

# Price Setting in Online Markets: Does IT Click?

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The views expressed herein are those of the authors and not of the Federal Reserve Bank of Boston nor the Federal Reserve System.

# Price Rigidity: Background

## Significant price rigidity in brick-and-mortar stores

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## Potential explanations:

- ▶ costs of nominal price adjustment (need to reprint price tags)
- ▶ search costs (consumers need to drive around multiple stores)
- ▶ costly to monitor competitors' prices
- ▶ informational frictions (uncertainty about demand, economy, etc.)
- ▶ customer markets (price fluctuations alienate consumers)

# Importance of Sticky Prices

Price rigidity gives rise to monetary non-neutrality  
and its source determines the degree of non-neutrality:

- ▶ the degree is lower in state- than in time-dependent models  
(e.g., menu cost vs. Calvo)
- ▶ models of “mechanical” rigidity may produce neutrality  
(e.g., Head et al. 2012)
- ▶ rigidity in posted and regular (excluding sales) prices affects MP  
(Kehoe and Midrigan 2012)
- ▶ even for a given source of rigidity, details matter  
(e.g., menu-cost models with multiproduct firms)

The source of price rigidity affects inflation persistence  
(Fuhrer 2006, 2010)

# Motivation

We look at markets where these frictions are smaller (online)

- ▶ lower costs of price changes  
expect shorter spells and smaller price changes
- ▶ lower search costs  
expect smaller price dispersion
- ▶ low cost of monitoring competitors' prices  
expect high synchronization
- ▶ unique opportunity for price experimentation  
expect dynamic pricing
- ▶ guarantees are partly outsourced to a shopping platform  
(e.g., Amazon Marketplace, Google Trusted Store)  
expect smaller role of reputation and customer relationship

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The market is shaped by many big players

(Amazon, Bestbuy, eBay, Google, Walmart)

- ▶ In 2013, Amazon's U.S. revenue was \$75.5 bln ( $\approx$ that of Target)
- ▶ In 2013, Amazon sold 230 mln items ( $\approx$ 30 times  $>$  than Walmart)



# This Paper

We analyze price-setting in online markets  
using high-quality price data  
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- ▶ Data on clicks for each price quote (proxy for sales in offline data)

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  5. Price-setting is related to market factors (not in macro models)  
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but doesn't change qualitative conclusions
  7. Striking similarities between the U.S. and the U.K.
  8. No evidence of dynamic pricing at high frequencies  
but some evidence at low freq. for micro shocks



# Relation to Literature

## EMPIRICS

- ▶ *Price stickiness*
  - ▶ *offline* (Bils and Klenow 2004; Klenow and Kryvtsov 2008; Nakamura and Steinsson 2008, 2012; Klenow and Malin 2010; Eichenbaum, Jaimovich, and Rebelo 2011; Kryvtsov and Vincent 2014)
  - ▶ *online* (Cavallo 2012; Cavallo, Neiman, and Rigobon 2014; Gorodnichenko and Talavera 2014)
- ▶ *Price dispersion*
  - ▶ *offline* (Lach 2002; Kaplan and Menzio 2014; Sheremirov 2014)
  - ▶ *online* (Brynjolfsson and Smith 2000; Chevalier and Goolsbee 2003; Baye, Morgan, and Scholten 2004, 2010; Lünnemann and Winttr 2011)
- ▶ *Responses to demand shocks* (Warner and Barsky 1995)

## THEORY

- ▶ *Price stickiness* (Benabou 1988, 1992; Diamond 1993; Golosov and Lucas 2007; Guimaraes and Sheedy 2011; Midrigan 2011; Alvarez and Lippi 2014)
- ▶ *Dispersion and IO* (Reinganum 1979; MacMinn 1980; Varian 1980)

## NOMINAL RIGIDITIES, MP, AND INFLATION PERSISTENCE

(Woodford 2003; Fuhrer 2006, 2010; Olivei and Tenreyro 2007; Head et al. 2012; Kehoe and Midrigan 2012)

# A Typical Shopping Platform



## Nabi 2 Kids 7 Android Tablet - NABI2NVA

\$180 online

★★★★★ 47 reviews

[Write a review](#)

[Add to Shortlist](#)

Handheld - Android OS - Wi-Fi Only - 7 inch - With Camera

The nabi 2 is a full-featured tablet made especially for kids. It comes preloaded with more than \$200 worth of apps, including 25 free games, 50 free songs, 30 free books, and more. In addition, the nabi 2 features state-standardized, core curriculum in math, science, social ... [more »](#)

[Browse Tablet Computers »](#)

[Online stores](#) [Nearby stores](#) [Related items](#) [Reviews](#) [Details](#)

### Online stores shipping to Berkeley, CA

Free shipping  Refurbished / used

Sponsored [ⓘ](#)

| Sellers ▼   | Seller Rating | Details               | Base Price               | Total Price |                        |
|---|---------------|-----------------------|--------------------------|-------------|------------------------|
| RadioShack  | ★★★★★ (5,379) | Free shipping         | \$199.99 \$17.50 tax     | \$217.49    | <a href="#">Shop »</a> |
| eBay - electronic_express   | ★★★★★ (605)   | Free shipping, No tax | \$206.97                 | \$206.97    | <a href="#">Shop »</a> |
| Abt Electronics & Appliances <span style="background-color: black; color: black;">[REDACTED]</span> | ★★★★★ (725)   | No tax                | \$199.99 \$7.13 shipping | \$207.12    | <a href="#">Shop »</a> |
| TechieWarehouse.com   | 10 ratings    | No tax                | \$269.99 \$3.99 shipping | \$273.98    | <a href="#">Shop »</a> |
| Walmart   | ★★★★☆ (140)   | Free shipping         | \$179.99 \$15.75 tax     | \$195.74    | <a href="#">Shop »</a> |
| eBay - save-on-retail + Show all 2  | ★★★★★ (369)   | Free shipping, No tax | \$229.98                 | \$229.98    | <a href="#">Shop »</a> |
| eBay + Show all 25  | No rating     | No tax                | \$189.99 \$6.85 shipping | \$196.84    | <a href="#">Shop »</a> |
| eBay - essentialtreasure  | ★★★★★ (203)   | Free shipping, No tax | \$207.00                 | \$207.00    | <a href="#">Shop »</a> |

# Data

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- ▶ Price distribution across goods, U.S. ( $N = 52,776$ )

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| 5th Per-<br>centile<br>(1) | 25th Per-<br>centile<br>(2) | Median<br>(3) | 75th Per-<br>centile<br>(4) | 95th Per-<br>centile<br>(5) |
|----------------------------|-----------------------------|---------------|-----------------------------|-----------------------------|
| \$4                        | \$11                        | \$25          | \$71                        | \$474                       |

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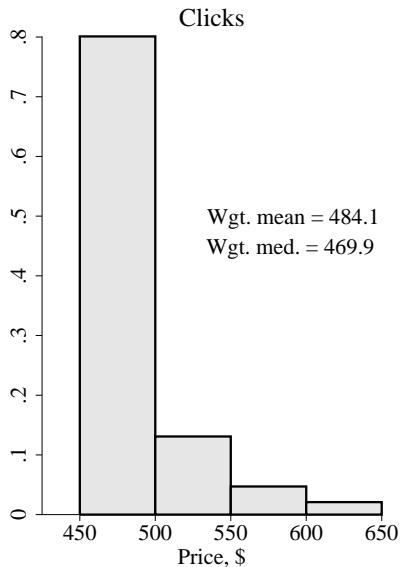
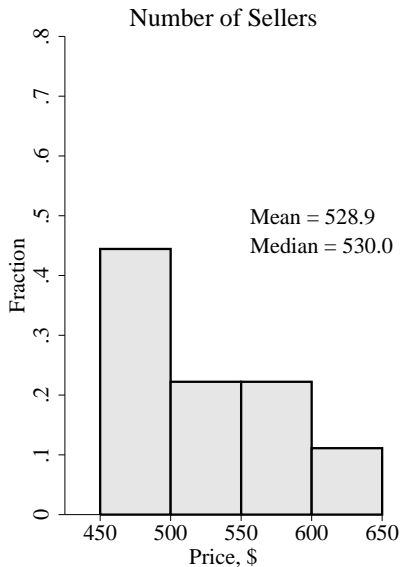
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|----------------|----------------------------|-----------------------------|---------------|-----------------------------|-----------------------------|
| No weights     | \$4                        | \$11                        | \$25          | \$71                        | \$474                       |
| Click weighted | \$7                        | \$22                        | \$61          | \$192                       | \$852                       |

# Coverage

| Category                    | Goods<br>(1)  | Sellers<br>(2) |
|-----------------------------|---------------|----------------|
| Media                       | 14,370        | 3,365          |
| Electronics                 | 7,606         | 8,888          |
| Home and Garden             | 5,150         | 6,182          |
| Health and Beauty           | 4,425         | 3,676          |
| Arts and Entertainment      | 2,873         | 2,779          |
| Hardware                    | 2,831         | 3,200          |
| Toys and Games              | 2,777         | 3,350          |
| Apparel and Accessories     | 2,645         | 2,061          |
| Sporting Goods              | 2,335         | 2,781          |
| Pet Supplies                | 1,106         | 1,241          |
| Luggage and Bags            | 1,077         | 1,549          |
| Cameras and Optics          | 978           | 2,492          |
| Office Supplies             | 849           | 1,408          |
| Vehicles and Parts          | 575           | 1,539          |
| Software                    | 506           | 1,041          |
| Furniture                   | 334           | 1,253          |
| Baby and Toddler            | 160           | 654            |
| Business and Industrial     | 67            | 324            |
| Food, Beverages and Tobacco | 67            | 174            |
| Mature                      | 43            | 385            |
| Services                    | 26            | 119            |
| Not Classified              | 1,976         | 3,465          |
| <b>Total</b>                | <b>52,776</b> | <b>27,308</b>  |

# Prices for a Smartphone in May 2011





# Weighting Schemes

Let  $f_{is}$  be a stickiness measure for good  $i$  sold by seller  $s$

*We compute 3 aggregate measures:*

## 1. Unweighted mean

$$\bar{f} = \sum_i \frac{1}{N} \sum_s f_{is} \frac{1}{S}$$

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## 3. Between-good weighted mean

$$\bar{f}^{\text{between}} = \sum_i \underbrace{\frac{\sum_s Q_{is}}{\sum_i \sum_s Q_{is}}}_{\text{between-good weights}} \cdot \sum_s f_{is} \cdot \underbrace{\frac{Q_{is}}{\sum_s Q_{is}}}_{\text{within-good weights}}$$

## Regular and Posted Prices

Lots of price changes last for a limited period of time  
(Nakamura and Steinsson 2008,  
Eichenbaum, Jaimovich, and Rebelo 2011)

Excluding temporary changes (sales) increases duration of spells  
from 4 to 8–11 months  
(Bils and Klenow 2004, Nakamura and Steinsson 2008)

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from 4 to 8–11 months  
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Sales do not affect monetary non-neutrality  
(Kehoe and Midrigan 2012, Guimaraes and Sheedy 2011)  
are acyclical (Coibion, Gorodnichenko, and Hong 2012)  
may interact with regular prices (Sheremirov 2014)  
are part of “sticky price plans” (Anderson et al. 2014)

## Frequency of Sales

|    | Mean<br>Freq.<br>(1) | Standard<br>Deviation<br>(2) | Med.<br>Freq.<br>(3) |
|----|----------------------|------------------------------|----------------------|
| No | 1.3                  | 3.1                          | 0.0                  |
| W  | 1.5                  | 3.2                          | 0.0                  |
| B  | 1.7                  | 1.9                          | 1.4                  |

One-week two-sided sales filter (Anderson et al. 2014)

## Frequency of Sales

|                | Mean<br>Freq.<br>(1) | Standard<br>Deviation<br>(2) | Med.<br>Freq.<br>(3) |
|----------------|----------------------|------------------------------|----------------------|
| <i>Online</i>  |                      |                              |                      |
| No             | 1.3                  | 3.1                          | 0.0                  |
| W              | 1.5                  | 3.2                          | 0.0                  |
| B              | 1.7                  | 1.9                          | 1.4                  |
| <i>Offline</i> | <b>1.9</b>           |                              |                      |

One-week two-sided sales filter (Anderson et al. 2014)

**Sales are almost as frequent online as offline**

## Frequency and Size of Sales

|                | Mean<br>Freq.<br>(1) | Standard<br>Deviation<br>(2) | Med.<br>Freq.<br>(3) | Med.<br>Size<br>(4) |
|----------------|----------------------|------------------------------|----------------------|---------------------|
| <i>Online</i>  |                      |                              |                      |                     |
| No             | 1.3                  | 3.1                          | 0.0                  | 10.5                |
| W              | 1.5                  | 3.2                          | 0.0                  | 4.8                 |
| B              | 1.7                  | 1.9                          | 1.4                  | 4.4                 |
| <i>Offline</i> | 1.9                  |                              |                      | 29.5                |

One-week two-sided sales filter (Anderson et al. 2014)

Sales are almost as frequent online as offline

However, consumers get a better discount offline



# Synchronization of Sales

$$\text{Synchronization Rate} = \frac{A-1}{B-1}, A \geq 1, B \geq 2$$

where  $A$  is # of sellers with sales and  $B$  is total # of sellers

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## Across Sellers

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|    | Mean<br>(1) | Std.<br>(2) | Med.<br>(3) |
|----|-------------|-------------|-------------|
| No | 0.8         | 5.2         | 0.0         |
| W  | 1.0         | 6.3         | 0.0         |
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consistent with models of segmented markets  
(e.g., Guimaraes and Sheedy 2011)

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|    | Across Sellers |             |             | Across Goods |             |             |
|----|----------------|-------------|-------------|--------------|-------------|-------------|
|    | Mean<br>(1)    | Std.<br>(2) | Med.<br>(3) | Mean<br>(4)  | Std.<br>(5) | Med.<br>(6) |
| No | 0.8            | 5.2         | 0.0         | 2.1          | 9.6         | 0.0         |
| W  | 1.0            | 6.3         | 0.0         | 2.4          | 11.4        | 0.0         |
| B  | 1.8            | 4.7         | 0.2         | 2.1          | 1.0         | 2.4         |

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consistent with models of segmented markets  
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Online retailers conduct sales for specific products

Are prices more flexible online?

## Frequency and Size of Price Changes

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| Weights:        | Raw       |          |          | Offline<br>(4) |
|-----------------|-----------|----------|----------|----------------|
|                 | No<br>(1) | W<br>(2) | B<br>(3) |                |
| Median Freq., % | 14.0      | 16.7     | 19.3     | 4.7            |
| Duration, weeks | 6.6       | 5.5      | 4.7      | 20.8           |

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| Median Freq., %         | 14.0        | 16.7        | 19.3        | 4.7            |
| Duration, weeks         | 6.6         | 5.5         | 4.7         | 20.8           |
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| <i>Posted Price</i>  |           |          |          |                |
| Median Freq., %      | 14.0      | 16.7     | 19.3     | 4.7            |
| Duration, weeks      | 6.6       | 5.5      | 4.7      | 20.8           |
| Absolute Size, %     | 11.0      | 10.7     | 11.2     | 10.7           |
| <i>Regular Price</i> |           |          |          |                |
| Median Freq., %      | 8.8       | 10.8     | 14.5     | 2.1            |
| Duration, weeks      | 10.9      | 8.7      | 6.4      | 47.1           |
| Absolute Size, %     | 10.9      | 10.6     | 10.9     | 8.5            |

Sales filter: 1-week two-sided filter

## Frequency and Size of Price Changes

| Weights:             | Raw       |          |          | Imputed   |          |          | Offline<br>(7) |
|----------------------|-----------|----------|----------|-----------|----------|----------|----------------|
|                      | No<br>(1) | W<br>(2) | B<br>(3) | No<br>(4) | W<br>(5) | B<br>(6) |                |
| <i>Posted Price</i>  |           |          |          |           |          |          |                |
| Median Freq., %      | 14.0      | 16.7     | 19.3     | 7.2       | 9.3      | 16.3     | 4.7            |
| Duration, weeks      | 6.6       | 5.5      | 4.7      | 13.4      | 10.2     | 5.6      | 20.8           |
| Absolute Size, %     | 11.0      | 10.7     | 11.2     |           |          |          | 10.7           |
| <i>Regular Price</i> |           |          |          |           |          |          |                |
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Sales filter: 1-week two-sided filter

Imputation:  $\{2,2,\dots,2\} \implies \{2,2,2\}$ , up to 4 weeks

Weighting by clicks improves measurement (imputation)



# Composition Effect

|                                  | Posted Price |          |         | Regular Price |          |         |
|----------------------------------|--------------|----------|---------|---------------|----------|---------|
|                                  | Online       |          | Offline | Online        |          | Offline |
|                                  | No<br>(1)    | B<br>(2) |         | No<br>(4)     | B<br>(5) |         |
| Audio Players and Recorders      | 17.1         | 23.5     | 6.2     | 10.8          | 19.8     | 1.8     |
| Bedding                          | 20.0         | 17.1     | 10.1    | 12.5          | 13.3     | 1.3     |
| Books                            | 20.0         | 23.8     | 1.7     | 14.2          | 16.7     | 1.3     |
| Camera Accessories               | 7.4          | 16.4     | 4.7     | 4.9           | 12.4     | 2.0     |
| Cameras                          | 17.6         | 34.9     | 5.2     | 15.6          | 30.3     | 2.7     |
| Camping, Backpacking, and Hiking | 13.3         | 18.0     | 3.4     | 7.8           | 14.5     | 1.1     |
| Computer Software                | 12.1         | 23.8     | 2.8     | 7.7           | 19.1     | 2.0     |
| Cookware                         | 13.2         | 17.7     | 4.8     | 7.7           | 10.6     | 0.7     |
| Costumes                         | 10.8         | 13.2     | 7.2     | 6.1           | 7.3      | 0.9     |
| Cycling                          | 15.8         | 16.5     | 3.6     | 10.3          | 12.5     | 1.7     |
| Doors and Windows                | 13.4         | 8.8      | 4.3     | 10.6          | 5.7      | 0.8     |
| Gardening                        | 12.5         | 12.8     | 2.3     | 6.8           | 9.1      | 1.3     |
| Hair Care                        | 14.3         | 22.4     | 5.2     | 9.7           | 14.7     | 1.7     |
| Household Climate Control        | 11.3         | 15.7     | 3.7     | 7.0           | 11.1     | 0.8     |
| Kitchen Appliances               | 13.4         | 13.2     | 5.7     | 9.3           | 10.6     | 0.9     |
| Musical String Instruments       | 1.9          | 2.1      | 2.4     | 0.7           | 1.6      | 1.5     |
| Oral Care                        | 14.4         | 23.5     | 1.8     | 11.3          | 17.5     | 1.2     |
| Tableware                        | 11.1         | 17.6     | 5.2     | 6.3           | 16.1     | 0.7     |
| Telephony                        | 15.9         | 23.4     | 4.7     | 9.1           | 22.8     | 2.7     |
| Vacuums                          | 15.2         | 32.1     | 7.1     | 11.6          | 25.4     | 2.0     |
| Vision Care                      | 1.3          | 5.7      | 2.9     | 0.0           | 5.7      | 1.4     |
| Watches                          | 12.2         | 11.8     | 5.7     | 7.9           | 9.0      | 1.0     |

# Product Substitution

Product substitution is a channel of price adjustment  
(Nakamura and Steinsson 2012)

Cavallo, Neiman, and Rigobon (2014) scrape online data  
from Apple, IKEA, H&M, and Zara

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from Apple, IKEA, H&M, and Zara

1. 77% of products in the U.S. sample have constant price
2. duration of life is short (15 weeks)
3. longer life duration ==> price changes are more likely

## Product Substitution

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|                    | All<br>Products        |                      |
|--------------------|------------------------|----------------------|
|                    | Const.<br>Price<br>(1) | Not<br>Const.<br>(2) |
| Share of goods, %  | 11.9                   | 88.1                 |
| Share of clicks, % | 1.3                    | 98.7                 |

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Only 12% of products have constant price (unlike in CNR)

## Product Substitution

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|                    | All Products        |                   | Apparel, One Seller |                   |
|--------------------|---------------------|-------------------|---------------------|-------------------|
|                    | Const. Price<br>(1) | Not Const.<br>(2) | Const. Price<br>(3) | Not Const.<br>(4) |
| Share of goods, %  | 11.9                | 88.1              | 31.0                | 69.0              |
| Share of clicks, % | 1.3                 | 98.7              | 25.7                | 74.3              |

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Only 12% of products have constant price (unlike in CNR)

The difference is due to sample composition

## Product Substitution

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|                    | All Products        |                   | Apparel, One Seller |                   | —excl. Jewelry and Watches |                   |
|--------------------|---------------------|-------------------|---------------------|-------------------|----------------------------|-------------------|
|                    | Const. Price<br>(1) | Not Const.<br>(2) | Const. Price<br>(3) | Not Const.<br>(4) | Const. Price<br>(5)        | Not Const.<br>(6) |
| Share of goods, %  | 11.9                | 88.1              | 31.0                | 69.0              | 42.4                       | 57.6              |
| Share of clicks, % | 1.3                 | 98.7              | 25.7                | 74.3              | 30.8                       | 69.2              |

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---

Only 12% of products have constant price (unlike in CNR)

The difference is due to sample composition

## Product Substitution

|                      | All Products        |                   | Apparel, One Seller |                   | —excl. Jewelry and Watches |                   |
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| Share of goods, %    | 11.9                | 88.1              | 31.0                | 69.0              | 42.4                       | 57.6              |
| Share of clicks, %   | 1.3                 | 98.7              | 25.7                | 74.3              | 30.8                       | 69.2              |
| Av. # of sellers     | 1.3                 | 5.1               | 1.0                 | 1.0               | 1.0                        | 1.0               |
| Life duration, weeks | 36.2                | 57.2              | 27.9                | 37.4              | 22.3                       | 30.3              |

Only 12% of products have constant price (unlike in CNR)

The difference is due to sample composition

Duration of life is shorter for apparel

shorter duration ==> price changes are less likely (as in CNR)

but the frequency is almost the same

Are prices synchronized online?



## Synchronization Rate, %

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For a Good across Sellers

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|    | Mean<br>(1) | Std<br>(2) | Med<br>(3) | 3m<br>(4) |
|----|-------------|------------|------------|-----------|
| No | 10.2        | 18.6       | 0.0        | 41.3      |
| W  | 10.6        | 19.2       | 0.0        | 43.2      |
| B  | 15.7        | 10.0       | 15.1       | 55.2      |

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## Synchronization Rate, %

| For a Good across Sellers |             |            |            |           |
|---------------------------|-------------|------------|------------|-----------|
|                           | Mean<br>(1) | Std<br>(2) | Med<br>(3) | 3m<br>(4) |
| <i>Posted</i>             |             |            |            |           |
| No                        | 10.2        | 18.6       | 0.0        | 41.3      |
| W                         | 10.6        | 19.2       | 0.0        | 43.2      |
| B                         | 15.7        | 10.0       | 15.1       | 55.2      |
| <i>Regular</i>            |             |            |            |           |
| No                        | 7.8         | 16.4       | 0.0        | 40.6      |
| W                         | 8.2         | 17.0       | 0.0        | 42.2      |
| B                         | 12.8        | 8.6        | 12.6       | 52.8      |

Posted price changes are slightly more synchronized

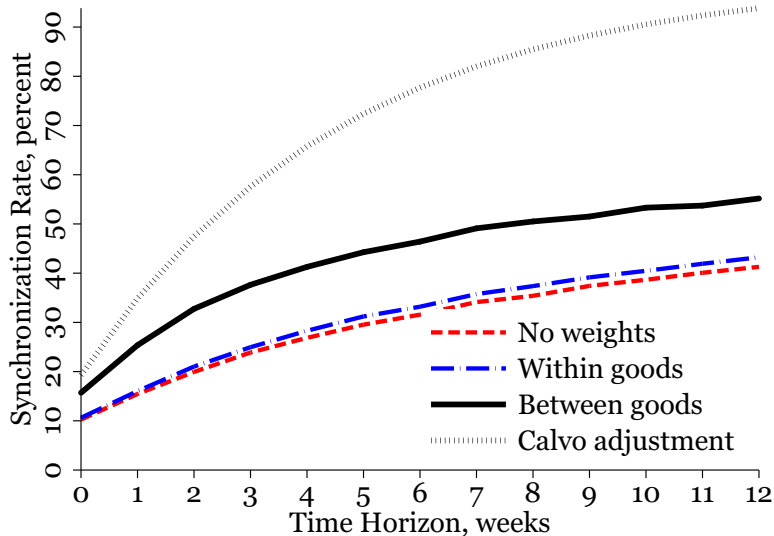
## Synchronization Rate, %

|                | For a Good across Sellers |            |            |           | For a Seller across Goods |            |            |           |
|----------------|---------------------------|------------|------------|-----------|---------------------------|------------|------------|-----------|
|                | Mean<br>(1)               | Std<br>(2) | Med<br>(3) | 3m<br>(4) | Mean<br>(5)               | Std<br>(6) | Med<br>(7) | 3m<br>(8) |
| <i>Posted</i>  |                           |            |            |           |                           |            |            |           |
| No             | 10.2                      | 18.6       | 0.0        | 41.3      | 17.2                      | 27.4       | 1.6        | 45.7      |
| W              | 10.6                      | 19.2       | 0.0        | 43.2      | 17.6                      | 28.3       | 1.2        | 47.6      |
| B              | 15.7                      | 10.0       | 15.1       | 55.2      | 22.5                      | 11.6       | 24.9       | 66.7      |
| <i>Regular</i> |                           |            |            |           |                           |            |            |           |
| No             | 7.8                       | 16.4       | 0.0        | 40.6      | 14.7                      | 25.7       | 0.0        | 46.1      |
| W              | 8.2                       | 17.0       | 0.0        | 42.2      | 15.2                      | 26.7       | 0.0        | 48.1      |
| B              | 12.8                      | 8.6        | 12.6       | 52.8      | 18.3                      | 10.3       | 20.3       | 64.3      |

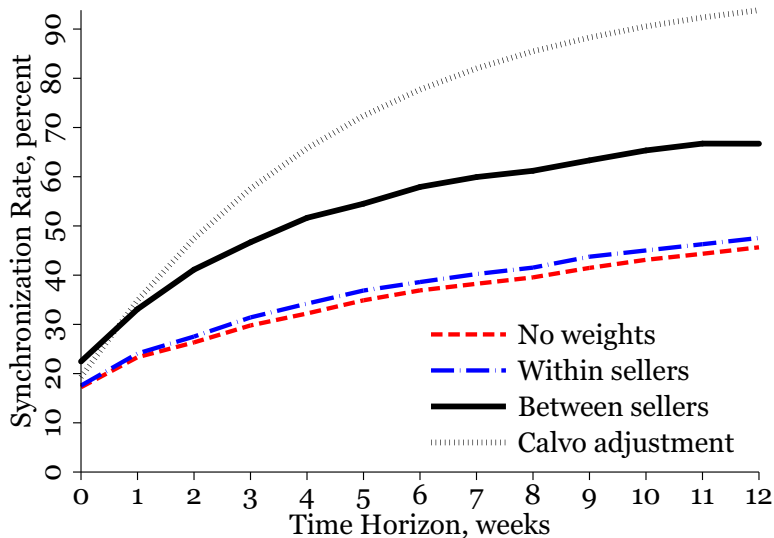
Posted price changes are slightly more synchronized

Synchronization across goods is higher,  
but hardly perfect within firms  
(unlike in models of Midrigan 2011, Alvarez and Lippi 2014)

# Synchronization over Time for a Good across Sellers



## Synchronization over Time for a Seller across Goods



Do micro factors play a role  
in price adjustment?

# Predictors of Price Stickiness

We run the following regressions:

$$f_i^w = \beta_1 \log S_i + \beta_2 \text{HHI}_i + \beta_3 \log Q_i + \beta_4 \overline{\log P}_i + \beta_5 \overline{\log P}_i^2 + \varepsilon_i$$

$f_i^w$  is click-weighted frequency, size, or sync. for good  $i$

$S_i$  — number of sellers;  $\text{HHI}_i$  — Herfindahl index based on clicks, (0, 1]

$Q_i$  — total number of clicks

$\overline{\log P}_i$  — median log price

Category FE; SE clustered at narrow categories; obs. weighted by clicks

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$Q_i$  — total number of clicks

$\overline{\log P}_i$  — median log price

Category FE; SE clustered at narrow categories; obs. weighted by clicks

| Determinant           | Freq.<br>(1)     | Abs. Size<br>(2) | Sync.<br>(3)    |
|-----------------------|------------------|------------------|-----------------|
| Log Number of Sellers | 10.7***<br>(0.6) | -1.3*<br>(0.7)   | 2.8***<br>(0.6) |
| $R^2$                 | 0.09             | 0.12             | 0.05            |
| $N$                   | 14,483           | 17,053           | 9,937           |



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| Determinant                | Freq.<br>(1)     | Abs. Size<br>(2) | Sync.<br>(3)     |
|----------------------------|------------------|------------------|------------------|
| Log Number of Sellers      | 10.7***<br>(0.6) | -1.3*<br>(0.7)   | 2.8***<br>(0.6)  |
| Concentration, HHI, (0, 1] | 24.9***<br>(2.8) | -6.6***<br>(1.5) | 13.3***<br>(2.9) |

|       |        |        |       |
|-------|--------|--------|-------|
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| Log Number of Sellers      | 10.7***<br>(0.6) | -1.3*<br>(0.7)   | 2.8***<br>(0.6)  |
| Concentration, HHI, (0, 1] | 24.9***<br>(2.8) | -6.6***<br>(1.5) | 13.3***<br>(2.9) |
| Log Total Clicks           | -4.2***<br>(0.3) | 0.3<br>(0.3)     | -0.6*<br>(0.4)   |

|       |        |        |       |
|-------|--------|--------|-------|
| $R^2$ | 0.09   | 0.12   | 0.05  |
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| Log Total Clicks           | -4.2***<br>(0.3) | 0.3<br>(0.3)     | -0.6*<br>(0.4)   |
| Log Median Price           | 0.1<br>(0.7)     | -9.2***<br>(0.7) | 2.0***<br>(0.6)  |
| Log Median Price, sq.      | -0.1<br>(0.1)    | 0.7***<br>(0.1)  | -0.1*<br>(0.1)   |
| $R^2$                      | 0.09             | 0.12             | 0.05             |
| $N$                        | 14,483           | 17,053           | 9,937            |

Is there more price convergence online?

# Price Dispersion: Importance

- ▶ In theory, should be small without menu & search costs
  
- ▶ Is tightly related to welfare
  - ▶  $MC = MR_1 = MR_2$  is violated
  - ▶ opportunity for store switching
  
- ▶ Allows distinguishing between various micro and macro theories
  - ▶ spatial vs. temporal
  - ▶ dynamics since product introduction
  - ▶ comovement with inflation

## Price Dispersion, % or log-p.

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|    | CV<br>$std(P)/\bar{P}$<br>(1) | $std(\log P)$<br>(2) |
|----|-------------------------------|----------------------|
| No | 21.5                          | 23.6                 |
| W  | 21.4                          | 22.9                 |
| B  | 19.9                          | 20.3                 |

---

The same order of magnitude as offline

Kaplan and Menzio (2014): CV=19% in the Nielsen data

Sheremirov (2014):  $std(\log P) = 10$  log-p. in the IRI data

## Price Dispersion, % or log-p.

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|    | CV<br>$std(P)/\bar{P}$<br>(1) | $std(\log P)$<br>(2) | VI<br>$\bar{p} - p_1$<br>(3) | IQR<br>$p_{75\%} - p_{25\%}$<br>(4) | Range<br>$p_{max} - p_1$<br>(5) | Gap<br>$p_2 - p_1$<br>(6) |
|----|-------------------------------|----------------------|------------------------------|-------------------------------------|---------------------------------|---------------------------|
| No | 21.5                          | 23.6                 | 24.4                         | 34.6                                | 40.7                            | 27.6                      |
| W  | 21.4                          | 22.9                 | 23.3                         | 32.0                                | 40.7                            | 27.6                      |
| B  | 19.9                          | 20.3                 | 24.8                         | 26.1                                | 50.1                            | 21.1                      |

---

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Kaplan and Menzio (2014): CV=19% in the Nielsen data

Sheremirov (2014):  $std(\log P) = 10 \log-p.$  in the IRI data

Less mass around the min. price

## Price Dispersion, % or log-p.

|   | CV<br>$std(P)/\bar{P}$<br>(1) | $std(\log P)$<br>(2) | VI<br>$\bar{p} - p_1$<br>(3) | IQR<br>$p_{75\%} - p_{25\%}$<br>(4) | Range<br>$p_{max} - p_1$<br>(5) | Gap<br>$p_2 - p_1$<br>(6) |
|---|-------------------------------|----------------------|------------------------------|-------------------------------------|---------------------------------|---------------------------|
| <i>Actual prices, <math>P_{ist}</math></i>                                |                               |                      |                              |                                     |                                 |                           |
| No  | 21.5                          | 23.6                 | 24.4                         | 34.6                                | 40.7                            | 27.6                      |
| W   | 21.4                          | 22.9                 | 23.3                         | 32.0                                | 40.7                            | 27.6                      |
| B   | 19.9                          | 20.3                 | 24.8                         | 26.1                                | 50.1                            | 21.1                      |
| <i>Prices net of seller fixed effects, <math>\varepsilon_{ist}</math></i> |                               |                      |                              |                                     |                                 |                           |
| No  |                               | 21.2                 | 18.3                         | 31.2                                | 36.8                            | 25.1                      |
| W   |                               | 20.7                 | 17.5                         | 28.9                                | 36.8                            | 25.1                      |
| B   |                               | 17.5                 | 18.6                         | 22.5                                | 43.8                            | 18.8                      |

The same order of magnitude as offline

Kaplan and Menzio (2014): CV=19% in the Nielsen data

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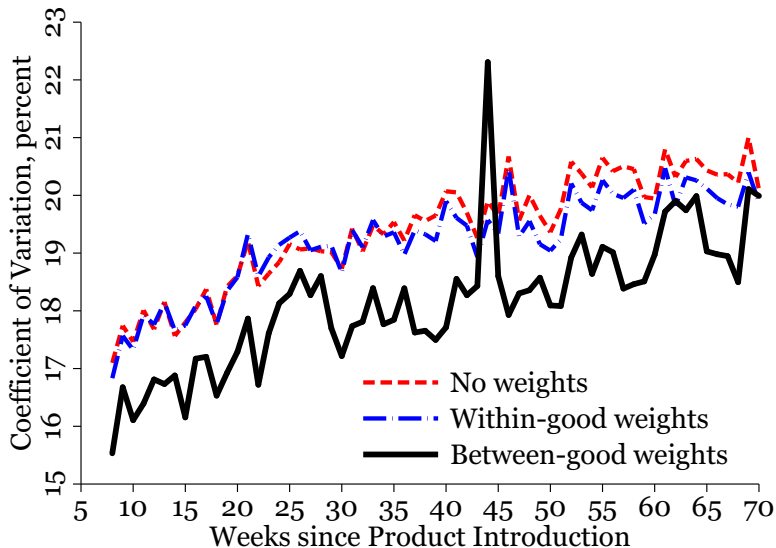
Less mass around the min. price

Seller FE control for delivery, return, customer experience, etc.

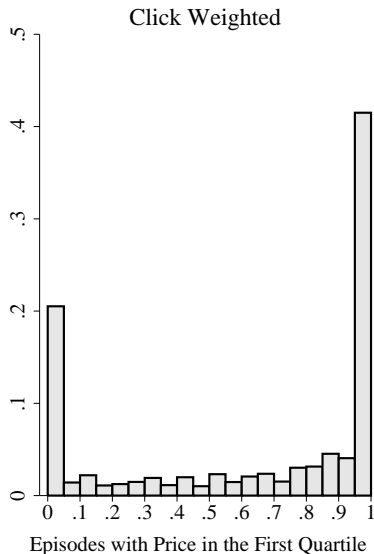
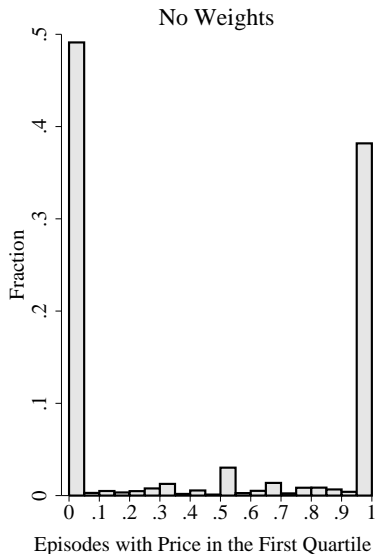
$$\log P_{ist} = \alpha_i + \gamma_s + \varepsilon_{ist}$$



## Price Dispersion since Product Introduction



# Spatial vs Temporal Price Dispersion



Do online retailers use dynamic pricing?

# Dynamic Pricing

Warner and Barsky's (1995):

firms permanently reset prices during high demand episodes

Uneven price staggering may affect the timing of monetary policy

—similar to Olivei and Tenreyro's (2007) argument

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Uneven price staggering may affect the timing of monetary policy  
—similar to Olivei and Tenreyro's (2007) argument

- ▶ We find confirmation for WB at low frequencies  
(around sales seasons: Thanksgiving or Christmas)
  - ▶ clicks  $\uparrow$ , prices permanently  $\downarrow$

# Dynamic Pricing

Warner and Barsky's (1995):

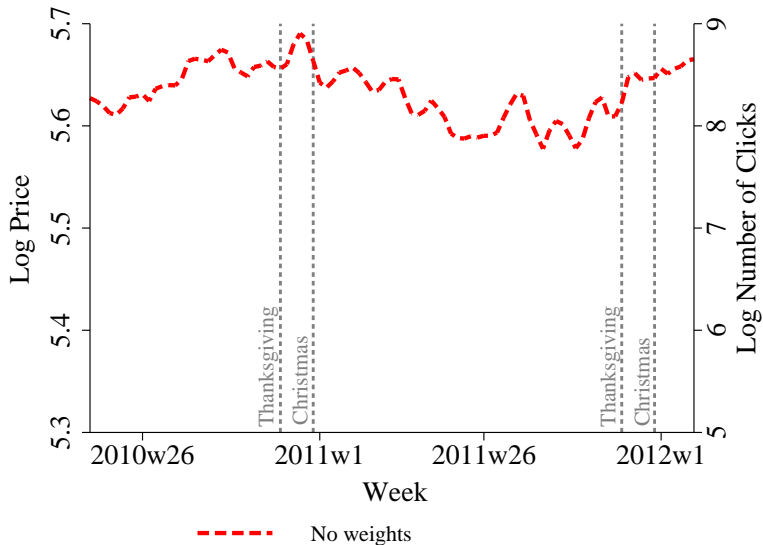
firms permanently reset prices during high demand episodes

Uneven price staggering may affect the timing of monetary policy  
—similar to Olivei and Tenreyro's (2007) argument

- ▶ We find confirmation for WB at low frequencies  
(around sales seasons: Thanksgiving or Christmas)
  - ▶ clicks  $\uparrow$ , prices permanently  $\downarrow$
- ▶ No confirmation at higher frequencies  
(days of the week or month)
  - ▶ Consumers shop online at the beginning of the week or month
  - ▶ No evidence firms adjust their prices more often

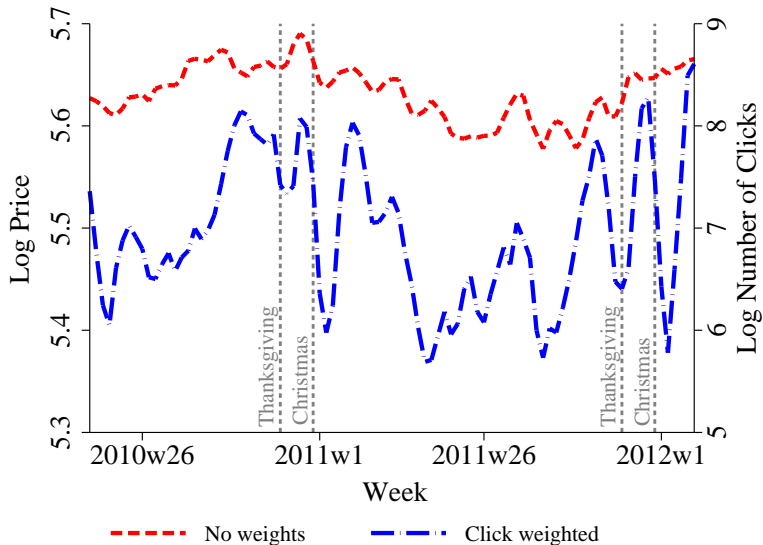
# Prices and Clicks around Sales Seasons

A Product in "Headphones" Category



# Prices and Clicks around Sales Seasons

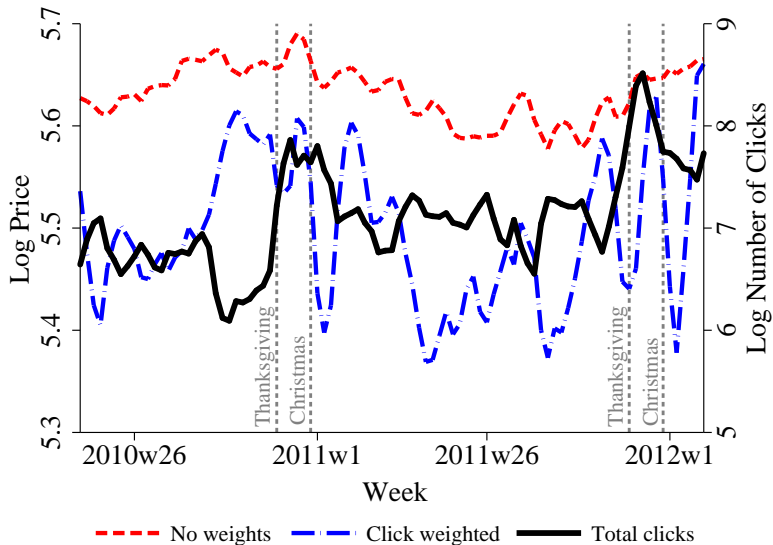
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# Prices and Clicks around Sales Seasons

A Product in "Headphones" Category



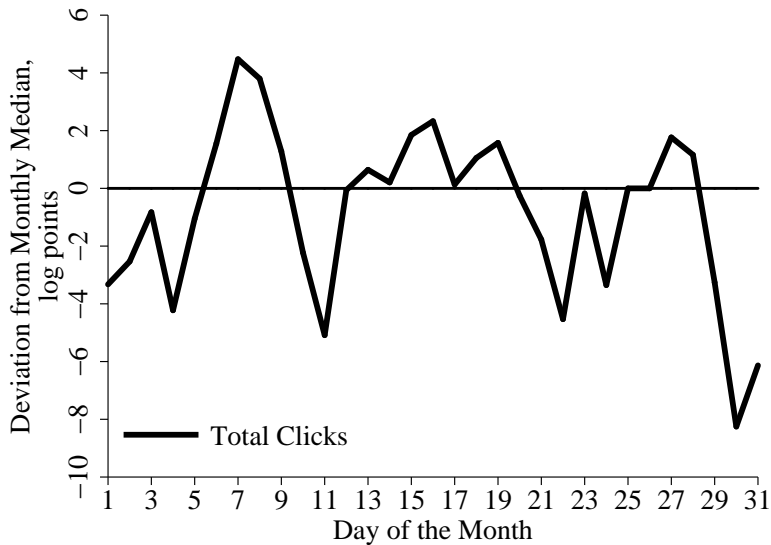
## Prices and Clicks by Day of the Week

|           |                                | Log Deviation from<br>Weekly Median, <i>log points</i> |
|-----------|--------------------------------|--|
|           | Click Share,<br><i>percent</i> | Total<br>Clicks  |
|           | (1)                            | (2)  |
| Monday    | 16.2                           | 10.0   |
| Tuesday   | 15.5                           | 6.4  |
| Wednesday | 14.8                           | 3.8  |
| Thursday  | 14.3                           | 0.0  |
| Friday    | 13.3                           | -6.6   |
| Saturday  | 12.1                           | -16.0  |
| Sunday    | 13.8                           | -4.4   |

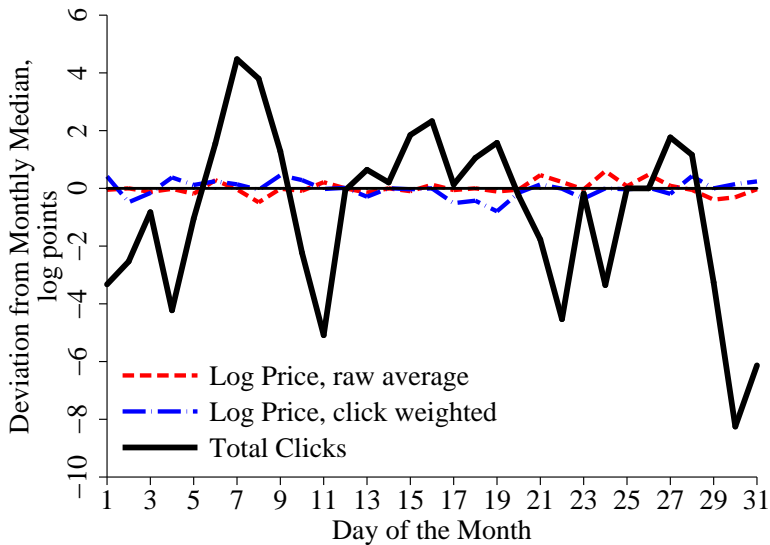
## Prices and Clicks by Day of the Week

|           |                                | Log Deviation from<br>Weekly Median, <i>log points</i> |               |                        |
|-----------|--------------------------------|--|---------------|------------------------|
|           | Click Share,<br><i>percent</i> | Total<br>Clicks  | Mean<br>Price | Weighted<br>Mean Price |
|           | (1)                            | (2)  | (3)           | (4)                    |
| Monday    | 16.2                           | 10.0   | -0.1          | 0.0                    |
| Tuesday   | 15.5                           | 6.4  | 0.2           | 0.0                    |
| Wednesday | 14.8                           | 3.8  | 0.5           | 0.0                    |
| Thursday  | 14.3                           | 0.0  | 1.4           | 0.1                    |
| Friday    | 13.3                           | -6.6   | 2.0           | 2.8                    |
| Saturday  | 12.1                           | -16.0  | -3.0          | -0.8                   |
| Sunday    | 13.8                           | -4.4   | -5.4          | -1.9                   |

## Prices and Clicks by Day of the Month



## Prices and Clicks by Day of the Month



# Concluding Remarks

## SUMMARY:

- ▶ Online prices are more flexible than offline prices
- ▶ Still, there are significant frictions in online markets
- ▶ Data on quantity margin improves measurement

## IMPLICATIONS:

- ▶ Price stickiness is unlikely to disappear due to e-commerce
- ▶ Online prices have special effects on aggregate price and inflation

## FUTURE RESEARCH:

- ▶ Need for alternative mechanisms that generate price stickiness
- ▶ Sellers with online and offline presence
- ▶ Data on inventories and costs