Measuring Price Discrimination and Steering on E-commerce Web Sites

Aniko Hannak          Gary Soeller          David Lazer
Alan Mislove          Christo Wilson

Northeastern University
Personalization on the Web

A search for "Old Navy" on Google shows a personalized result page. OldNavy.com provides the latest fashions at great prices for the whole family. Shop Men's, Women's and Kids', departments, Womens Plus, and clothing for baby ...

- **Women's Clothing**: Express yourself in women's clothing at great prices from Old ...
- **Men's Clothing**: Shop our men's clothing, at unbeatable prices, for ...
- **Maternity Clothes**: Keep your sense of style with maternity clothes from Old Navy ...
- **Boys Clothing**: Shop boys clothing for quality, style and the value you are ...
- **Plus Size Clothing**: Update your wardrobe with plus size clothing featuring many ...
- **Baby Girl Clothes**: Shop our baby girl clothes and dress her from head to toe in ...

Places for Old Navy near Amherst, MA

- **Old Navy**
  - [www.oldnavy.com](http://www.oldnavy.com)
  - Google+ page
  - 50 Holyoke Street
  - Holyoke
  - (413) 535-0195

- **Old Navy**
  - [www.oldnavy.com](http://www.oldnavy.com)
  - Google+ page
  - 1655 Boston Road
  - Springfield
  - (413) 543-5100

- **Old Navy**
  - [www.oldnavy.com](http://www.oldnavy.com)
  - Google+ page
  - 25 Hazard Avenue
  - Enfield, CT
  - (860) 741-5595

More results from oldnavy.com »
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2 Google reviews
More results from oldnavy.com »

Recommended

More results near Amherst, MA »
Personalization on the Web
Focus of this work: E-commerce sites

Online purchasing now extremely common

Significant, comprehensive user tracking
  • Clear economic incentive to use data to increase sales

These processes are hidden from users
  • What personal data is collected?
  • How is it used? Possibly to users’ disadvantage

Examine two trends: Price discrimination and steering
Price Discrimination

Showing users different prices

- In econ: differential pricing

Example: Amazon in 2001

- DVDs were sold for $3-4 more to some users

Surprisingly, not illegal

- Anti-Discrimination Act does not protect consumers
Price Steering

Altering the rank order of products

- Steering
- E.g. high priced items rank higher for some people

Example: Orbitz in 2012

- Users received hotels in a different order when searching
- Normal users: cheap hotels first; Mac users: expensive hotels first

*THE WALL STREET JOURNAL.*

On Orbitz, Mac Users Steered to Pricier Hotels
Goals of Our Work

Methodology to measure personalization of e-commerce

Measure personalization on e-commerce sites

- Price Discrimination
  - Are the same products offered at different prices to people?
- Price Steering
  - Are products presented in a different order?
  - Do some people see more expensive products?

Explore how online retailers personalize

- What features do their algorithms personalize on?
Outline

- Methodology
- Measuring Price Discrimination
  - Real User Accounts (extent)
  - Synthetic User Accounts (features)
- Conclusion
Scope of measurements

10 General retailers
BestBuy CDW HomeDepot JCPenney Macy’s NewEgg OfficeDepot Sears Staples Walmart

6 travel sites (hotels & car rental)
CheapTickets, Expedia, Hotels, Priceline, Orbitz, Travelocity

Focus on products retuned by searches, 20 search terms / site
Are all differences **personalization**?

No! Could be due to
- Updates to inventory/prices
- Tax/Shipping differences
- Distributed infrastructure
- Load-balancing

Only interested in **personalization** due to client-side state associated with request

How do we measure **personalization**?
Measuring personalization

129.10.115.14

129.10.115.15

74.125.225.67
Measuring personalization

129.10.115.14

129.10.115.15

IP addresses in the same /24

74.125.225.67
Measuring personalization

Queries run at the same time

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129.10.115.14

product1 $ Lorem ipsum dolor sit amet

129.10.115.15

product2 $ Lorem ipsum dolor sit amet

129.10.115.16

74.125.225.67

product2 $ Lorem ipsum dolor sit amet
Measuring personalization

Difference – Noise = Personalization

Noise
Methodology

Measuring Price Discrimination
- Real User Accounts
- Synthetic User Accounts

Conclusion
Experimental Treatments

Questions we want to answer:
- To what extent are products personalized?
- What user features drive personalization?
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Real User Data

Leverage real users who have history
Measure personalization in real life
Experimental Treatments

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- To what extent are products personalized?
- What user features drive personalization?

Real User Data

- Leverage real users who have history
- Measure personalization in real life

Synthetic User Accounts

- Create accounts that each vary by one feature
- Measure the impact of specific features
Collecting personalization for real users
Collecting personalization for real users

Gather data from Mechanical Turk

- 300 participants
  - 100 users each for e-commerce, hotel, rental car sites
- 20 searches for each site
Collecting personalization for real users

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Use web server+proxy to launch, intercept searches
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Use web server + proxy to launch, intercept searches
Price steering for real users

Are products presented in the same order?

- Kendall’s Tau Correlation
Price *steering* for real users

Are products presented in the same order?
- Kendall’s Tau Correlation
Price steering for real users

Are products presented in the same order?
• Kendall’s Tau Correlation

![Bar chart showing Kendall Tau values for different websites: Macy's, Newegg, Sears, Walmart, Cheaptickets, Expedia, Hotels, Priceline. The chart compares Control/Control and Turker/Control conditions. Inherent Noise is indicated.]
Price steering for real users

Are products presented in the same order?
- Kendall’s Tau Correlation

![Bar chart showing Kendall Tau for different products]

- Control/Control
- Turker/Control

Personalization
Price discrimination for real users

Do users see the same prices for the same products?

Percentage of products with inconsistent pricing
Do users see the **same prices** for the same products?

Percentage of products with inconsistent pricing

<table>
<thead>
<tr>
<th>E-commerce</th>
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<th>Car rental</th>
</tr>
</thead>
<tbody>
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<td>Priceline</td>
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<td>Cheaptickets</td>
<td>Expedia</td>
</tr>
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<td>Orbitz</td>
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<tr>
<td>Orbitz</td>
<td>Expedia</td>
<td>Travelocity</td>
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% of Items with Inconsistent Prices

- **Control/Control**
- **Turker/Control**
Price discrimination for real users

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Control/Control

Turker/Control
Price discrimination for real users

Do users see the same prices for the same products?

Percentage of products with inconsistent pricing

Many sites show more inconsistencies for real users

Up to 3.6% of all products!
Price discrimination for real users

How much money are we talking about..?

- E-commerce
- Hotels
- Car rental

Diagram showing the difference in $ for various companies across different industries, with 95th, 75th, mean, 25th, and 5th percentile differences indicated.
Price discrimination for real users

How much money are we talking about...?

Inconsistencies can be $100s! (per day/night for hotels/cars)
Methodology is able to identify personalization

- Manually verified incidents in HTML source

Significant levels of price steering and discrimination

- Not random — a small group of users are often personalized

But, cannot say how or why these users get different prices

- Could be due to browsers, purchase history, etc
Methodology

Measuring Price Discrimination
  - Real User Accounts
  - Synthetic User Accounts

Conclusion
What user features enable personalization?

Methodology: use synthetic (fake) accounts

- Give them different features, look for personalization
- Each day for 1 month, run standard set of searches
- Add controls

<table>
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<tr>
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<th>Feature</th>
<th>Tested Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Account</td>
<td>Cookie</td>
<td>No Account, Logged In, No Cookies</td>
</tr>
<tr>
<td>User-Agent</td>
<td>OS</td>
<td>Win XP, Win 7, OS X, Linux</td>
</tr>
<tr>
<td></td>
<td>Browser</td>
<td>Chrome 33, Android Chrome 34, IE 8, Firefox 25, Safari 7, iOS Safari 6</td>
</tr>
<tr>
<td>History</td>
<td>Click</td>
<td>Big Spender, Low Spender</td>
</tr>
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Example result: Home Depot
Example result: Home Depot
Mobile users see completely different products
Example result: Home Depot

Mobile users see completely different products...

...in different order
Example result: Home Depot
Example result: Home Depot

Jaccard Index

Kendall Tau

% of Items w/ Diff Prices

Avg. Price Diff. ($)
Android users get different prices for 6% of products
Example result: Home Depot

Android users get different prices for 6% of products

Only 40 cents difference
Results for different e-commerce sites
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Orbitz & Cheaptickets
- Logged in users get cheaper prices ($12 on average)
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Expedia & Hotels
- A/B testing: assigns users to random bucket upon first visit
- Some buckets are steered towards higher prices
- $17 difference between buckets
Results for different e-commerce sites

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Travelocity: discriminates in favor of mobile users
- $15 cheaper for mobile on average
Results for different e-commerce sites

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• Logged in users get cheaper prices ($12 on average)

Expedia & Hotels
• A/B testing: assigns users to random bucket upon first visit
• Some buckets are steered towards higher prices
• $17 difference between buckets

Travelocity: discriminates in favor of mobile users
• $15 cheaper for mobile on average

Priceline: recognizes cheapskates
• They get different products in different order
Methodology

Measuring Price Discrimination
  - Real User Accounts
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Conclusion
Recap

Developed methodology, measurement infrastructure to study price discrimination and steering

Collected real-world data from 300 users
  - Evidence of personalization on 9 of the measured sites

Conducted controlled experiments to identify features
  - Observed sites altering results based on: Account, Browser/OS, Purchase History
Discussion

Part of a larger project
- Understanding how web services collect data
- How it effects the information users see

Transparency
- People don’t know when and how they are discriminated
- Raising awareness is important

Continuous Monitoring
- Observe if, when, and how algorithms are changing
- Develop active defense mechanisms
Questions?

http://personalization.ccs.neu.edu