

# Measuring Price Discrimination and Steering on E-commerce Web Sites

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**Northeastern University**

# Personalization on the Web

2

Google

Old Navy

## [Old Navy](#)

[www.oldnavy.com/](http://www.oldnavy.com/)

**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 ...

### [Boys Clothing](#)

Shop boys clothing for quality, style and the value you are ...

### [Men's Clothing](#)

Shop our men's clothing, at unbeatable prices, for ...

### [Plus Size Clothing](#)

Update your wardrobe with plus size clothing featuring many ...

### [Maternity Clothes](#)

Keep your sense of style with maternity clothes from Old Navy ...

### [Baby Girl Clothes](#)

Shop our baby girl clothes and dress her from head to toe in ...

[More results from oldnavy.com »](#)

## [Places for Old Navy near Amherst, MA](#)

### [Old Navy](#)

[www.oldnavy.com](http://www.oldnavy.com)

[Google+ page](#)

**A** 50 Holyoke Street  
Holyoke  
(413) 535-0195

### [Old Navy](#)

[www.oldnavy.com](http://www.oldnavy.com)

[Google+ page](#)

**B** 1655 Boston Road  
Springfield  
(413) 543-5100

### [Old Navy](#)

[www.oldnavy.com](http://www.oldnavy.com)

2 Google reviews

**C** 25 Hazard Avenue  
Enfield, CT  
(860) 741-5595

[More results near Amherst, MA »](#)

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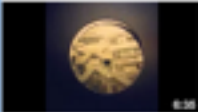


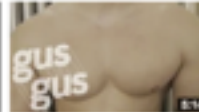







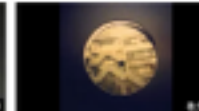






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[More results near Amherst, MA »](#)

Recommended

 Recondite - Equilibrium [Dystopian 003] by Recondite 84,884 views 1 year ago	 Atoms For Peace Live at ACL Festival Special Show... by atomsforpeace 244,877 views 1 year ago	 Nouvelle Vague - Nouvelle Vague by nouvelle vague 275,384 views 8 months ago	 GusGus - Crossfade [Official Video] by GusGus 227,848 views 4 months ago	 The Beatles Abbey Road Full Album (2009 Stereo... by The Beatles Fan Tv 96,437 views 4 months ago	 Metronomy "The Bay" (YouTube Presents) by Metronomy 80,508 views 2 years ago
 Ten Walls - Requiem / Original Mix (Life and... by scumymf 142,432 views 11 months ago	 Gus Gus - Full Performance (Live on KEXP) by KEXP 1,345,715 views 2 years ago	 Thom Yorke - The Eraser - Single Mix by Robyn 503,348 views 3 years ago	 John Deacon Sings Radio Ga Ga!! by Silver Life 167,540 views 3 years ago	 Marian Hill - One Time by Metronomy 379,857 views 8 months ago	 Recondite - Cleric [Dystopian 003] by Recondite 550,329 views 1 year ago
 Metronomy - Trick or Treats by Metronomy 22,729 views 1 year ago	 Kandig esöcol vildvige by stakgr 26,240 views 3 months ago	 we said "nah" by MestherBannous 505,893 views 4 years ago	 Röyksopp & Robyn "Monument" (Music Video) by The Creators Project 1,854,709 views 2 months ago	 Tori Amos - Promise by ToriAmos/VO 196,875 views 2 months ago	 The Story of the Chinese Farmer by Sustainable Human 51,487 views 3 months ago

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## Recommendations for You in Health & Personal Care

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2 Google reviews

More results near Amherst, MA »



Playtex Diaper Genie Refill, 270 count

★★★★☆ (1,124)

\$22.64 **\$18.99**

Why recommended?

[See more recommendations](#)



Pampers Sensitive Wipes 7x Box 448 Count

★★★★☆ (1,385)

\$16.23 **\$10.97**

Why recommended?



Bounty Select-A-Size Paper Towels...

★★★★☆ (298)

\$38.43 **\$33.75**

Why recommended?



Seventh Generation Thick & Strong...

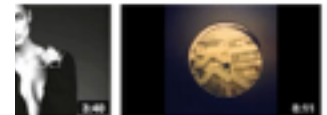
★★★★☆ (990)

**\$14.99**

Why recommended?



My Road | Stereo...  
by [channel] 36,427 views  
Metronomy "The Day" (YouTube Presents)  
by Metronomy 80,508 views  
2 years ago



Time  
157 views  
Reconcile - Cleric [Dystopian 003]  
by Reconcile 550,329 views  
1 year ago



Time  
1,196,875 views  
The Story of the Chinese Farmer  
by Sustainable Human 51,487 views  
3 months ago



American Baby Company 100% Organic...

★★★★☆ (497)

\$15.99 **\$9.99**

Why recommended?

[See more recommendations](#)



American Baby Company Waterproof...

★★★★☆ (428)

\$14.99 **\$14.12**

Why recommended?



Dream On Me 3" Foam Graco Pack...

★★★★☆ (816)

**\$48.01**

Why recommended?



Kolorcraft Cozy Soft Portable Crib...

★★★★☆ (268)

\$29.99 **\$25.93**

Why recommended?

# Focus of this work: E-commerce sites

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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

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Showing users different prices

- In econ: differential pricing

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Websites Vary Prices, Deals

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

5

## 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

6

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?



- ❑ Methodology
- ❑ Measuring Price Discrimination
  - ❑ Real User Accounts (extent)
  - ❑ Synthetic User Accounts (features)
- ❑ Conclusion

# Scope of measurements

8

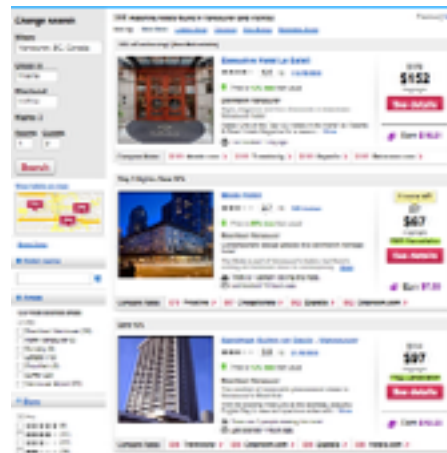
## 10 General retailers

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 returned by searches, 20 search terms / site



	Budget	Enterprise	Hertz	Thrifty	ACE	Home	Alamo	AVIS
Basic	\$11/day	\$11/day	\$11/day	\$12/day	\$12/day	\$20/day	\$20/day	\$20/day
Compact	\$11/day	\$11/day	\$11/day	\$12/day	\$12/day	\$20/day	\$20/day	\$20/day
Midsize	\$11/day	\$12/day	\$12/day	\$12/day	\$12/day	\$20/day	\$20/day	\$20/day
Standard	\$15/day	\$17/day	\$17/day	\$18/day	\$18/day	\$20/day	\$20/day	\$20/day
Full Size	\$15/day	\$17/day	\$17/day	\$18/day	\$18/day	\$20/day	\$20/day	\$20/day
Premium	\$24/day	\$28/day	\$28/day	\$28/day	\$28/day	\$40/day	\$40/day	\$40/day

# Are all differences *personalization*?

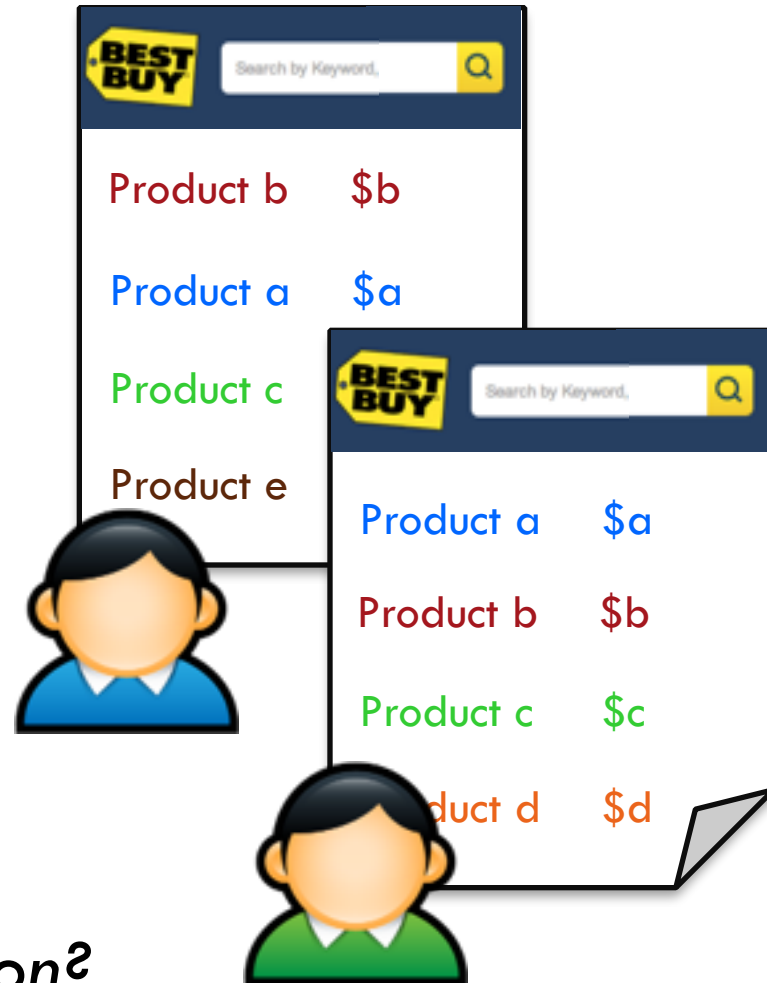
9

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

10



129.10.115.14



129.10.115.15



74.125.225.67

# Measuring personalization

10



129.10.115.14

IP addresses in  
the same /24



129.10.115.15



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Queries run at the same time



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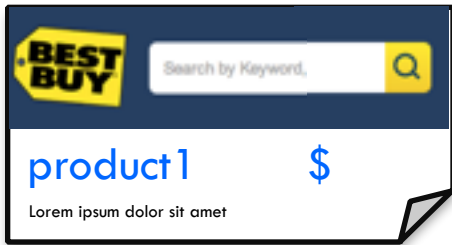


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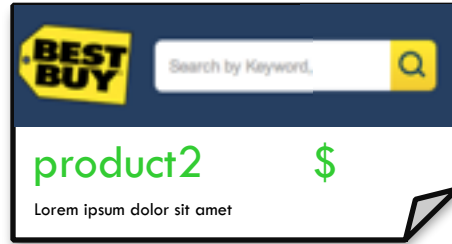


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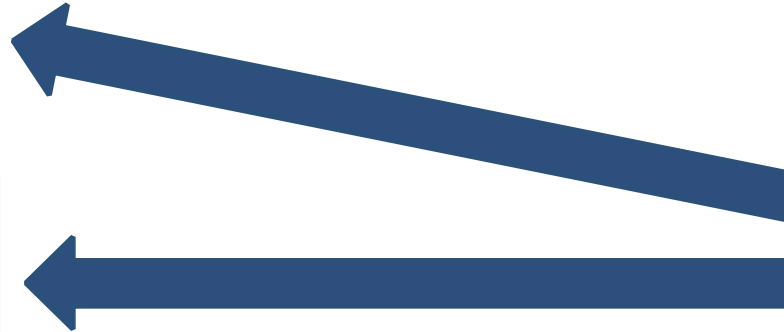
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129.10.115.15

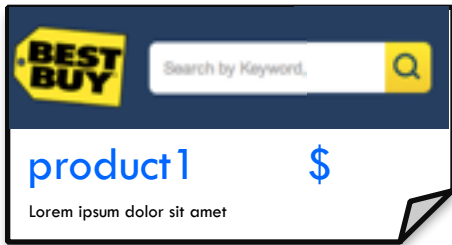


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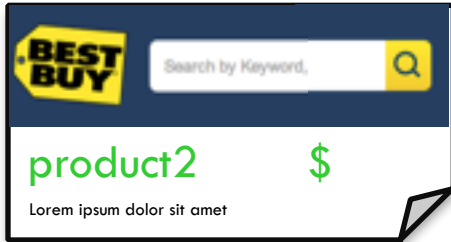


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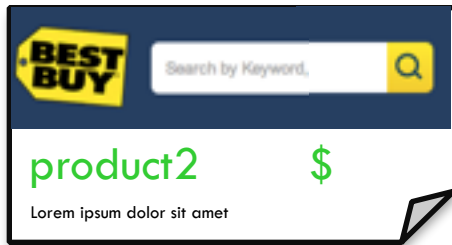
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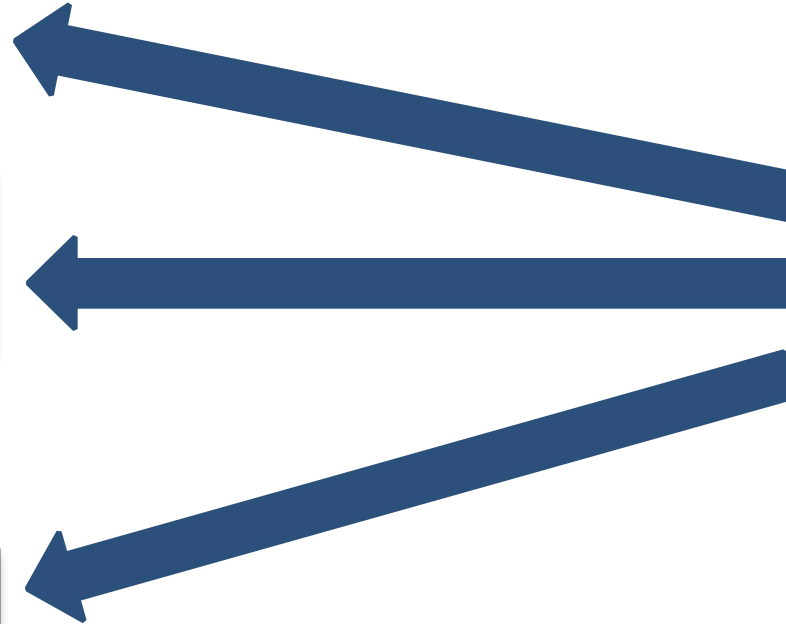
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129.10.115.15



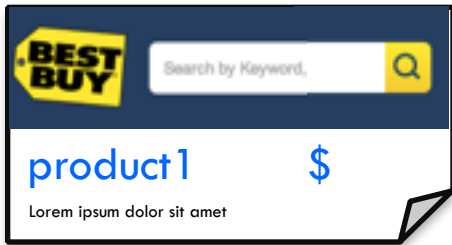
129.10.115.16



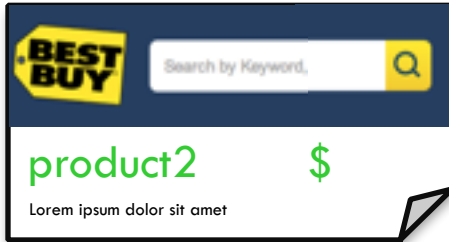
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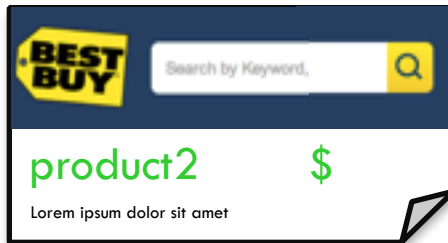
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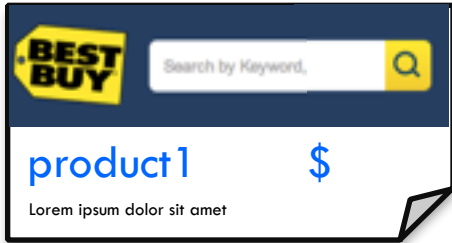
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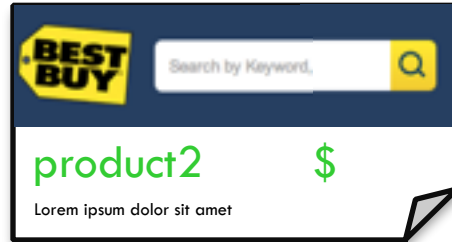
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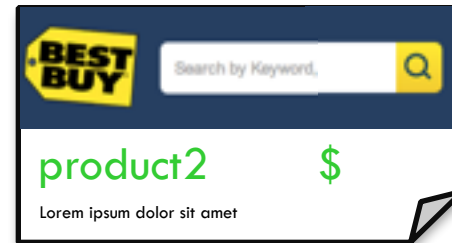
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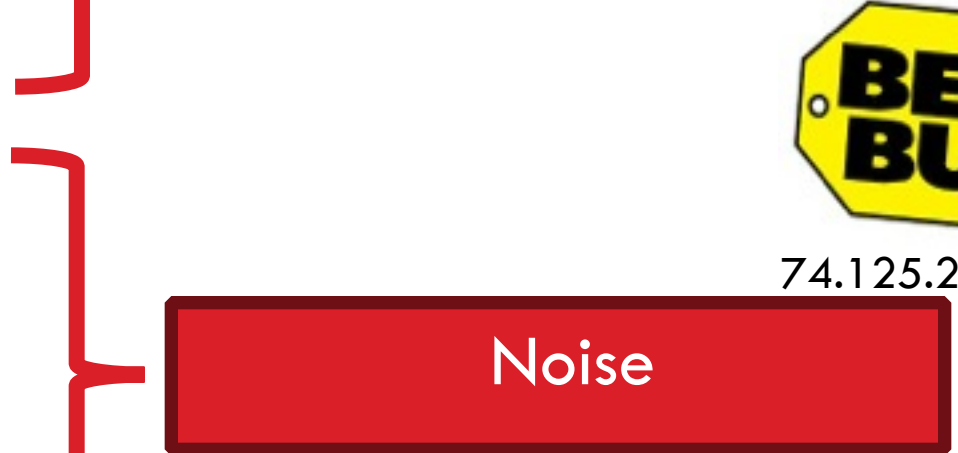
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129.10.115.16



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- Methodology
- Measuring Price Discrimination
  - Real User Accounts
  - Synthetic User Accounts
- Conclusion

# Experimental Treatments

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Questions we want to answer:

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Leverage real users who  
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Measure personalization in  
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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

13



HTTP Proxy



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## Gather data from Mechanical Turk

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



HTTP Proxy



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HTTP Proxy



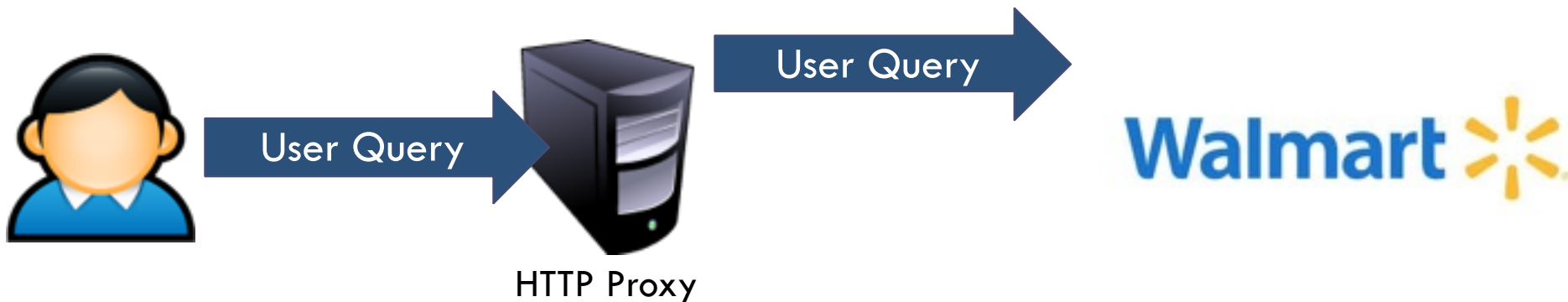
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# Price *steering* for real users

14

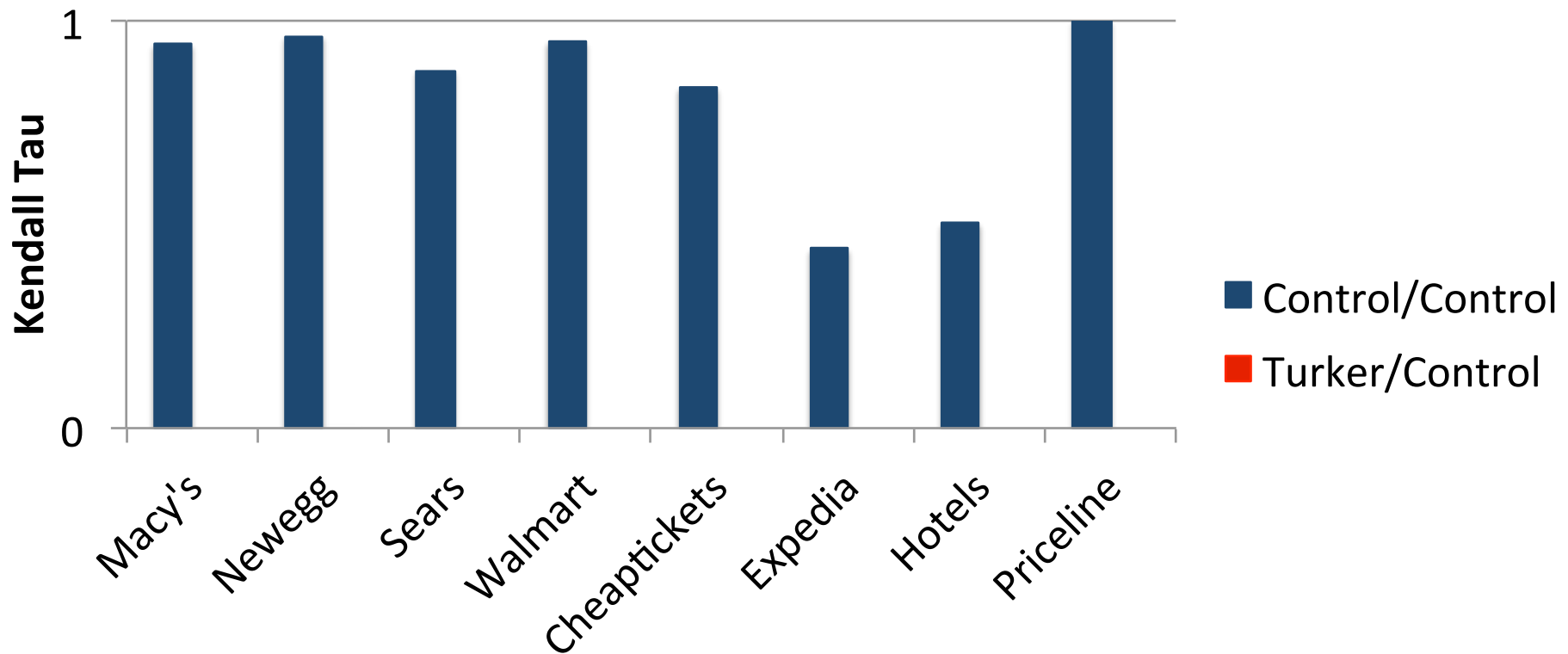
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# Price steering for real users

14

Are products presented in the same order?

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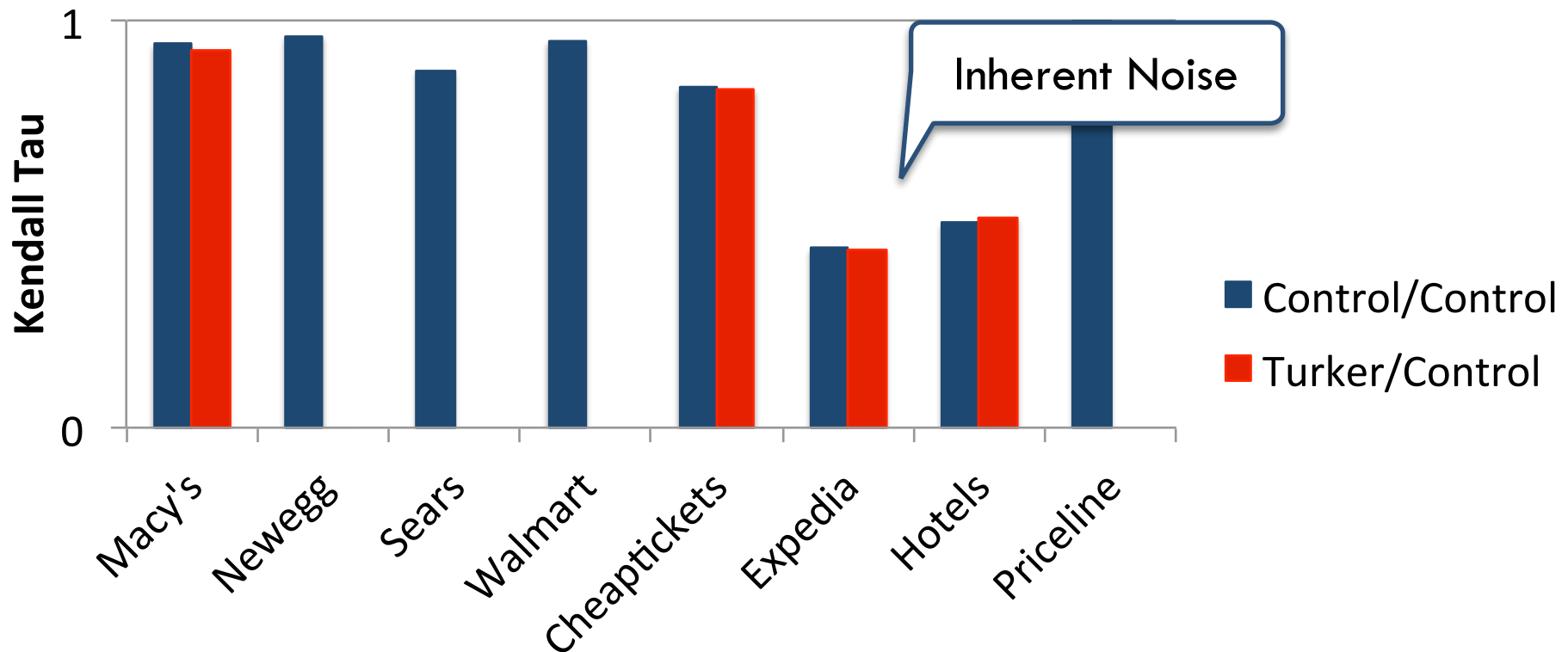


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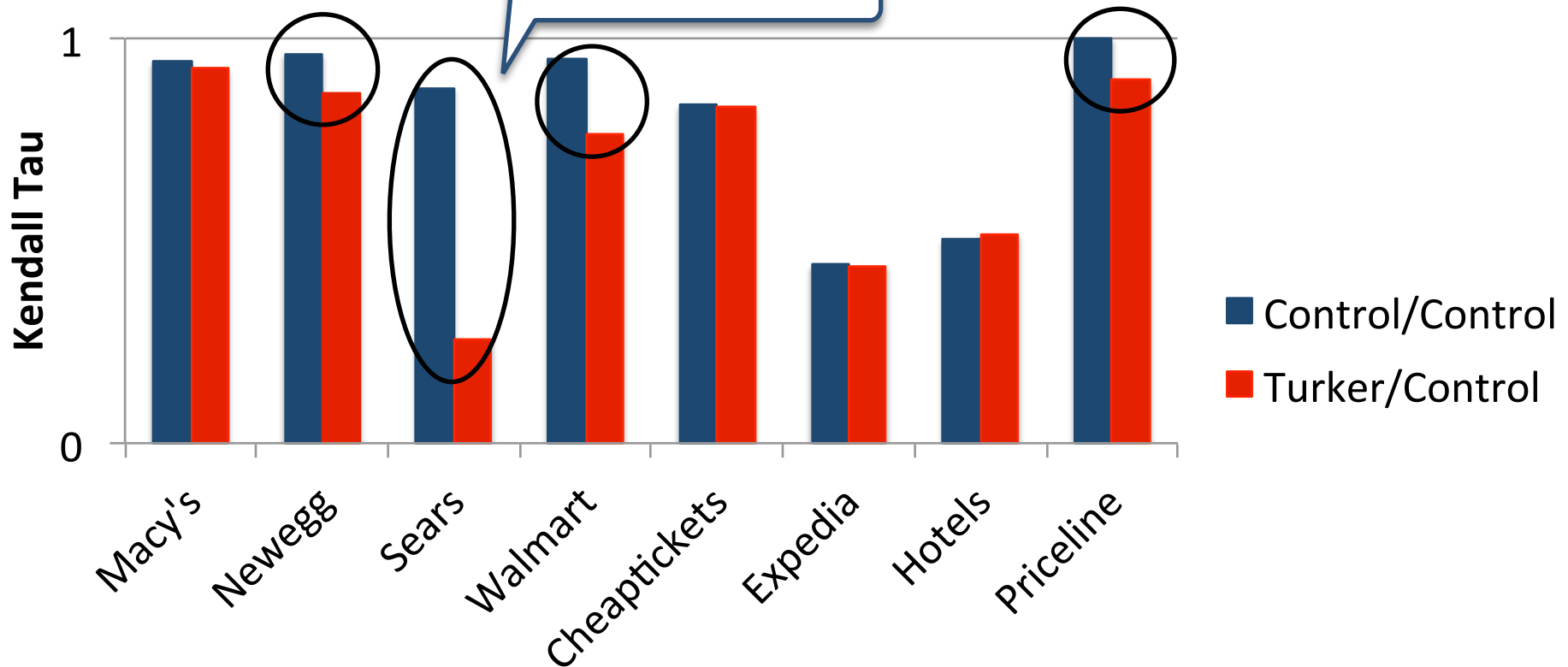


# Price steering for real users

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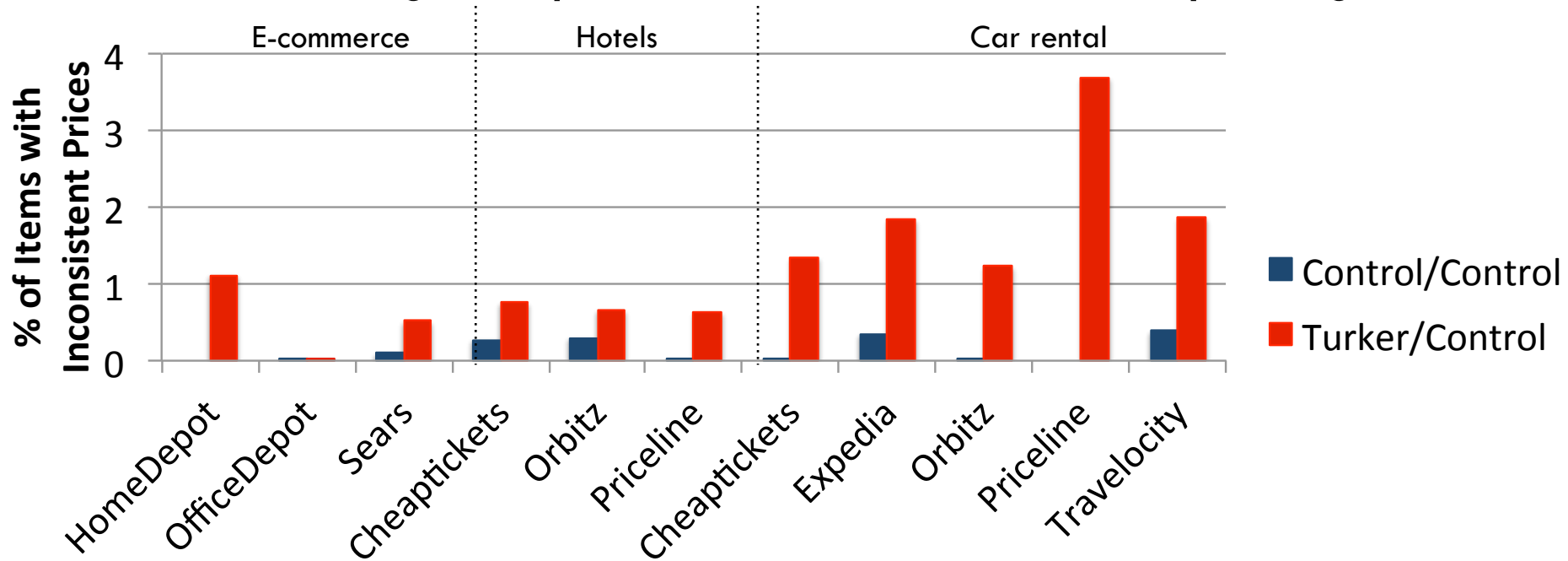
Percentage of products with inconsistent pricing

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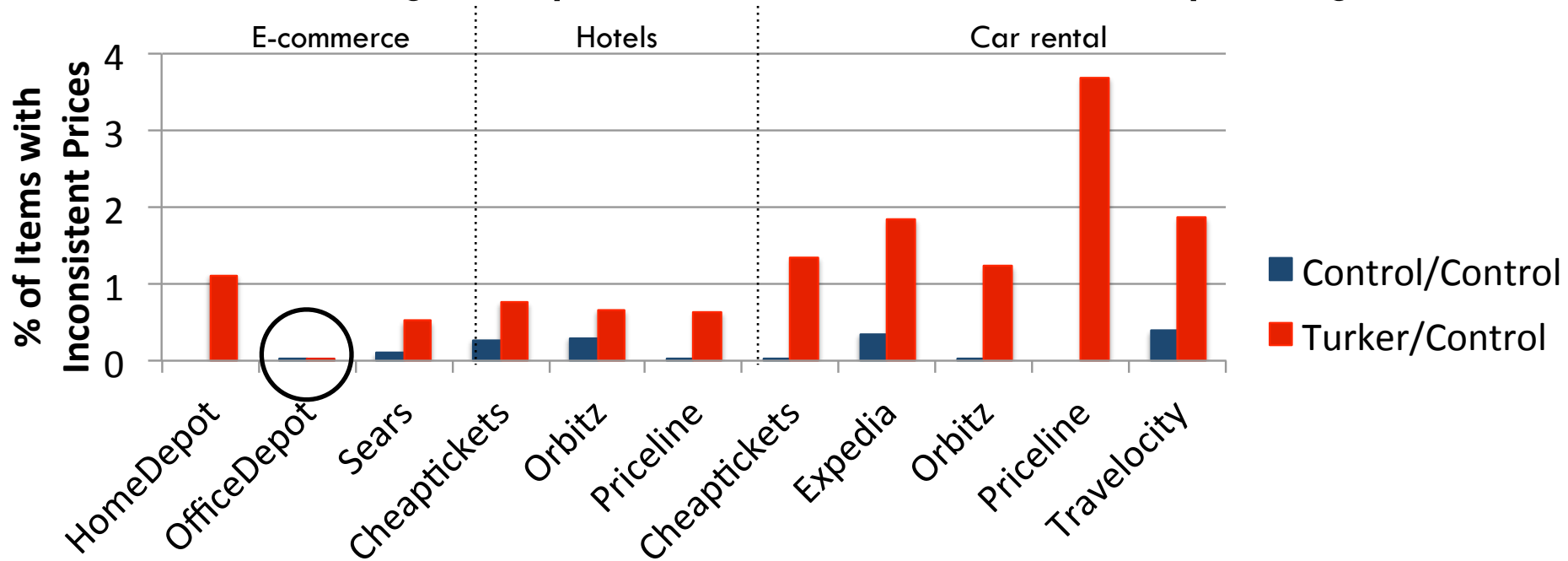


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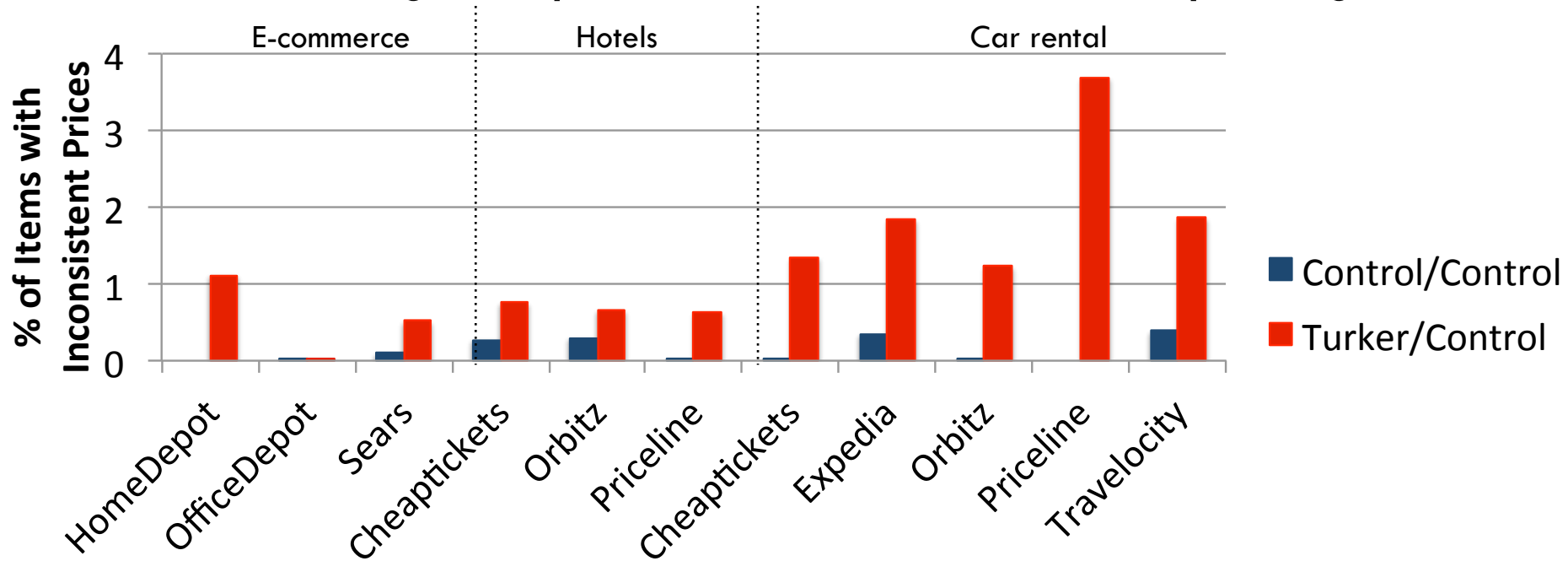


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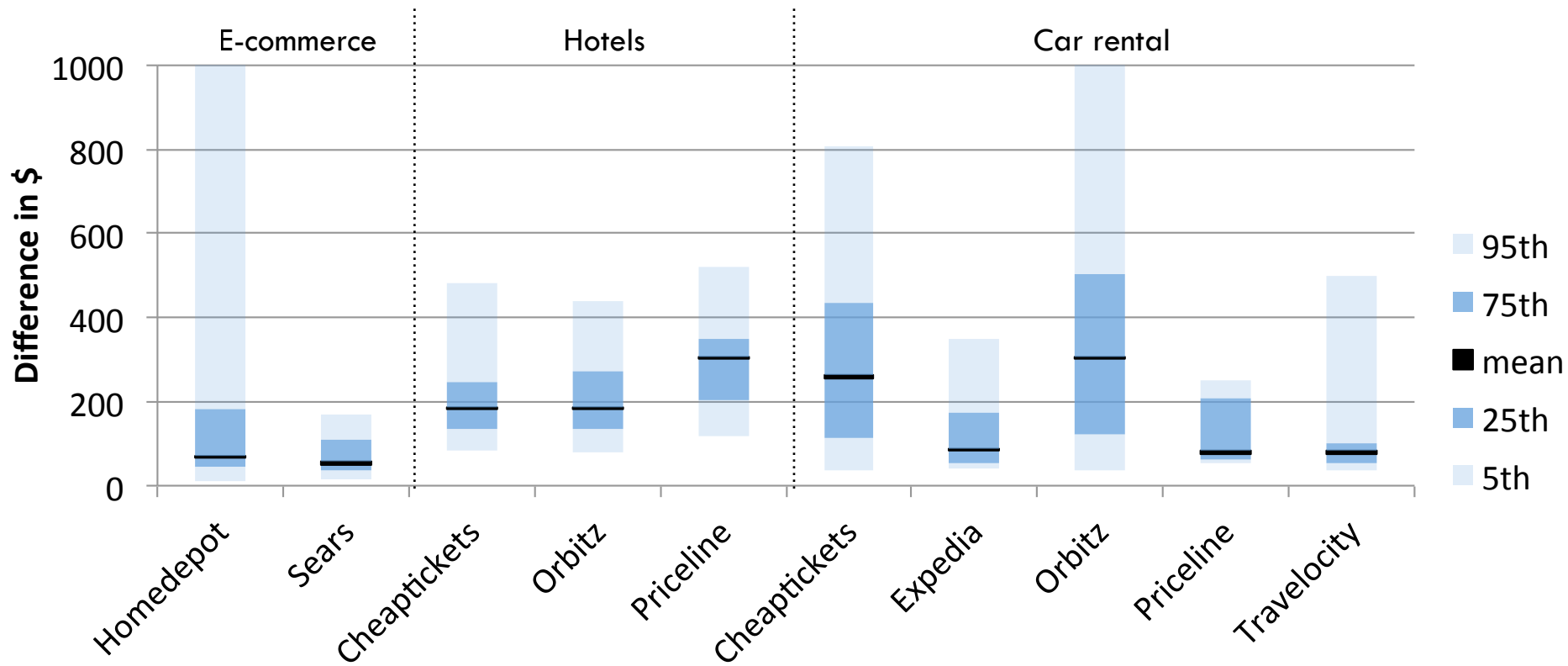
Many sites show more inconsistencies for real users

Up to 3.6% of all products!

# Price *discrimination* for real users

16

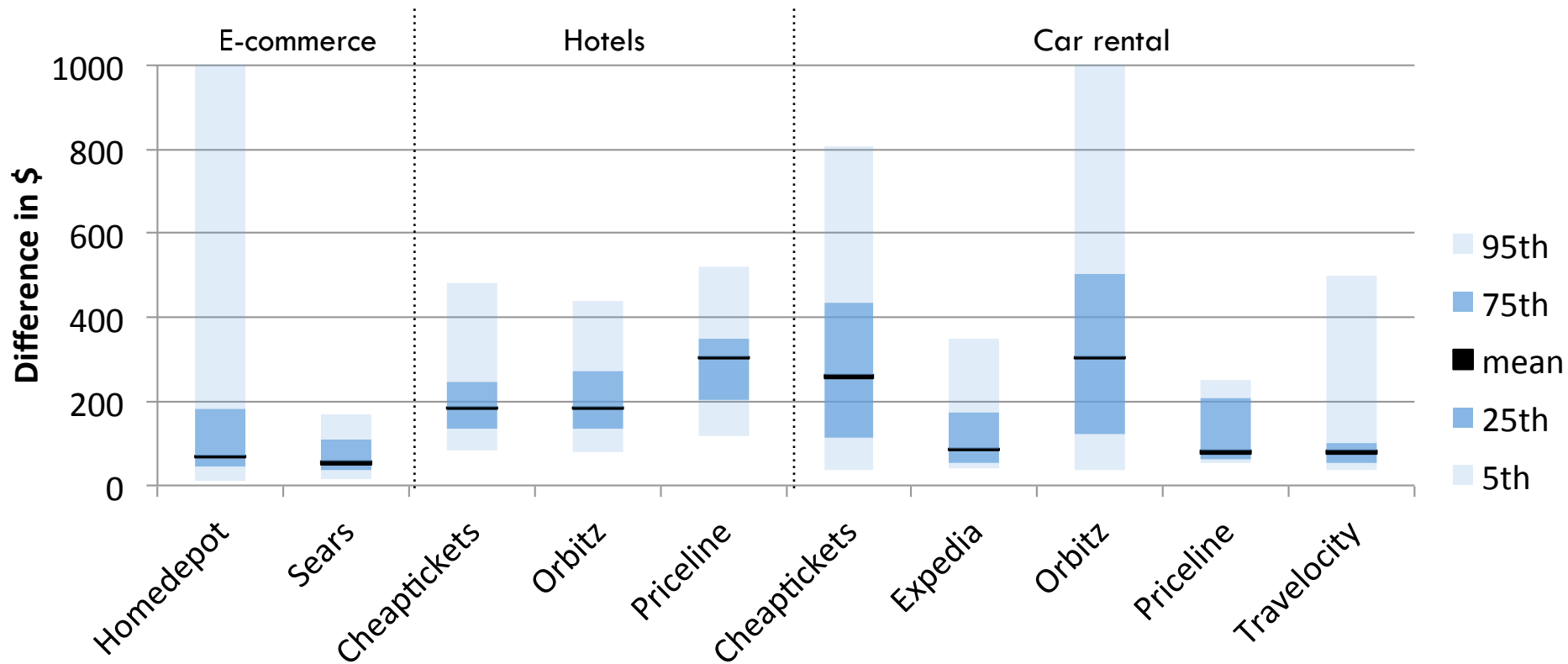
## How much money are we talking about..?



# Price *discrimination* for real users

16

## How much money are we talking about..?



Inconsistencies can be \$100s! (per day/night for hotels/cars)

# Take-aways

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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
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# What user features enable personalization?

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Methodology: use synthetic (fake) accounts

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

Category	Feature	Tested Features
Account	Cookie	No Account, Logged In, No Cookies
User-Agent	OS	Win XP, Win 7, OS X, Linux
	Browser	Chrome 33, Android Chrome 34, IE 8, Firefox 25, Safari 7, iOS Safari 6
History	Click	Big Spender, Low Spender
	Purchase	Big Spender, Low Spender

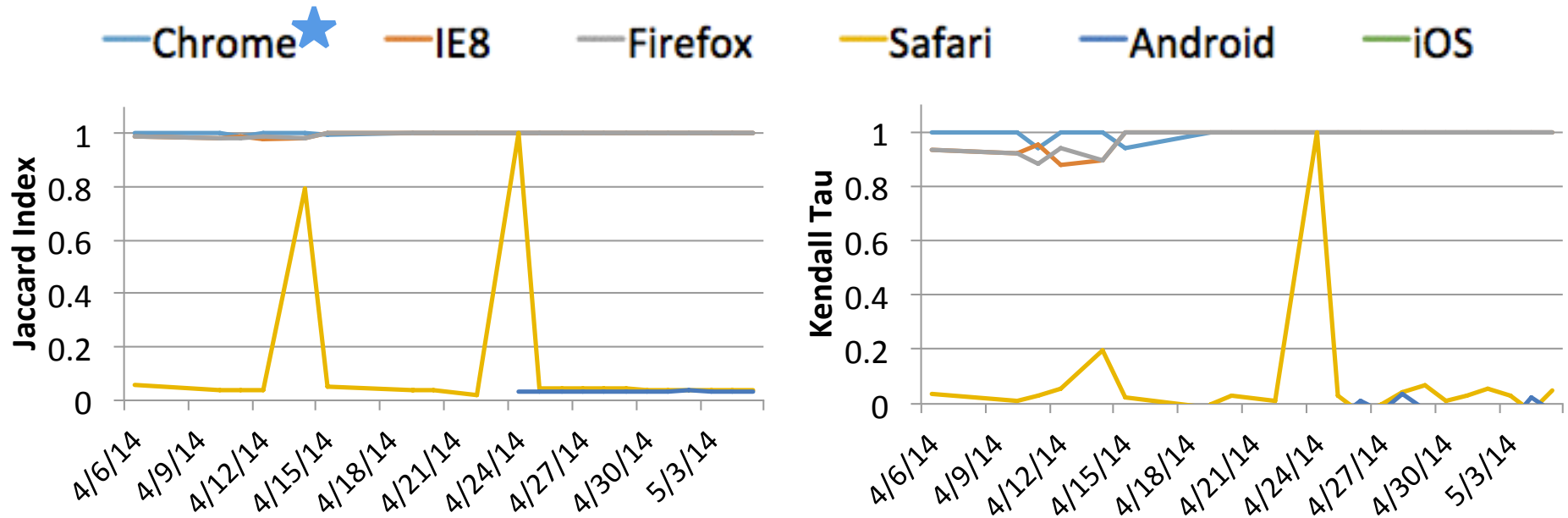
# Example result: Home Depot

20

— Chrome★ — IE8 — Firefox — Safari — Android — iOS

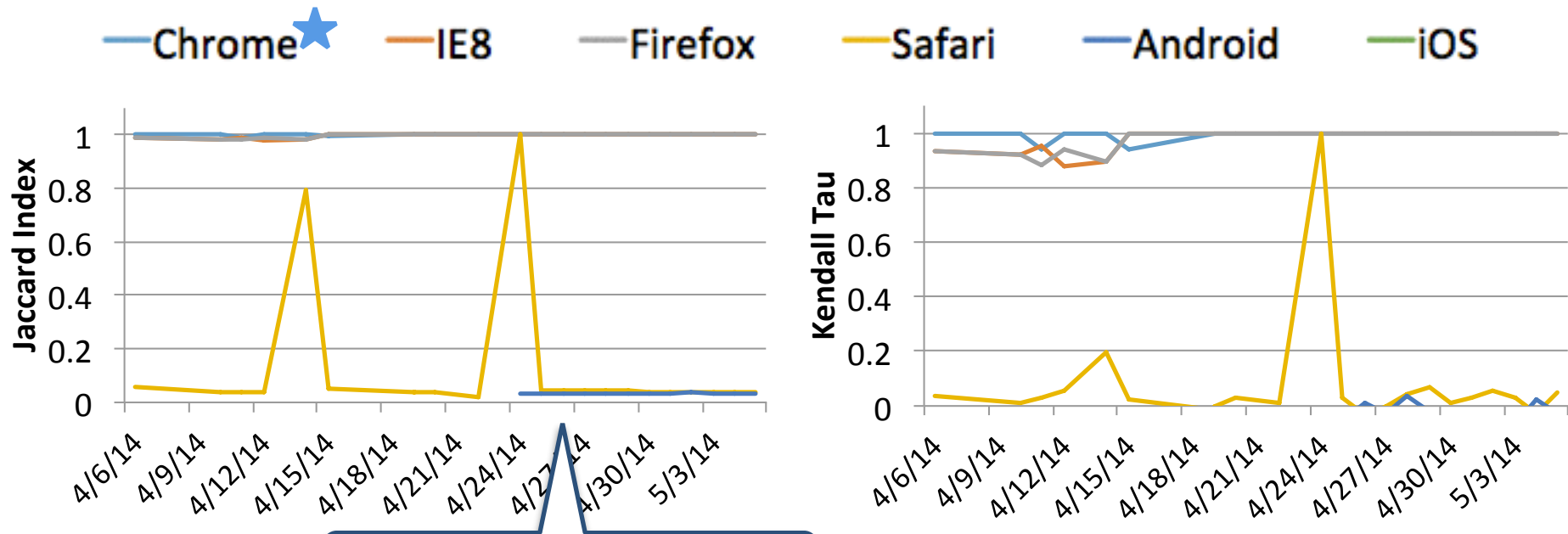
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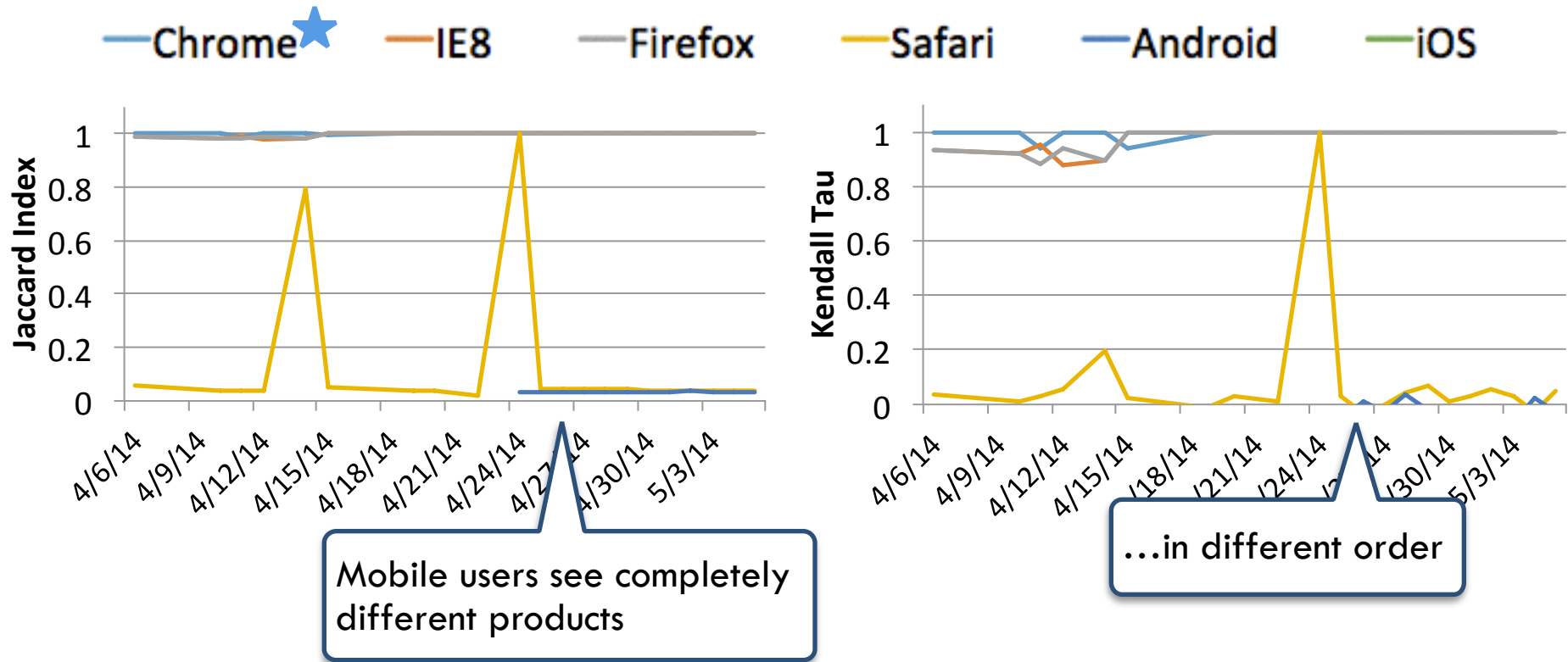
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Mobile users see completely different products

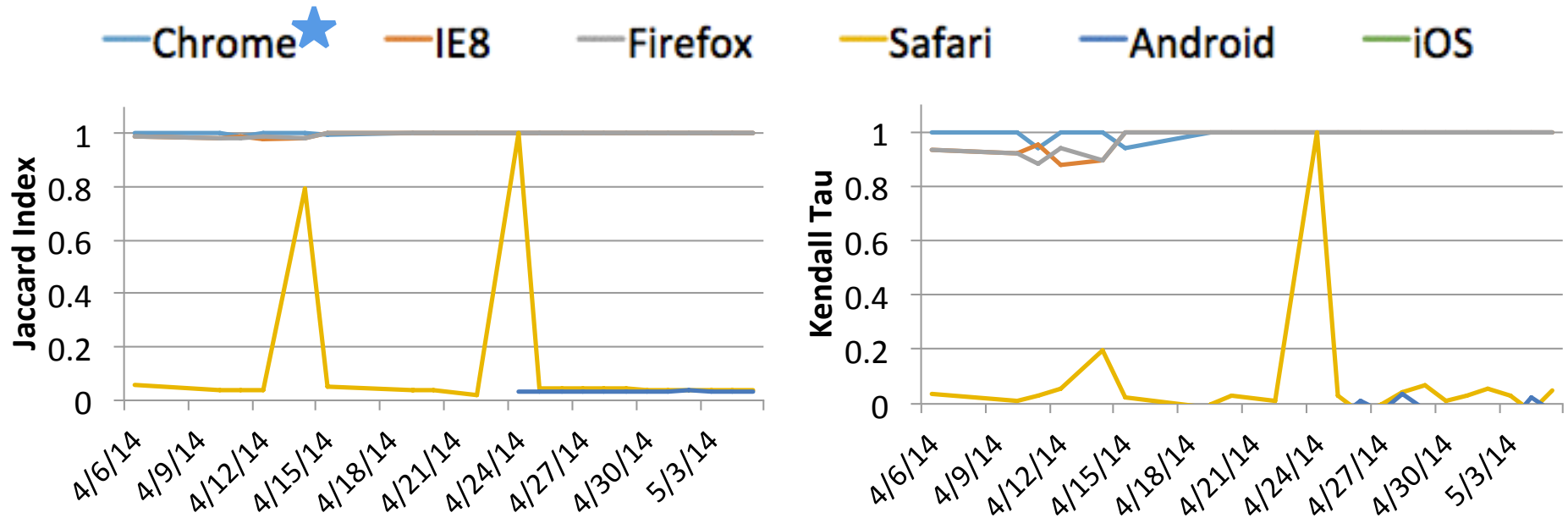
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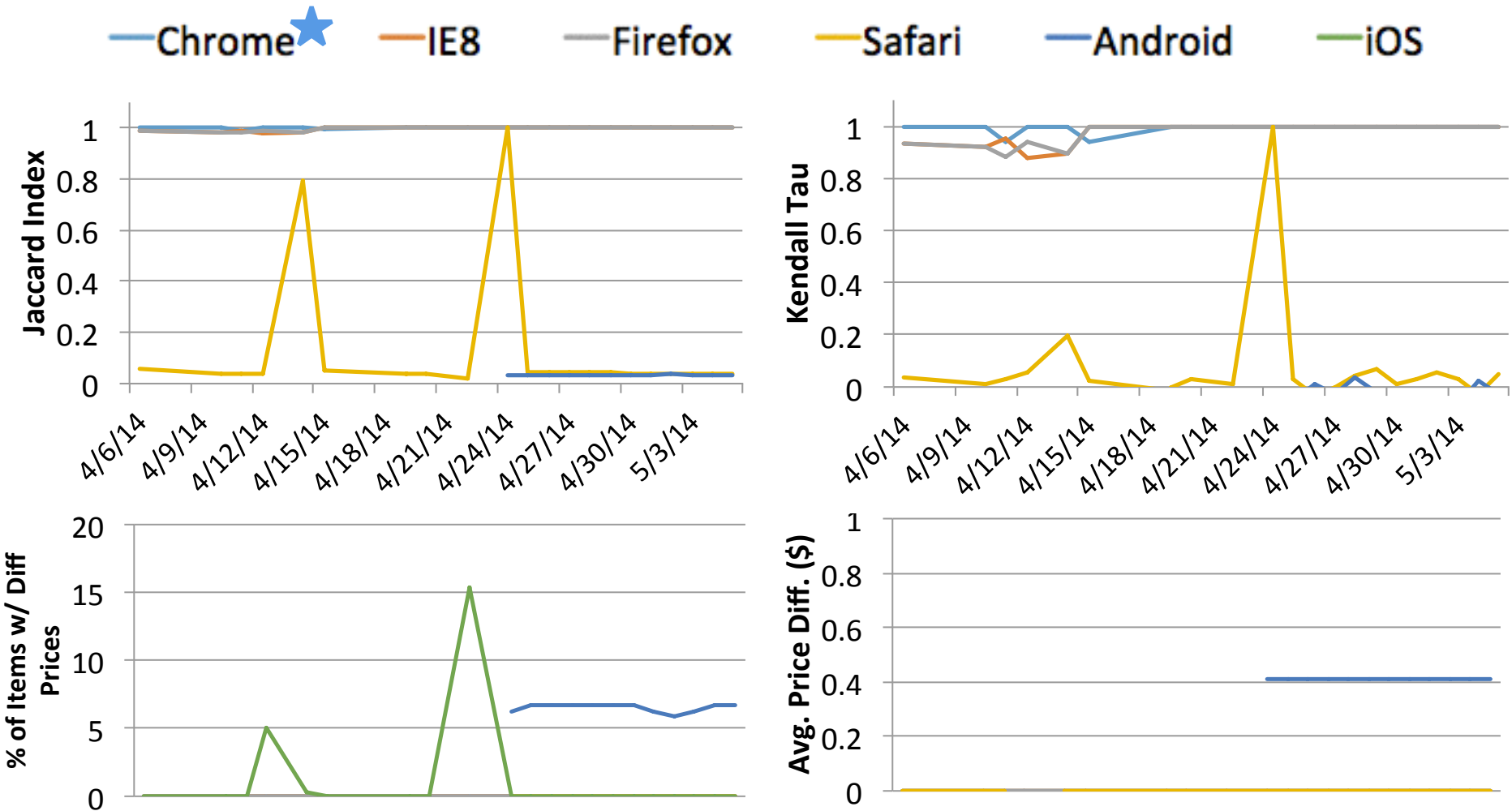
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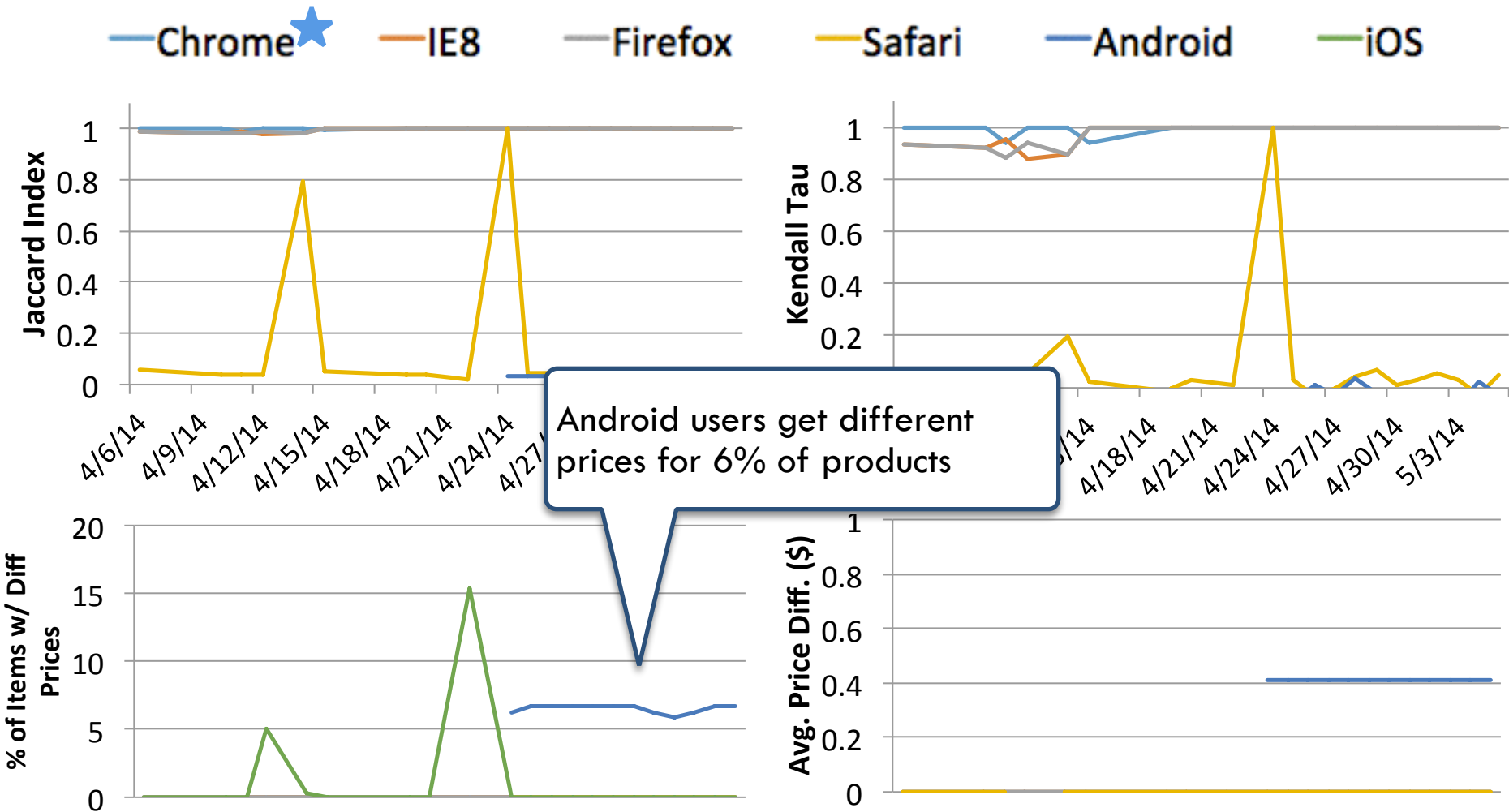
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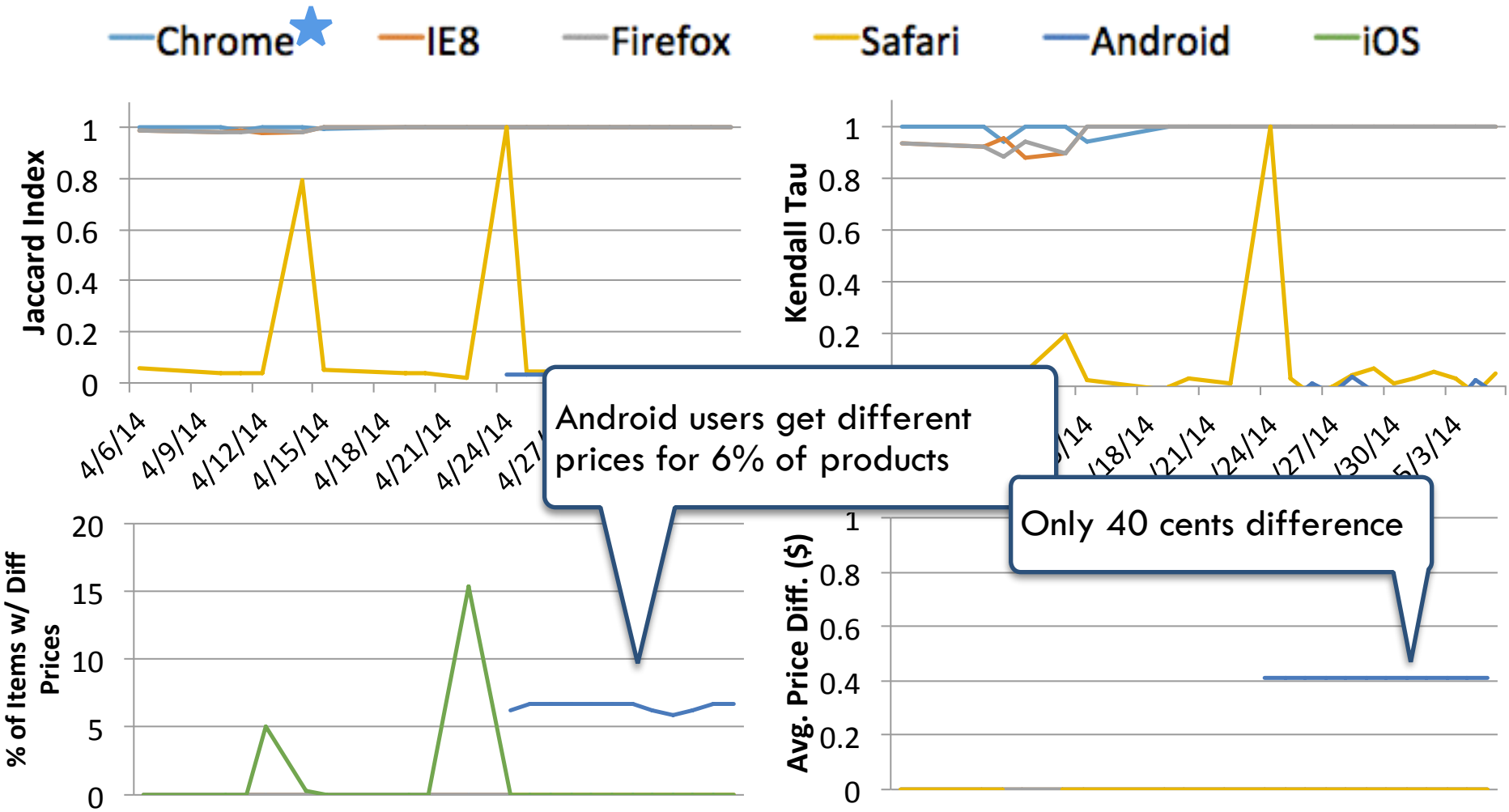
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# Results for different e-commerce sites

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21

## 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

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## Travelocity: discriminates in favor of mobile users

- \$15 cheaper for mobile on average

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## Travelocity: discriminates in favor of mobile users

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## Priceline: recognizes cheapskates

- They get different products in different order

- ❑ Methodology
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# Recap

23

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 based on:  
Account, Browser/OS, Purchase History

# Discussion

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## 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>