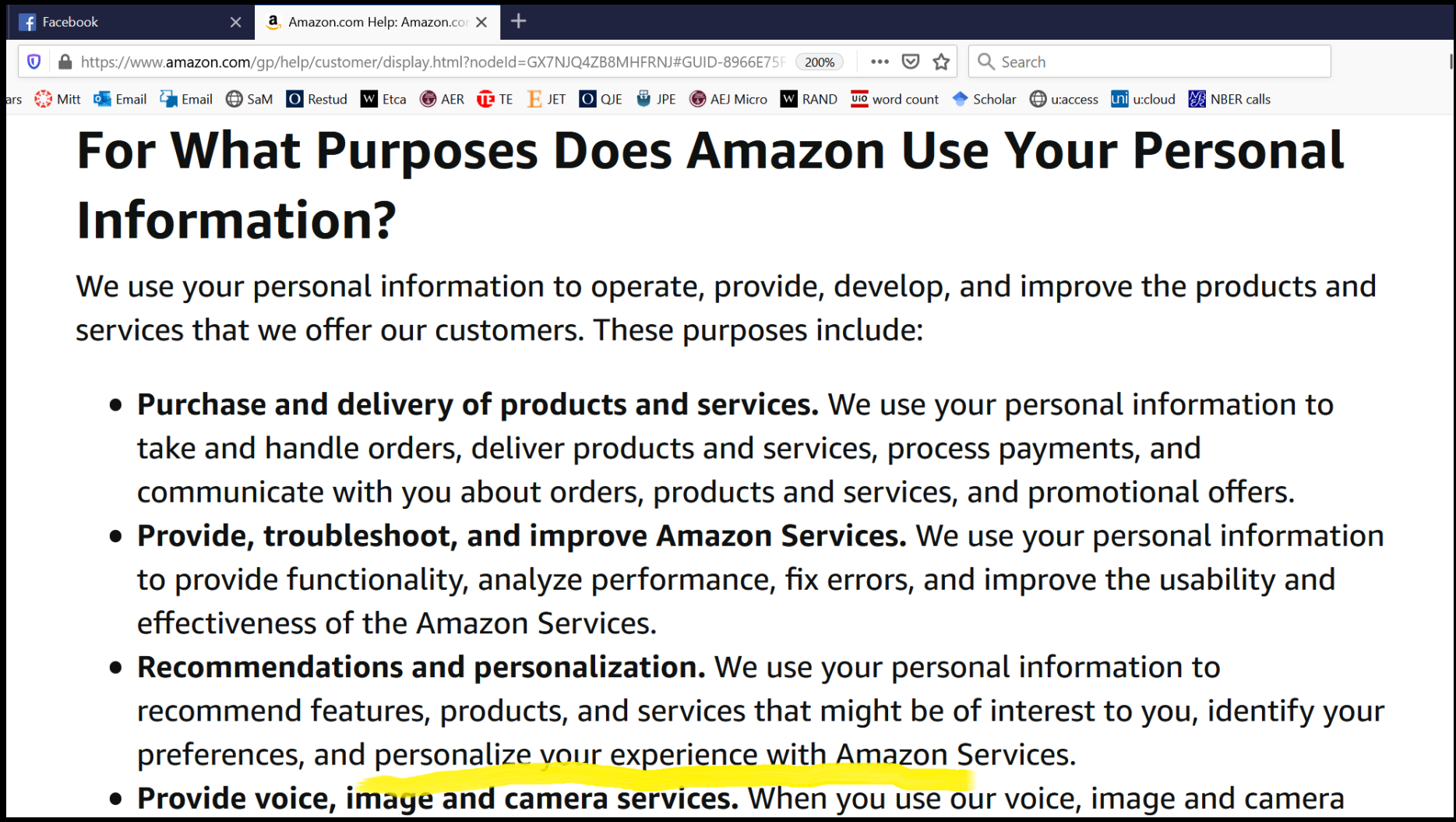


Automatic Information

Examples of the information we collect and analyse include:

- the Internet protocol (IP) address used to connect your computer to the Internet;
- login; e-mail address; password;
- the location of your device or computer;
- content interaction information, such as content downloads, streams, and playback details including duration and number of simultaneous streams and downloads, and network details for streaming and download quality, including information about your internet service provider;
- device metrics such as when a device is in use, application usage, connectivity data, and any errors or event failures;
- Amazon Service metrics (e.g., the occurrences of technical errors, your interactions with service features and content, your settings preferences and backup information, location of your device running an application, information about uploaded images and files (e.g., file name, dates, times and location of your images));
- purchase and content use history, which we sometimes aggregate with similar information from other customers to create features such as Best Sellers;
- the full Uniform Resource Locators (URL) clickstream to, through and from our website (including date and time); cookie number; products and/ or content you viewed or searched for; page response times, download errors, length of visits to certain pages, page interaction information (such as scrolling, clicks, and mouse-overs),
- phone numbers used to call our customer service number.

We may also use device identifiers, cookies, and other technologies on devices, applications and our web pages to collect browsing, usage or other technical information for fraud prevention purposes.



For What Purposes Does Amazon Use Your Personal Information?

We use your personal information to operate, provide, develop, and improve the products and services that we offer our customers. These purposes include:

- **Purchase and delivery of products and services.** We use your personal information to take and handle orders, deliver products and services, process payments, and communicate with you about orders, products and services, and promotional offers.
- **Provide, troubleshoot, and improve Amazon Services.** We use your personal information to provide functionality, analyze performance, fix errors, and improve the usability and effectiveness of the Amazon Services.
- **Recommendations and personalization.** We use your personal information to recommend features, products, and services that might be of interest to you, identify your preferences, and personalize your experience with Amazon Services.
- **Provide voice, image and camera services.** When you use our voice, image and camera

Motivation

- Firms use this information to personalise offers
  - “personalize your experience” (Amazon, 2021)
  - “create personalised Products” (Facebook, 2021)
  - “provide personalized services” (Google, 2021)
- Some evidence of personalised prices based on online behaviour
  - car and home insurance (FCA, 2019)
  - hotels and car rental (Hannak et al., 2014)
  - travel and office equipment (Ipsos et al., 2018)
- Regulators are concerned
  - EU’s General Data Protection Regulation GDPR in 2018.
  - Californian Consumer Privacy Act CCPA in 2020.

This paper

What are the effects of limited price discrimination based on search costs in online markets?

Literature

- Sequential search with shoppers and nonshoppers: Stahl (1989), ..., Janssen et al. (2005), ...
- Search and price discrimination: Fabra and Reguant (2020), Atayev (2020), Bergemann et al. (2020), Preuss (2021)
- Behaviour-based price discrimination: Hart and Tirole (1988); Villas-Boas (1999), Fudenberg and Tirole (2000); Chen (1997), Taylor (2003), Armstrong and Zhou (2016)
- Probabilistic price discrimination: Belleflamme et al. (2020)
- Online privacy: Acquisti and Varian (2005), Conitzer et al. (2012), Montes et al. (2019), Ichihashi (2020), Hidir and Vellodi (2020), Braghieri (2019)

Model

Consumers

- Shoppers with zero search cost, fraction $\lambda > 0$.
- Nonshoppers with $\alpha > 0$ search cost, fraction $1 - \lambda$.
- Each has unit demand and valuation is v.
- Search for low price.

Firms

- $N \geq 2$ firms produce homogeneous product.
- Maximise expected profits.
- Each sets three prices
  - common price p_c,
  - shoppers' price p_s, and
  - nonshoppers' price p_n.
- Price discriminate probabilistically:
  - $\mu_s = Pr(\text{identifies shopper}) = Pr(\text{offers shopper } p_s)$,
  - $\mu_n = Pr(\text{identifies nonshopper}) = Pr(\text{offers nonshopper } p_n)$,
  - otherwise, offers consumer p_c.
- Price offers independent across firms and consumers.

Timing, information and strategies

1. Firm i sets prices p_c^i, p_s^i and p_n^i, for $i = 1, \ldots, N$.
2. Shopper sees offers at all i and decides where to buy.
3. Nonshopper visits firm i at random, sees offer at i, and decides whether to buy.
4. Nonshoppers who did not buy continue to search at random.
5. Consumers who buy exit and utilities are realised.

Equilibrium

- Symmetric equilibria.
- Firm's price distributions F_c, F_s and F_n are optimal.
- Nonshopper's decision is optimal: buys at firm i if price offer at i is below cutoff price ϕ_n.
- Shopper's decision is optimal: buys at firm i if price offer at i is lowest among all offers.

Equilibrium price distributions

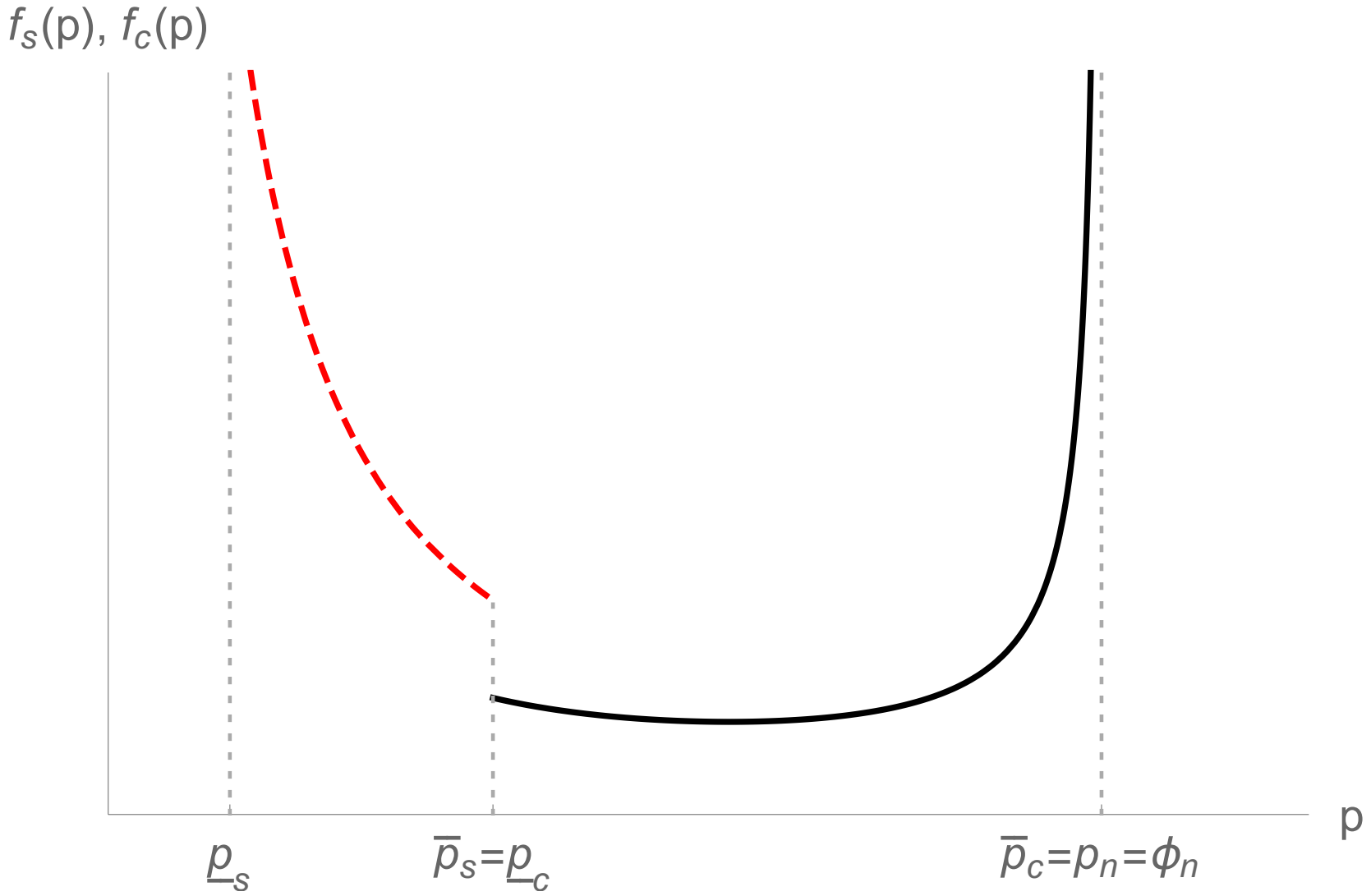
Proposition 1 (Equilibrium).

In the unique symmetric equilibrium the strategy of

- *firms comprises*
  - (i) *common price distribution* $F_c(p_c) = 1 - \left(\frac{\bar{p}_c - p_c}{\gamma N p_c}\right)^{\frac{1}{N-1}}$, *with support* $[\underline{p}_c, \bar{p}_c]$ *where* $\gamma := \frac{\lambda(1-\mu_s)^N}{(1-\lambda)(1-\mu_n)}$, $\underline{p}_c = \frac{\bar{p}_c}{1+\gamma N}$, *and* $\bar{p}_c = \phi_n = \min\left\{\frac{\alpha}{1-\mu_n}\left[1 - \int_0^1 (1+\gamma N y^{N-1})^{-1}\,\mathrm{d}y\right]^{-1}, v\right\}$,
  - (ii) *shoppers' price distribution* $F_s(p_s) = \frac{1}{\mu_s}\left[1 - (1-\mu_s)\left(\frac{\bar{p}_s}{p_s}\right)^{\frac{1}{N-1}}\right]$, *with support* $[\underline{p}_s, \bar{p}_s]$ *where* $\underline{p}_s = \bar{p}_s(1-\mu_s)^{N-1}$ *and* $\bar{p}_s = \underline{p}_c$, *and*
  - (iii) *nonshoppers' price* $p_n = \phi_n$.
- *nonshoppers is to accept all prices as* $p_n = \bar{p}_c = \phi_n$.
- *shoppers is to buy at the firm that offers them the lowest price.*

Equilibrium distributions f_s and f_c

$N = 5, \lambda = \frac{1}{2}, \alpha = \frac{1}{20}, v = 1, \mu_s = \mu_n = \frac{1}{4}$



Consumer welfare

Consumer welfare

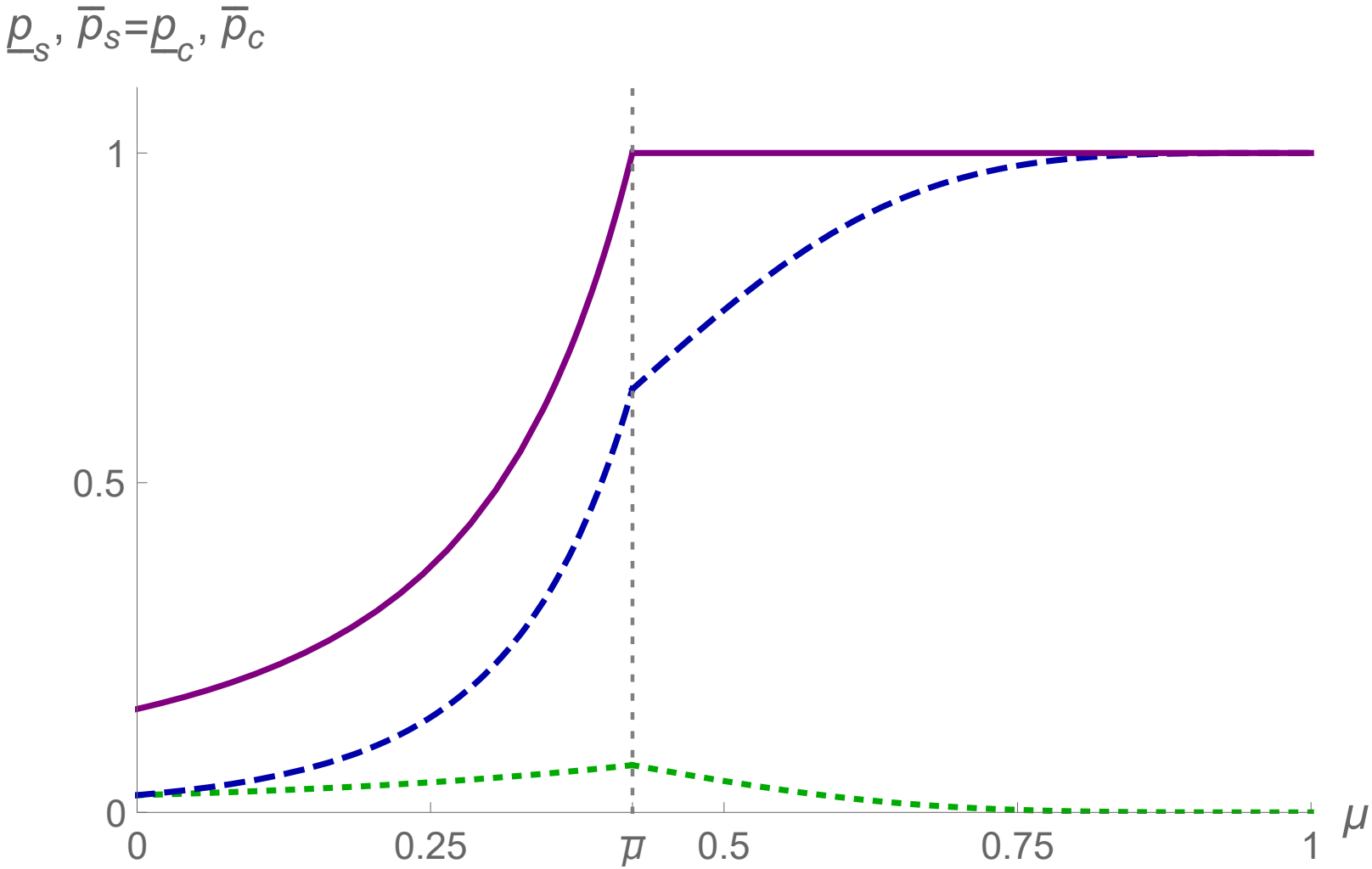
- In equilibrium,
  - all buyers buy, and
  - each nonshopper searches once,
  - so consumer surplus and total profits are negatively related.
- Individual firm's profit

$$\pi = \frac{1-\lambda}{N}\bar{p}_c + \lambda\mu_s\underline{p}_s.$$

- If μ_n, μ_s or N increases, consumers lose if both $\bar{p}_c$ and $\underline{p}_s \uparrow$.

Likelier price discrimination

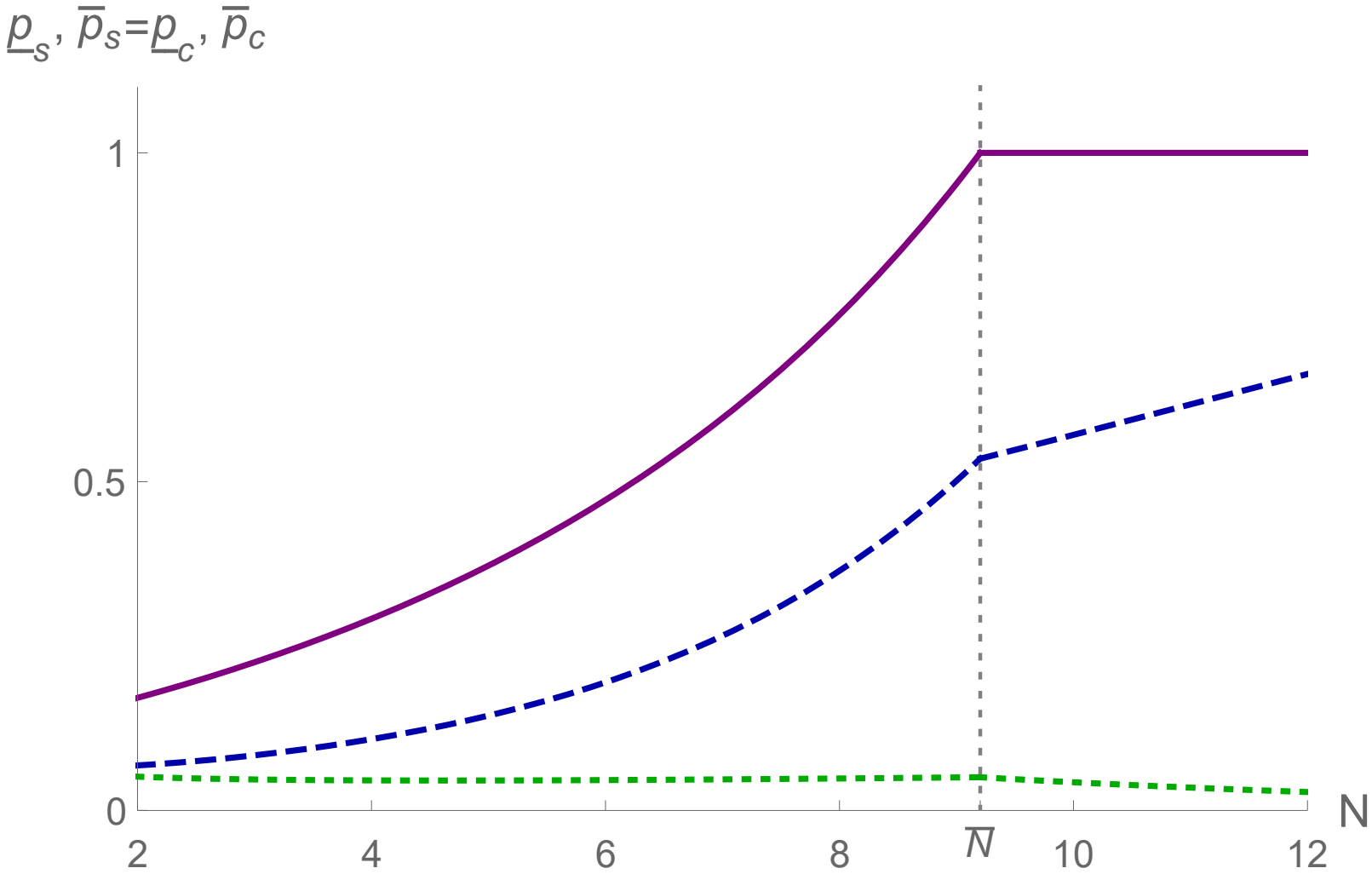
Likelier joint price discrimination and boundary prices: $\bar{p}_c$, $\underline{p}_c = \bar{p}_s$, and $\underline{p}_s$; $N = 5$, $\lambda = \frac{1}{2}$, $\alpha = \frac{1}{20}$, $v = 1$



More firms

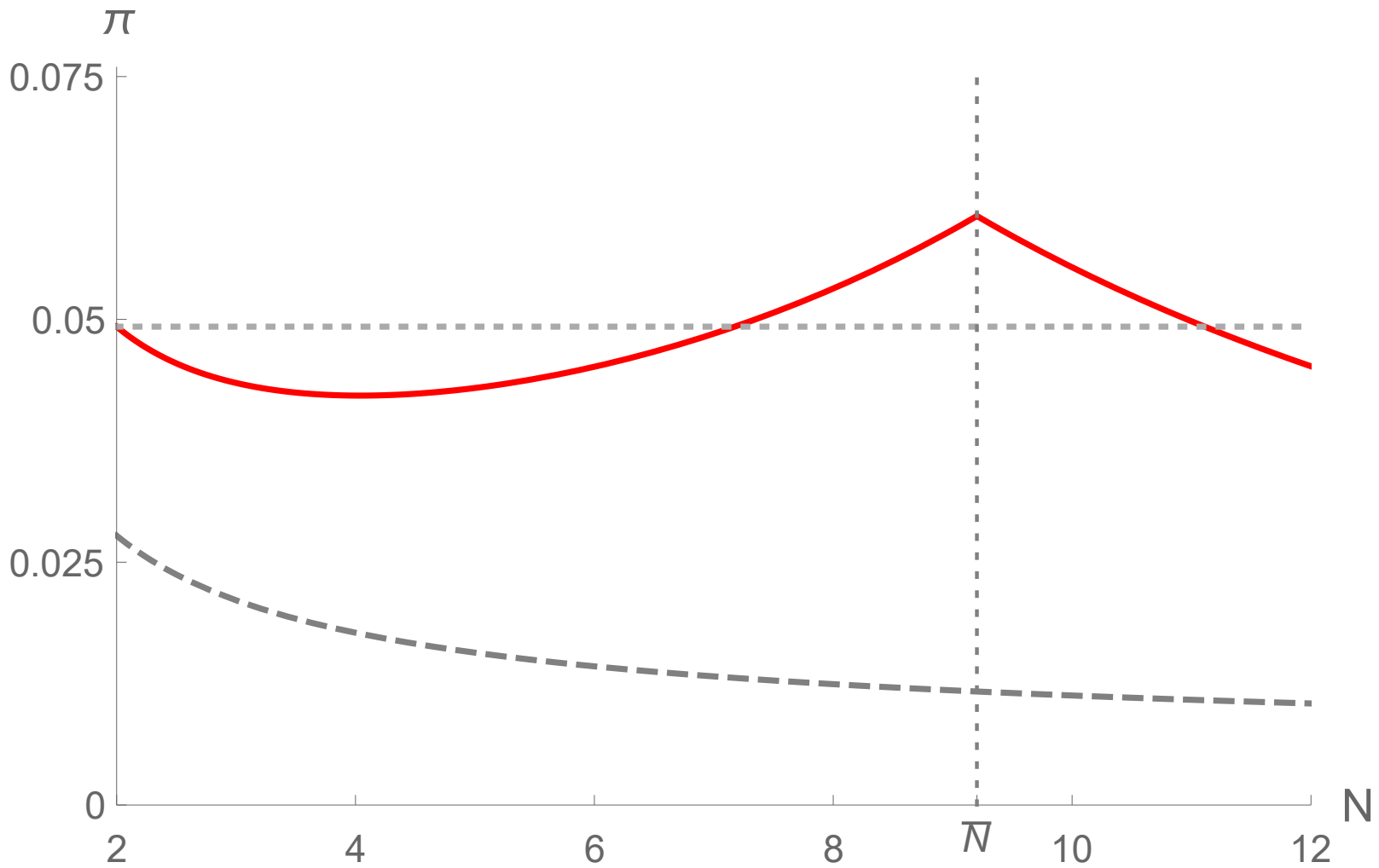
More firms and boundary prices $\bar{p}_c$, $\underline{p}_c = \bar{p}_s$, and $\underline{p}_s$

$\mu_s = \mu_n = \frac{1}{4}, \lambda = \frac{1}{2}, \alpha = \frac{1}{20}, v = 1$



More firms and expected profit π for $\mu = \frac{1}{4}$ and Stahl (1989)

$\lambda = \frac{1}{2}, \alpha = \frac{1}{20}, v = 1$



Summary

- Effects of consumer tracking in online markets.
- Limited price discrimination in standard sequential search model.
- Firms offer different prices to identified consumers
  - shoppers get discounts on common prices.
  - nonshoppers asked highest acceptable price.
- Consumers suffer from likelier price discrimination.
- More competitors can benefit individual firm and increases price dispersion.
- Key drivers of results
  - consumers differ in degree of price sensitivity.
  - firms can discriminate based on price sensitivity.
  - prices offered to different consumers are related in equilibrium.

- GDPR and CCPA in general good for consumers.
- Encouraging “competition” online may backfire.

Thank you!

https://sites.google.com/site/eevamauring/research

Extensions

Extensions

- Privacy choices
- Behaviour-based identification probabilities
- More dispersed search costs
- Heterogeneous valuations
- Perfectly correlated identification events
- Imperfectly correlated identification events

Privacy choices

- Consumer can reveal search type or hide at cost.
- If cost positive and same
  - shoppers reveal type, and
  - nonshoppers hide type.
- Realistic? Not if some consumers know data is
  - difficult to retract, and
  - easy to pass on.
- More realistic
  - consumers differ in privacy cost.
  - cost is negative for some: revealing search type costly on other markets.
- Then some consumers of each search type hide, others reveal.
- Analysis like in main model.

Behaviour-based identification probabilities

- More likely to be identified if visit more firms.
- If $\mathbb{E}_s[p_s] < \mathbb{E}_c[p_c] < \mathbb{E}_n[p_n]$,
  - shopper wants to visit many firms.
  - nonshopper wants to visit few firms.
  - as when μ_s and μ_n are exogenous.
- Firms jointly would want to identify nonshoppers: set some $p > \phi_n$.
- But individual firm would deviate to $p = \phi_n$.
- So same equilibrium characterisation as before with $\mu_n < \mu_s$.

More dispersed search costs

- Consumers differ in search cost $\alpha \sim G(\alpha)$ on $[0, \bar{\alpha}]$ with $G(0) > 0$.
- Type-α consumer identified with probability μ_α.
- Consumers with $\alpha > 0$ like nonshoppers, except differ in ϕ_α.
  - Identified nonshoppers still asked cutoff price.
  - Nonhoppers prices become dispersed.
- Identified shoppers still ($\alpha = 0$) still asked dispersed prices.
- Highest nonshoppers' prices can exceed highest common price
  - if $\mu_{\bar{\alpha}}$ and $\bar{\alpha}$ are large,
  - then $\phi_{\bar{\alpha}}$ is large,
  - but $p_c = \phi_{\bar{\alpha}}$ accepted by very few,
  - so $\bar{p}_c < \phi_{\bar{\alpha}}$ may be optimal.

Heterogeneous valuations

- Consumers differ in valuation v of product.
- Firm can see valuation of identified consumer.
- Shoppers' prices still dispersed and low.
- Common prices still serve all consumer types: dispersed and higher than shoppers' prices.
- Nonshoppers' cutoff prices differ.
- So firms offer dispersed nonshoppers' prices.
- Some common prices can exceed some nonshoppers' prices: supports may overlap.
- Leads to some nonshoppers searching more than once.

Perfectly correlated identification events

- Shopper identified by all firms with pronbaility μ_s (and nonshopper with probability μ_n).
- Head-on competition for identified shoppers: $p_s = 0$.
- No real search option for identified nonshoppers: $p_n = v$.
- Common prices still dispersed.
- Can show that firms prefer independent identification to perfectly correlated if v is low.
- If v is low, earning profits from identified shoppers is attractive.
- So want to buy data from data intermediary only if v is high.

Imperfectly correlated identification events

- Consumer identified by first firm is more likely to be identified (vs unidentified) by others.
- Consumer knows if he is identified by firm.
- Nonshoppers' continuation value depends on if identified
  - if identified, more likely to be offered p_n elsewhere,
  - if unidentified, more likely to be offered p_c elsewhere.
  - highest acceptable p_c is lower than p_n.
- In general, nonshoppers' price exceeds highest common price.
- Shoppers' more likely to be identified by many or few firms.
- Fierce competition for identified shoppers: lower shoppers' prices.
- Effect on common prices depends, but dispersed.