Notes for Jessoe and Rapson

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1 Summary

- RCT study of the effect of price changes on electricity usage

- 2 treatment groups:

    - price increase

    - price increase + in-house display (IHD)

- Both groups decrease usage, but price+IHD group is more elastic

2 Background

- Households' electricity demand is inelastic (Reiss and White 2005; Allcott 2011; Ito 2014)

- Could be due to lack of full information; price vs non-price attributes:

- Price salience

  * Taxes on price tags (Chetty, Looney, and Kroft 2009)

  * eBay shipping and handling fees (Hossain and Morgan 2006)

  * Electronic toll collection (Finkelstein 2009)

- Non-price attributes

  * household consumption of services, not direct inputs, e.g., durables that convert inputs into outputs

- Quantity of electricity consumed hidden due to infrequent billing

- Households could be inelastic, or just appear to be inelastic due to lack of complete information

3 Experimental details

3.1 Context

- Partnership with United Illuminating Company (UI), a regulated electric utility in Connecticut

- Field experiment in Bridgeport and New Haven, July and August 2011

- Short-term price increases and real-time information

3.2 Experimental setup

- Eligibility: live in townhouse or single family home, broadband Inernet, sign agreement

- Incentive: $20 for completion of pre-survey prior to assignment, $20 for completion of survey after end of pilot

- Recruitment: 60,000 emails to customers with paperless billing, 1,152 participants

- Sample: 437 households

- Randomly assigned into 3 groups:

  - Control: 207 households

  - Price-only: 130 households exposed to pricing events

  - Price+IHD: 100 households esposed to pricing events, but also receive real-time information via in-home displays (IHD)

- IHD removes information acquisition cost as it provides real-time usage, electricity price, estimated monthly usage and bill-to-date

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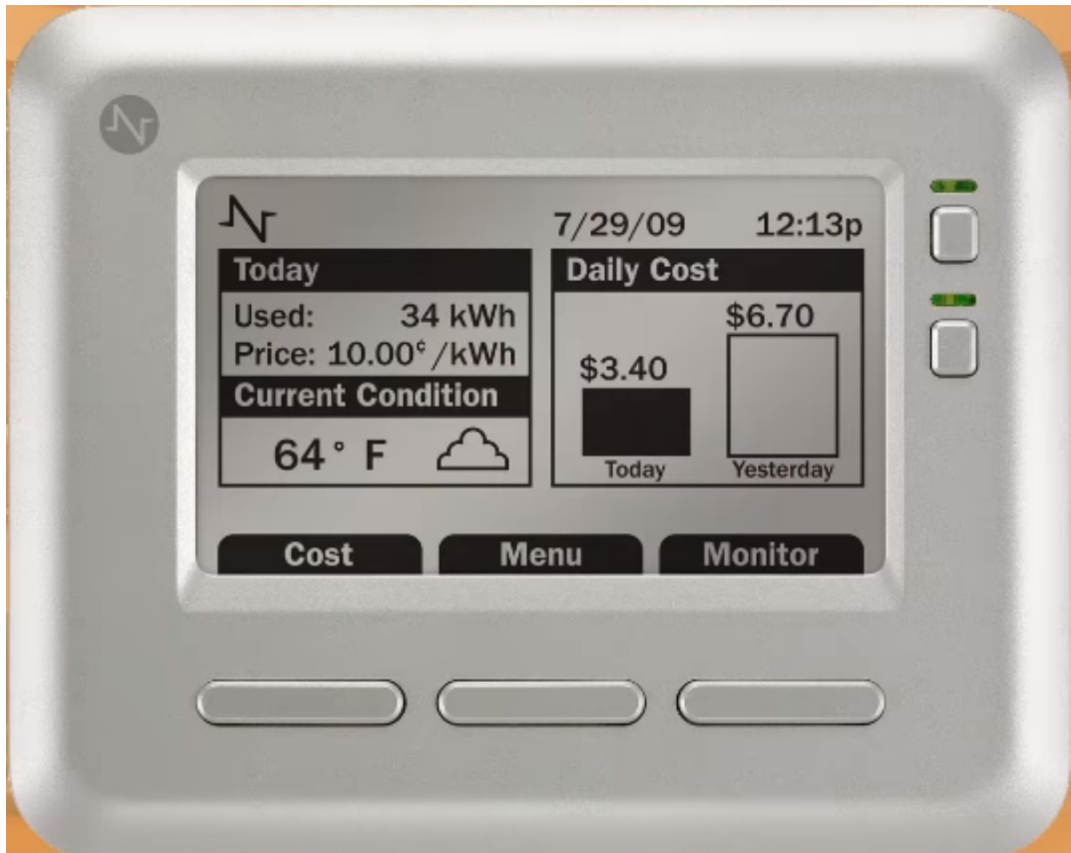
- Allows households to learn about electrical consumption by appliance, enabling better optimization

- 2 types of pricing events:

  - Day ahead (DA): notification one day prior of a $0.50 increase in per-kWh price of electricity (250% increase on base price of $0.20 per-kWh)

  - Thity minutes (TM): notification 30 minutes before a $1.25 increase in per-kWh price of electricity (625% increase on base price)

TABLE 1—TREATMENT EVENTS

Event date	Desc	Type	Start hour	High temp	Mean temp	Humidity
07/21/11	4 hr $0.50	DA	12	89	82	75
07/22/11	4 hr $1.25	TM	12	103	90	61
08/04/11	2 hr $0.50	DA	15	80	74	68
08/10/11	2 hr $1.25	TM	16	88	80	63
08/17/11	2 hr $1.25	TM	16	86	75	64
08/26/11	4 hr $0.50	DA	12	84	78	69

- Notification received via phone-call, email, or text messages

- Transmission of incentives via off-bill account credited with $100

- (Amount of electricity consumed during pricing event)∗(increase in price during pricing event) is subtracted from off-bill account, and remaining amount given to customer

4 Data

- High-frequency meter data on household electricity usage, collected in 15-minute intervals

- Data on receipt of event notification

- 2 surveys: demographics, housing unit characteristics, appliance ownership, conservation-related actions, tendency to be home during the day, frequency of use of IHD

- Technical software issue: random missing observations

- Balance seems good

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	Control		Price			Price + IHD		
	Mean	Obs.	Mean	Obs.	Difference	Mean	Obs.	Difference
Panel A. Initial group								
Off-peak usage (kWh/h)	1.230	207	1.282	130	0.052	1.225	100	−0.005
	(0.738)		(0.739)		(0.629)	(0.658)		(0.058)
Peak usage (kWh/h)	1.519	207	1.533	130	0.014	1.413	100	−0.106
	(1.197)		(1.036)		(0.109)	(0.984)		(0.772)
TOU Rate (1 = yes)	0.184	207	0.200	130	0.016	0.240	100	0.056
	(0.388)		(0.402)		(0.373)	(0.429)		(1.153)
Home ownership (1 = yes)	0.768	203	0.798	129	0.030	0.773	97	0.005
	(0.423)		(0.403)		(0.641)	(0.42)		(0.091)
Annual income ($1,000)	72.00	203	74.00	129	2.000	71.00	97	−0.001
	(29.00)		(29.00)		(0.690)	(31.00)		(0.181)
Home size (1,000 square feet)	1.529	189	1.880	119	0.351**	1.451	91	−0.078
	(1.10)		(1.83)		(2.100)	(1.14)		(0.550)
Age of home (years)	52.423	156	57.619	97	5.195	52.239	71	−0.184
	(30.29)		(31.34)		(1.309)	(26.94)		(0.044)
Panel B. Final group								
Off-peak usage (kWh/h)	1.232	203	1.297	124	0.065	1.229	72	−0.003
	(0.74)		(0.73)		(0.77)	(0.63)		(0.033)
Peak usage (kWh/h)	1.529	203	1.556	124	0.026	1.468	72	−0.061
	(1.20)		(1.04)		(0.20)	(0.99)		(0.389)
TOU Rate (1 = yes)	0.182	203	0.202	124	0.019	0.181	72	−0.002
	(0.39)		(0.40)		(0.43)	(0.39)		(0.032)
Home ownership (1 = yes)	0.774	199	0.821	123	0.047	0.855	69	0.081
	(0.42)		(0.39)		(1.01)	(0.355)		(1.439)
Annual income ($1,000)	72.00	199	75.00	123	0.003	76.00	69	0.004
	(29.00)		(20.00)		(0.93)	(28.00)		(1.006)
Home size (1,000 square feet)	1.541	185	1.908	114	0.367**	1.611	66	0.069
	(1.10)		(1.84)		(2.16)	(1.16)		(0.433)
Age of home (years)	52.221	154	56.574	94	4.354	53.375	56	1.154
	(30.43)		(31.02)		(1.09)	(28.59)		(0.247)

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- Attriton: 38 households did not complete: 4 control, 6 price-only, 28 price+IHD

- Estimate LPM of treatment indicator on mean off-peak usage and rate class; neither variable is significant

- Estimate LPM of compliance dummy on mean off-peak usage and rate class; rate class is significant, suggesting selective attrition

	Initial group		Compliers	
	Price	Price + IHD	Price	Price + IHD
Mean off peak kWh	0.021	−0.019	0.030	0.060
	(0.040)	(0.040)	(0.029)	(0.071)
TOU rate (1=yes)	0.010	0.088	−0.018	−0.263**
	(0.074)	(0.071)	(0.053)	(0.109)
F-statistic	0.206	0.775	0.579	2.915
p-value	0.814	0.462	0.562	0.059
Observations	337	307	130	100

5 Raw data and mean difference

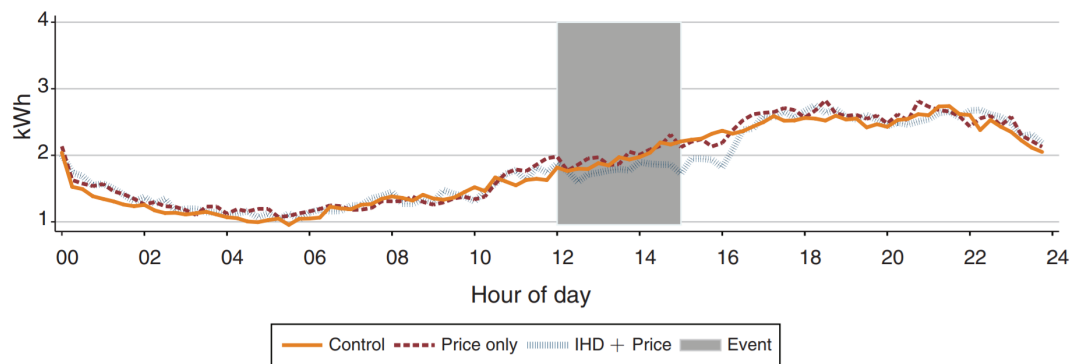- Price+IHD group consume less during pricing events relative to other groups

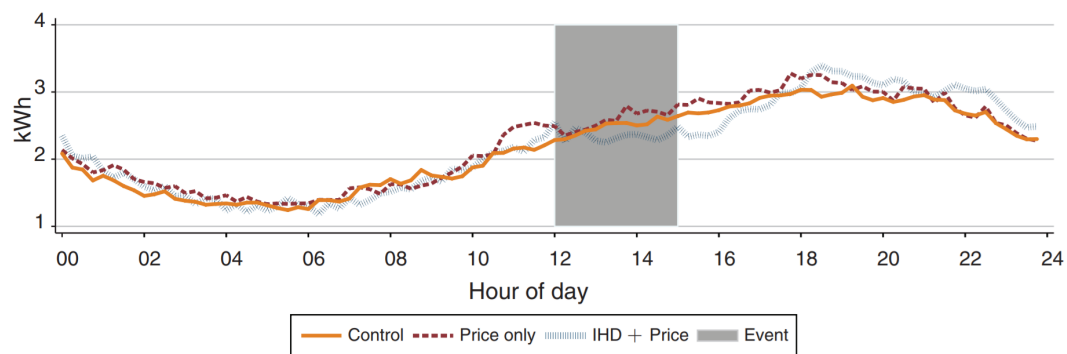FIGURE 1. JULY 21, 2011: 4HR $0.50 INCREASE, DAY-AHEAD NOTICE
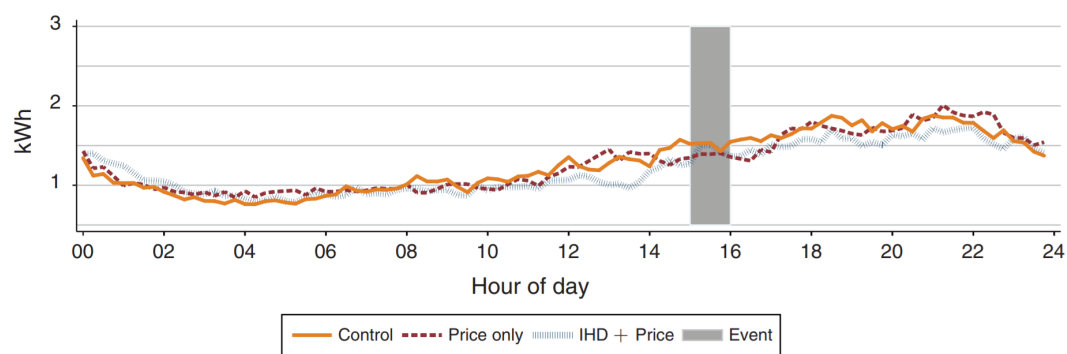
FIGURE 2. JULY 22, 2011: 4HR $1.25 INCREASE, 30-MIN NOTICE

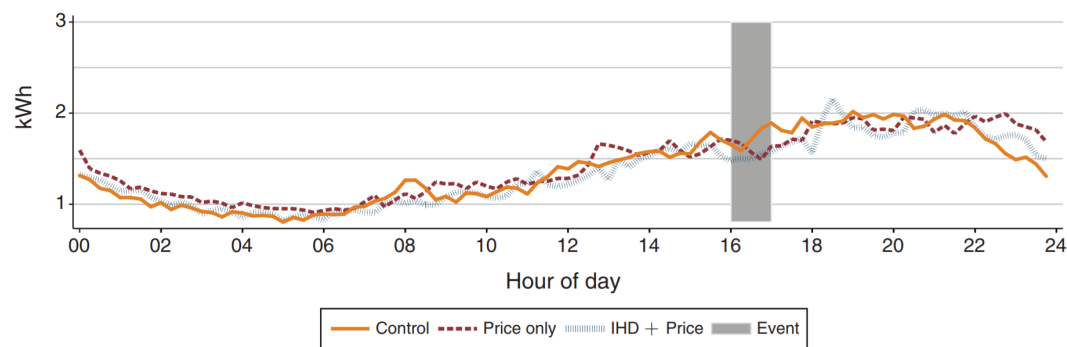FIGURE 3. AUGUST 4, 2011: 2HR $0.50 INCREASE, DAY-AHEAD NOTICE

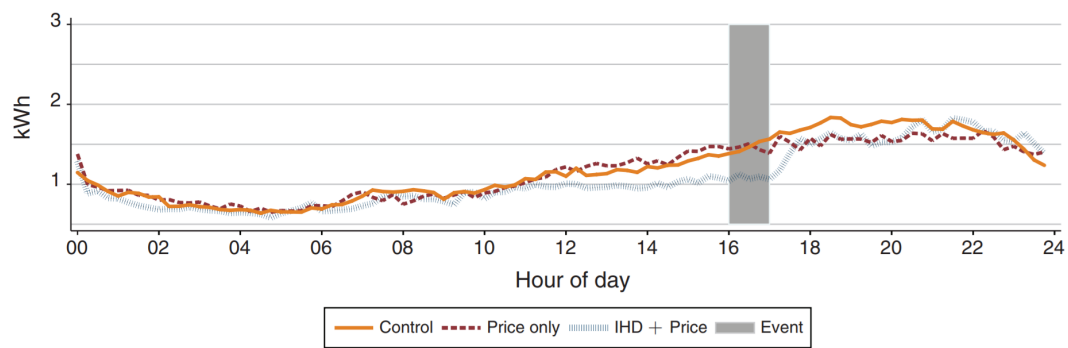FIGURE 4. AUGUST 10, 2011: 2HR $1.25 INCREASE, 30-MIN NOTICE

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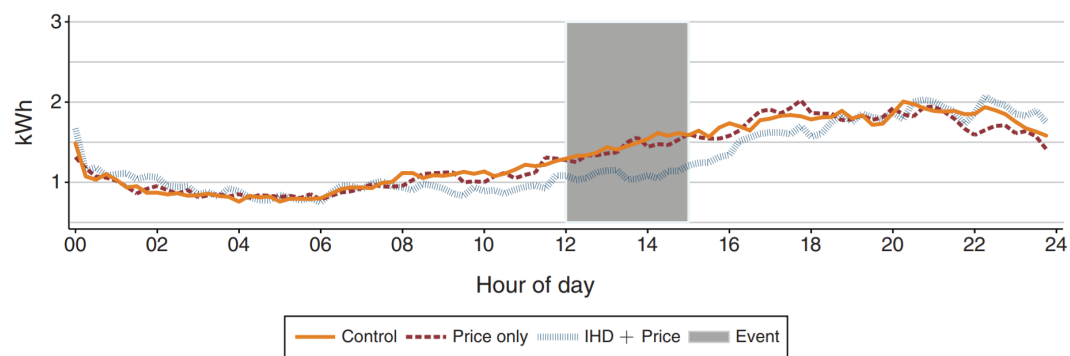FIGURE 5. AUGUST 17, 2011: 2HR $1.25 INCREASE, 30-MIN NOTICE

FIGURE 6. AUGUST 26, 2011: 4HR $0.50 INCREASE, DAY-AHEAD NOTICE

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TABLE 4—MEAN kWH DIFFERENCES (WRT CONTROL) BY TREATMENT GROUP

Event type	Variable	Mean kWh during events			Difference in mean kWh wrt control	
		Control	Price	Price + IHD	Price	Price + IHD
Sample: Unbalanced panel						
DA	Mean	1.65	1.59	1.35	−0.06	−0.30*
	SD	(1.51)	(1.25)	(1.22)		
	Obs	207	130	100		
TM	Mean	2.07	1.99	1.79	−0.07	−0.28
	SD	(1.77)	(1.54)	(1.42)		
	Obs	186	128	87		
Sample: Balanced panel						
DA	Mean	1.79	1.67	1.54	−0.13	−0.25
	SD	(1.56)	(1.13)	(1.24)		
	Obs	172	90	77		
TM	Mean	2.17	2.17	1.92	0.00	−0.25
	SD	(1.79)	(1.39)	(1.44)		
	Obs	172	90	77		

6 Results

6.1 Intent-to-treat (ITT)

- Simple DiD equation:

$$q_{it} = \sum_{g \in \{P, P+I\}} \beta_g D_{it}^g + \gamma_g + \delta_e + \mu_{it}$$

- Also include hour-by-calendar-date dummies and household fixed effects

6.2   Treatment effect on treated (TOT)

- Instrument for receipt of treatment using initial assignment

- Obtain slightly larger coefficients

- Arc elasticity: 0.12

Event type:	All (1)	All (2)	All (3)	All (4)	Day ahead (DA) (5)	30min (TM) (6)
Panel A. ITT unbalanced panel						
Price-only	−0.031	−0.054	−0.027	−0.038	−0.071*	0.006
	(0.036)	(0.036)	(0.036)	(0.036)	(0.042)	(0.044)
Price + IHD	−0.116**	−0.137***	−0.123***	−0.137***	−0.171***	−0.084
	(0.048)	(0.048)	(0.047)	(0.046)	(0.051)	(0.057)
Prob($P = P + I$)	0.096*	0.098*	0.051*	0.044**	0.066*	0.130
R^2	0.001	0.054	0.536	0.583	0.583	0.583
Panel B. ToT unbalanced panel						
Price-only	−0.032	−0.056	−0.028	−0.040	−0.074*	0.007
	(0.037)	(0.037)	(0.037)	(0.037)	(0.044)	(0.046)
Price + IHD	−0.143**	−0.170***	−0.153***	−0.170***	−0.217***	−0.100
	(0.058)	(0.058)	(0.057)	(0.057)	(0.064)	(0.067)
Prob($P = P + I$)	0.061*	0.052*	0.030**	0.023**	0.025**	0.115
R^2	0.001	0.054	0.536	0.583	0.583	0.583
HH FEs	No	No	Yes	Yes	Yes	Yes
Hour-by-day FEs	No	Yes	No	Yes	Yes	Yes
Number of events	6	6	6	6	3	3
Number of HHs	437	437	437	437	437	401

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6.3   Price events or learning?

- 2 possible channels via IHD: increase awareness of price events and learning

- To eliminate price channel, add confirmation of receipt of notification variable, interact with treatment dummies

- Estimation equation is

$$q_{it} = \sum_{g \in \{P,P+I\} A \in \{0,1\}} \beta_g D_{it}^g \times 1A_{it=A} + \gamma_i + \sigma_h + \mu_{it}$$

Event type:	All events (1)	DA events (2)	TM events (3)
Price $\times$ 1[Not confirmed]	-0.007	-0.043	0.038
	(0.048)	(0.066)	(0.057)
Price $+$ IHD $\times$ 1[Not confirmed]	-0.050	-0.104	0.037
	(0.080)	(0.087)	(0.110)
Price $\times$ 1[Confirmed]	-0.049	$-0.080*$	-0.005
	(0.040)	(0.046)	(0.051)
Price $+$ IHD $\times$ 1[Confirmed]	-0.162***	-0.192***	$-0.113*$
	(0.052)	(0.057)	(0.062)
p-value (PIHD $\times$ NC $=$ P $\times$ NC)	0.628	0.557	0.991
p-value (PIHD $\times$ C $=$ P $\times$ C)	0.047**	$0.073*$	0.120

- Conditional on confirmation of receipt, statistically significant difference between price-only and price+IHD group

- Conditional on non-confirmation of receipt, no statistically significant difference between price-only and price+IHD group

- Evidence against price event awareness

- Now interact treatment dummy with indicator variables for frequency of IHD interaction

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	Percent of HHs	All events	DA events	TM events
Price + IHD × 1[0/None]	4	−0.453** (0.196)	−0.690*** (0.181)	−0.161 (0.338)
Price + IHD × 1[1−2 times]	10	−0.013 (0.139)	−0.028 (0.137)	0.007 (0.160)
Price + IHD × 1[3−5 times]	8	0.02 (0.083)	−0.02 (0.083)	0.06 (0.091)
Price + IHD × 1[More than 5 times]	40	−0.248*** (0.077)	−0.279*** (0.085)	−0.204** (0.086)
Price + IHD × 1[Missing]	38	−0.023 (0.096)	−0.065 (0.095)	0.037 (0.119)
p-value (PIHD × >5 = PIHD × 1−2)		0.123	0.102	0.225
p-value (PIHD × >5 = PIHD × 3−5)		0.011**	0.017**	0.020**

- Higher frequency $\Rightarrow$ larger response

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7 Conservation

- Add indicator for periods 2 hours before and after price events

- Price+IHD has large decrease in these periods for DA events but price-only has no decrease for DA events

- Both price-only and price+IHD has no response for TM events

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	DA events	TM events
Price-only: 2hrs pre-event	0.002	0.053
	(0.038)	(0.038)
Price-only: 2hrs post-event	−0.043	−0.051
	(0.046)	(0.045)
Price + IHD: 2hrs pre-event	−0.097**	−0.024
	(0.042)	(0.045)
Price + IHD: 2hrs post-event	−0.103*	−0.027
	(0.054)	(0.056)

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- Evidence of habit formation: average daily decrease in usage for different times

$$q_{it} = \sum_g \beta_g D_{it}^g + \sum_g \sum_{hod} \lambda_{g,hod} \times D_i^g \times d + \gamma_i + \sigma_h + \mu_{it}$$

	Price	Price + IHD
12–1 PM Calendar day trend	−0.0023	−0.0030**
	(0.0016)	(0.0015)
1–2 PM Calendar day trend	−0.0024	−0.0027*
	(0.0015)	(0.0014)
2–3 PM Calendar day trend	−0.0025*	−0.0032**
	(0.0014)	(0.0013)
3–4 PM Calendar day trend	−0.0027*	−0.0031**
	(0.0014)	(0.0013)
4–5 PM Calendar day trend	−0.0033**	−0.0034***
	(0.0014)	(0.0013)
5–6 PM Calendar day trend	−0.0032**	−0.0033**
	(0.0014)	(0.0013)
6–7 PM Calendar day trend	−0.0038**	−0.0032**
	(0.0015)	(0.0014)
7–8 PM Calendar day trend	−0.0037**	−0.0029**
	(0.0017)	(0.0015)

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- Three observations

– Attenuation of main effect estimate: reduction in baseline usage to which event-period effects are compared. Also, spillovers larger for price+IHD group: even larger effect of information feedback on price elasticity

– Cumulative response similar irrespective of information feedback, but feedback may allow better response to short-run incentives

– Habit formation similar for both price-only and price+IHD groups, leading to large GHG abatement benefits