Default Effects And Follow-On Behavior: Evidence From An Electricity Pricing Program

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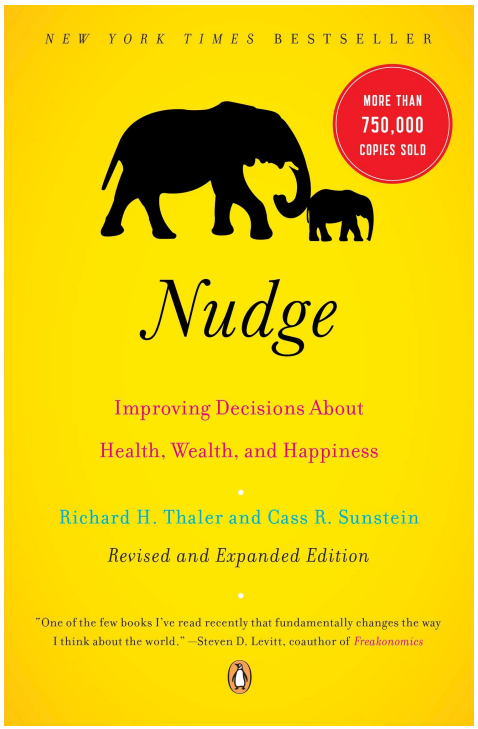
Nov. 23, 2017

Where We Stand



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   - Choice: You have A, I offer you B.
   - Opt-in: A is the default. No answer implies A.
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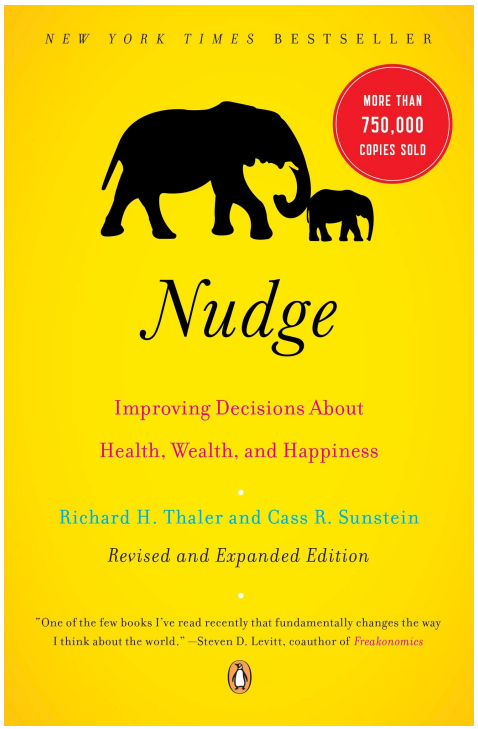

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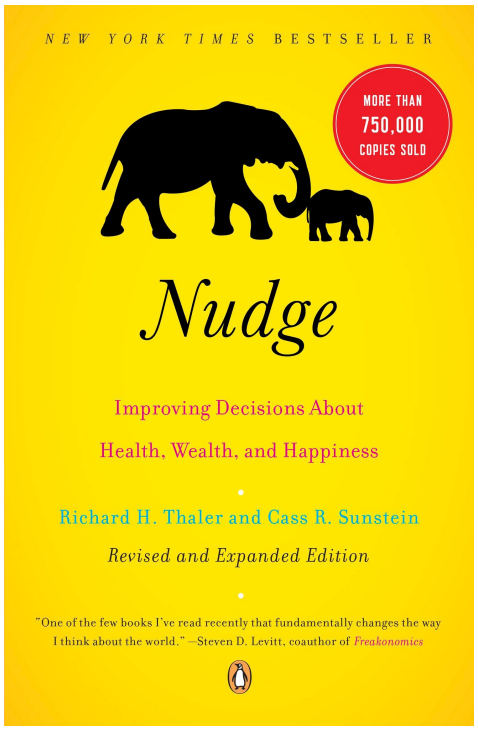

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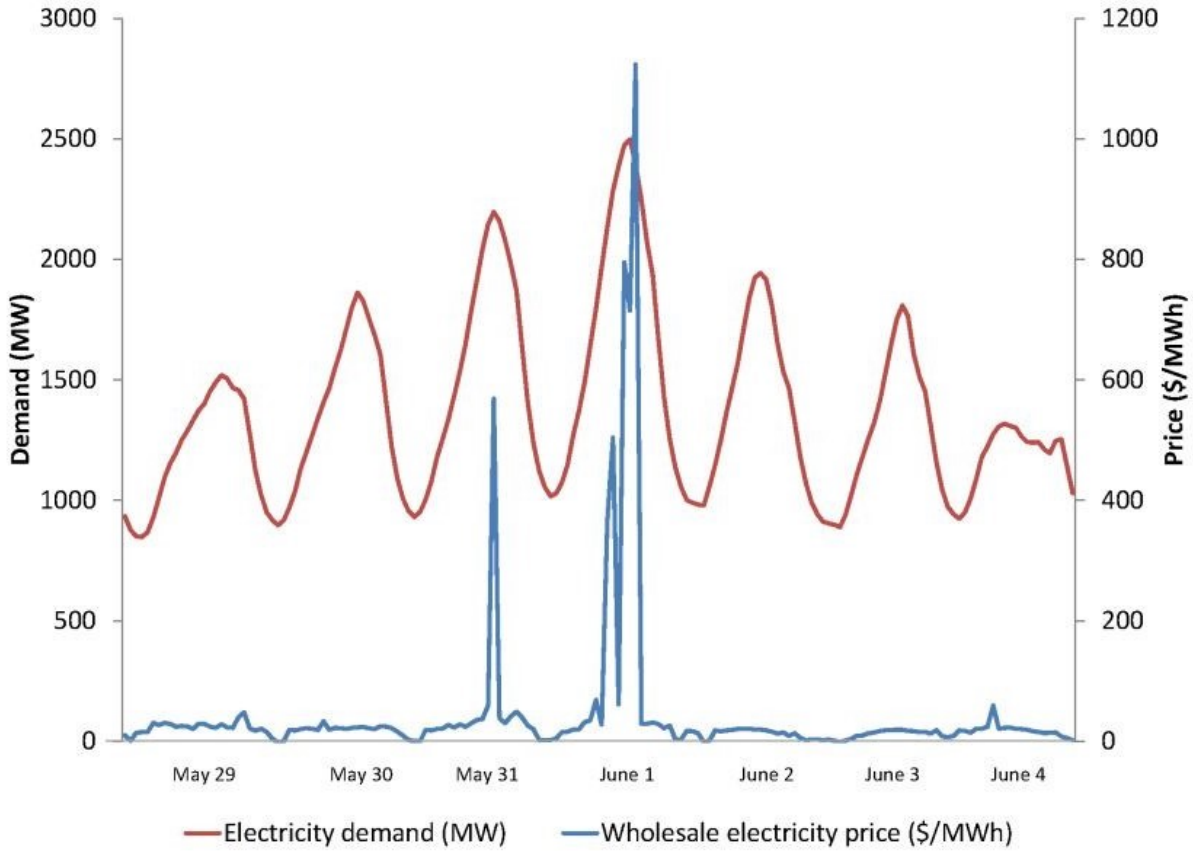
2. What we know: people are very passive.
3. What we don't know: what happens then?
   - Do people change their initial "choice"?
   - Do defaults lead to long-term behavioral change?
   - Do active and passive adopters react differently?

Electricity Market



- *Peaking plants* run only several hours per year and are very costly.
- Peak demand is a challenge for grid management.
- Standard electricity plans have uniform prices.

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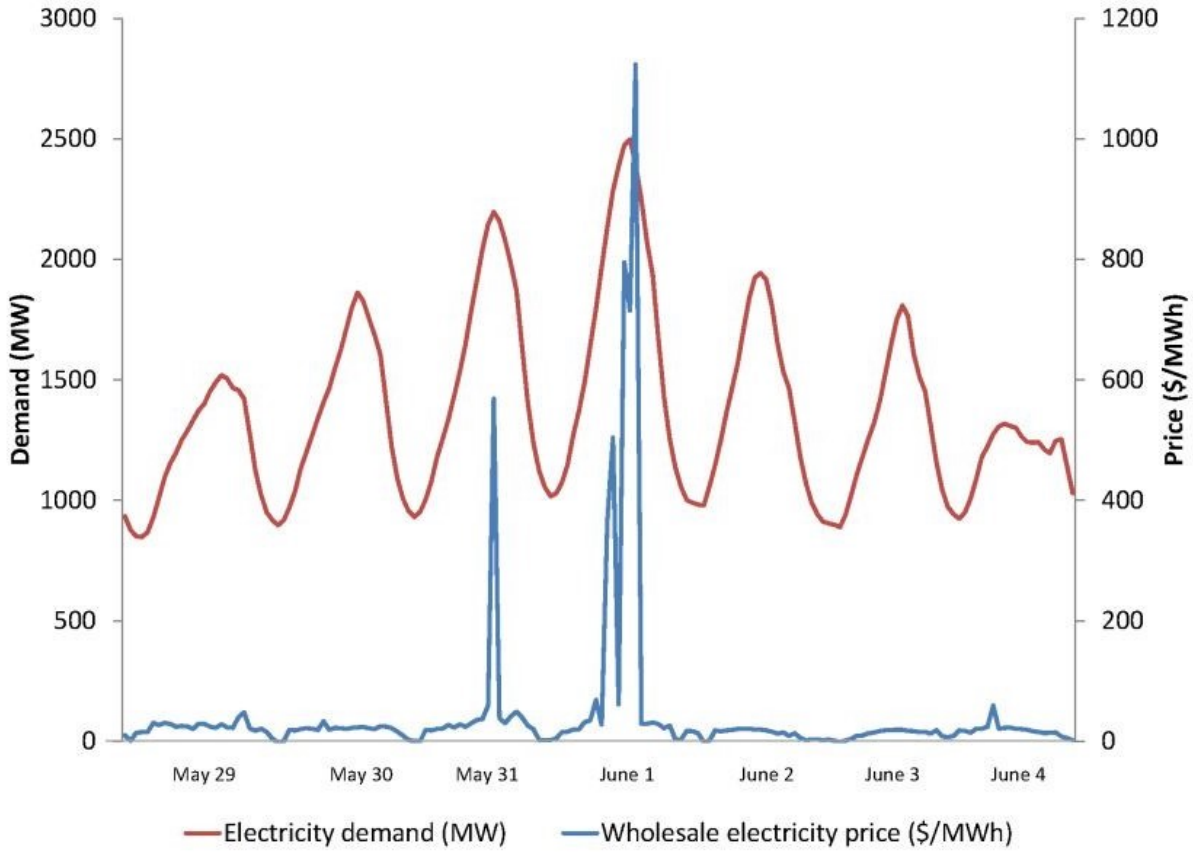

- *Peaking plants* run only several hours per year and are very costly.
- Peak demand is a challenge for grid management.
- Standard electricity plans have uniform prices.
- Variable price plans exist, but nobody signs up.

This Study

- Field-experiment in Sacramento, California, June 2011 – September 2013.
- Sacramento Municipal Utility District (SMUD)
- Randomize access to a new, variable price plan.
- Experimental groups
  - Control
  - T1: Variable Price Plan + Opt-in
  - T2: Variable Price Plan + Opt-out
- Data
  - Initial and later plan choices
  - Hourly electricity consumption
  - Billing data

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- Contribution
  1. Stickiness of the initial "choice"
  2. Long-term impact of the initial "choice"
  3. Differences between active and passive adopters

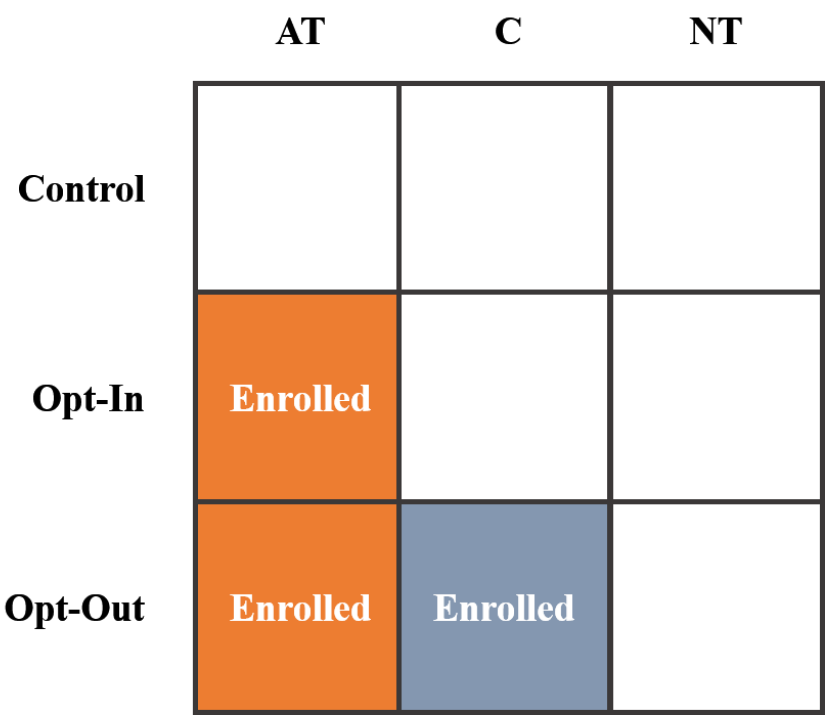
Pricing Plans, Recruitment, Real-time Feedback

		Control	Treatment (CPP)	
Panel A: Plan Details				
Regular day	0 - 700 kWh	9.38	8.51	
(¢ per kWh)	> 700 kWh	17.65	16.65	
Event day (4.00 - 7.00 PM)		-	75.00	
Panel B: Recruitment and Feedback				
Recruitment method		No	Two mail packages, door hangers, phone calls	
Real-time feedback		No	Offered	
			Opt-In	**Opt-Out**
No response by customer		-	Control plan	Treatment plan
Households		45,839	9,190	846

Notes:

- CPP rates apply between June 1 and September 30 from 2012 to 2013.
- Event-Day consumption does not count into Non-Event-Day 700 kWh.
- Event days announced at least one day in advance. The total number of event days was 12 in 2012.
- CPP rates designed to be revenue neutral assuming random choice and no demand response.

Why Control, Opt-in and Opt-out?



▸ Derivations and Estimators

Types

- Active adopters (AT)
- Passive adopters (C)

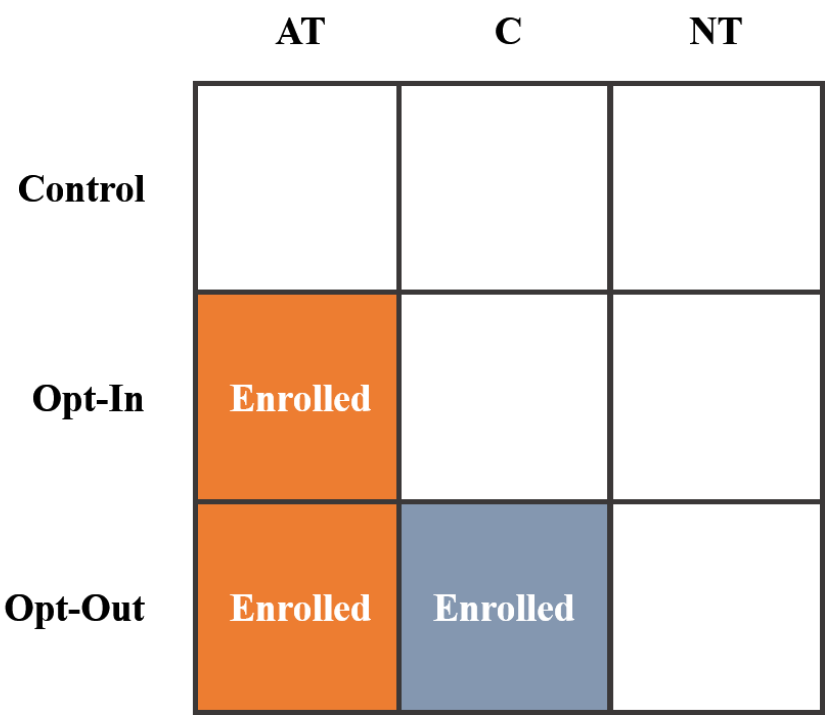
Average Reduction of AT

- Difference between Control and Opt-in
- Rescale by share enrolled under opt-in.

Average Reduction of C

- Difference between Opt-in and Opt-out.
- Rescale by difference in shares enrolled under opt-in and opt-out.

Why Control, Opt-in and Opt-out?



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Average Reduction of C

- Difference between Opt-in and Opt-out.
- Rescale by difference in shares enrolled under opt-in and opt-out.

Design contribution Average reduction of active and passive adopters identifiable.

Parameters of Interest

1. Variables
   - y_{it} electricity consumption (by hour or month) or total bill size per month.
   - $A_{it} = 1$ if i had *access* to treatment and t is post June 1, 2012.
   - $D_{it} = 1$ if i *enrolled* to treatment and t is post June 1, 2012.

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$$y_{it} = \beta_{ITT} A_{it} + \gamma_i + \delta_t + \varepsilon_{it}$$

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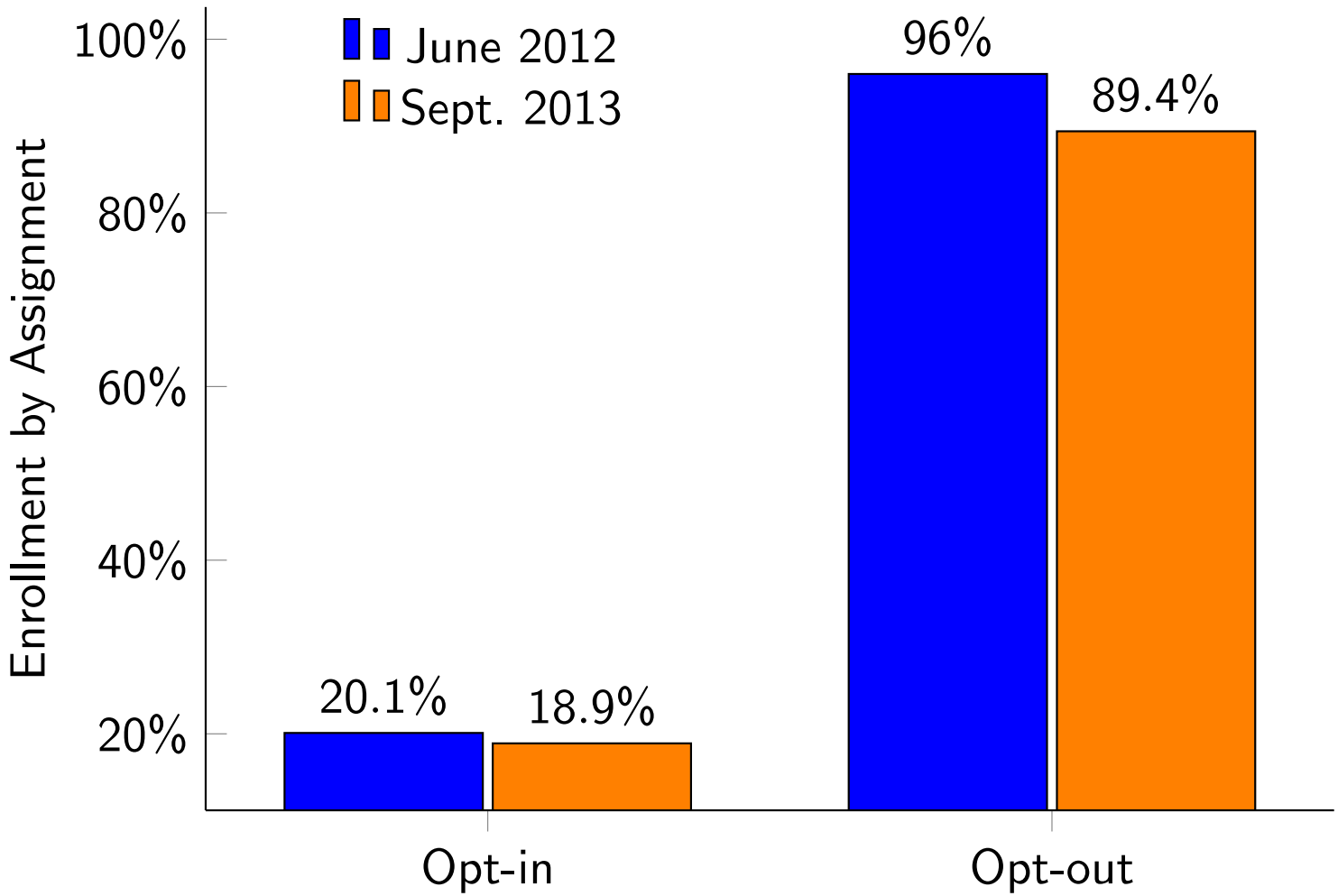
3. LATE (or IV DiD)

$$D_{it} = \lambda A_{it} + \mu_i + \nu_t + \omega_{it} \qquad \text{(First Stage)}$$
$$y_{it} = \beta_{LATE} D_{it} + \gamma_i + \delta_t + \varepsilon_{it} \qquad \text{(Second Stage)}$$

4. Response by behavioral type

Results

Default Effect



Results

1. Default effect: Strong and stable over time.

ITT: What would the utility company prefer?

	Critical event		Non-event peak	
	Opt-in	Opt-out	Opt-in	Opt-out
Encouragement (CPP)	−0.129***	−0.305***	−0.029***	−0.094***
	(0.010)	(0.037)	(0.006)	(0.020)
Mean usage (kW)	2.49	2.5	1.8	1.8
Customers	55,028	46,684	55,028	46,684
Customer-hours	4,832,874	4,104,263	31,198,201	26,495,612

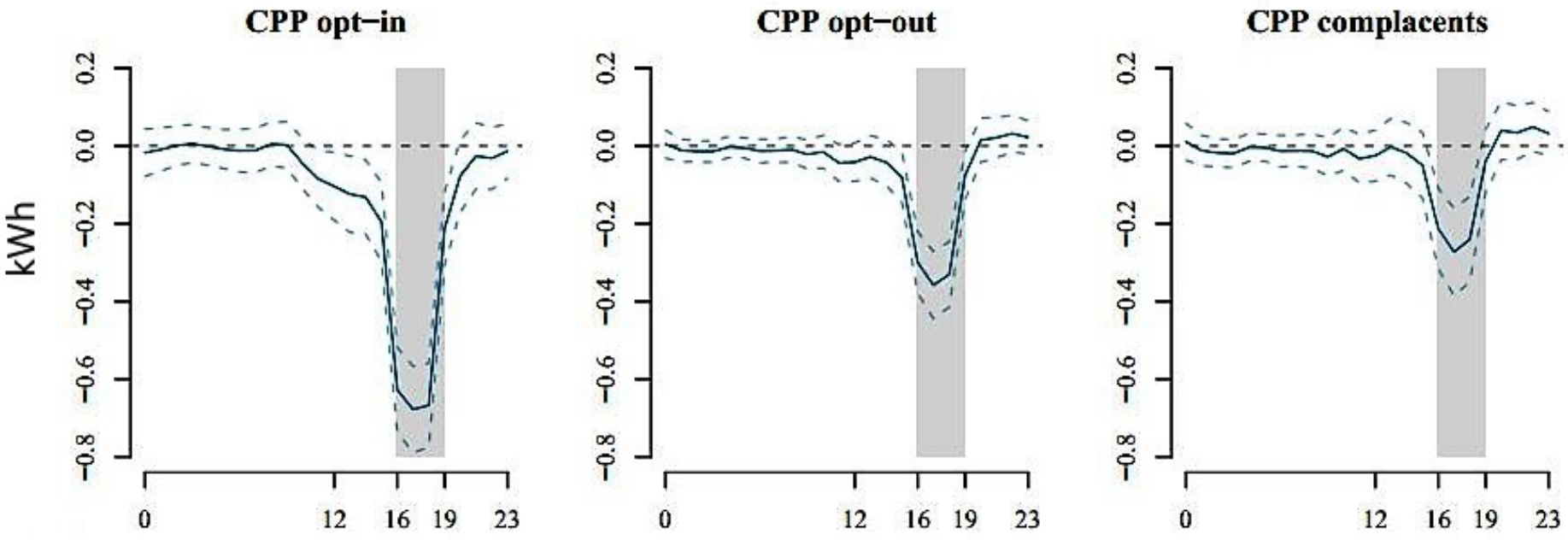
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, standard errors clustered by customer.

▸ Cost-Benefit Analysis

Results

1. Default effect: Strong and stable over time.
2. ITT: Larger total savings under opt-out + spillover to regular days.

LATE by Hour on Event Days



Results

1. Default effect: Strong and stable over time.
2. ITT: Larger total savings under opt-out + spillover to regular days.
3. LATE by hour: Reduction concentrated on event-window + stronger for active adopters.

LATE by Type

	Critical event hours			Non-event day peak hours		
	Opt-in (AT)	Opt-out (AT+C)	Complacents (C)	Opt-in (AT)	Opt-out (AT+C)	Complacents (C)
Treatment (CPP)	−0.664***	−0.323***	−0.233***	−0.145***	−0.102***	−0.059***
	(0.052)	(0.041)	(0.053)	(0.031)	(0.022)	(0.018)
Mean usage (kW)	2.51	2.51	2.46	1.79	1.79	1.75

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, standard errors clustered by customer.

▸ Heterogeneous Effects ▸ Exclusion Restriction ▸ Randomization check

Conclusion

1. Do people change their initial "choice"?
   - No, less than 10% return to their previous plan.
2. Do defaults lead to long-term behavioral change?
   - Yes, active and passive adopters reduce their electricity consumption.
   - Spillover to regular days.
3. Do active and passive adopters react differently?
   - Active adopters react 2-3 times stronger to the incentives than passive adopters.

References

Fowlie et al. (2017). Default Effects and Follow-On Behavior: Evidence from an Electricity Pricing Program. *NBER Working Paper 23553*, Version: June 2017.

Madrian, B. C., & Shea, D. F. (2001). The power of suggestion: Inertia in 401 (k) participation and savings behavior. *The Quarterly Journal of Economics*, 116(4), 1149-1187.

Results

1. Default effect: Strong and stable over time.
2. ITT: Larger total savings under opt-out + spillover to regular days.
3. LATE by hour: Consumption change concentrated on event-window.
4. LATE by type: ATs save three times as much as Cs on event days.

Bill amount

Table 5: Bill impacts of enrollment

	Opt-in (AT)	Opt-out (AT+C)	Complacents (C)
Treatment (CPP)	−6.515***	−4.499***	−3.121**
	(2.358)	(1.428)	(1.485)
Mean bill ($)	114	114	114
Customers	55,029	46,685	10,036
Customer-months	552,087	468,843	100,552

* p < 0.05, ** p < 0.01, *** p < 0.001, standard errors clustered by customer.

Heterogeneous Effects

	Critical event hours		
	Opt-in (AT)	Opt-out (AT+C)	Complacents (C)
My Account			
Treatment (CPP)	−0.600***	−0.225***	−0.151***
	(0.080)	(0.045)	(0.056)
× My Account	−0.108	−0.251***	−0.238**
	(0.104)	(0.085)	(0.117)
Low income			
Treatment (CPP)	−0.815***	−0.370***	−0.267***
	(0.066)	(0.047)	(0.060)
× Low income	0.543***	0.176**	0.104
	(0.098)	(0.089)	(0.125)
Year 2			
Treatment (CPP)	−0.714***	−0.298***	−0.186***
	(0.054)	(0.043)	(0.056)
× Year 2	0.126**	−0.069*	−0.124**

Return to Average Effects

Household Characteristics by Customer Type

Table 7: Household characteristics by customer type

	AT	C	NT	AT-C	AT-NT	C-NT
CPP households						
Daily usage	27	27	27	[0.81]	[0.95]	[0.98]
	(16)	(18)	(25)			
Peak to off-peak	1.77	1.78	1.79	[0.62]	[0.76]	[0.99]
	(0.56)	(0.57)	(0.55)			
Bill amount	106	110	113	[0.42]	[0.59]	[0.83]
	(77)	(90)	(132)			
Structural winner (CPP)	0.50	0.52	0.49	[0.34]	[0.87]	[0.51]
	(0.50)	(0.50)	(0.50)			
Structural winner (TOU)	0.35	0.34	0.33	[0.73]	[0.54]	[0.70]
	(0.48)	(0.48)	(0.47)			
My Account	0.54	0.42	0.52	[0.00]	[0.64]	[0.03]
	(0.50)	(0.49)	(0.50)			
My Account logins	9.16	6.65	11.81	[0.00]	[0.30]	[0.04]
	(23.00)	(2.86)	(28.35)			
Paperless	0.24	0.19	0.18	[0.02]	[0.12]	[0.80]
	(0.43)	(0.40)	(0.39)			
Low income	0.29	0.19	0.15	[0.00]	[0.00]	[0.32]
	(0.45)	(0.40)	(0.36)			

Test of the Exclusion Restriction

- Diff-in-diff estimation comparing the control group and those assigned but not enrolled in treatment.
- Tests if encouragement to enroll affects electricity consumption via channels independent of enrollment.

Table A4: Exclusion restriction test

	Critical event		Non-event peak	
	Opt-in	Opt-out	Opt-in	Opt-out
Encouragement (CPP)	−0.012	0.027	−0.003	−0.016
	(0.010)	(0.109)	(0.007)	(0.095)
Bound of bias	−0.0614	0.0048	−0.0151	−0.0030
Mean usage (kW)	2.52	2.52	1.8	1.79
Customers	53,381	45,867	53,381	45,867
Customer-hours	4,675,263	4,031,723	30,179,735	26,026,802

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, standard errors clustered by customer.

Randomization check

Table 1: Comparison of means by treatment assignment

	Control group	Treatment groups: CPP		TOU	
		Opt-in	Opt-out	Opt-in	Opt-out
Daily usage (kWh)	26.6	26.8	26.9	26.5	26.4
		(-0.818)	(-0.452)	(0.825)	(0.713)
Peak to off-peak ratio	1.77	1.77	1.78	1.78	1.78
		(0.017)	(-0.503)	(-0.565)	(-0.374)
Bill amount ($)	109	109	109	108	108
		(-0.342)	(-0.006)	(1.08)	(0.687)
Structural winner (CPP)	0.509	0.512	0.516	0.51	0.502
		(-0.51)	(-0.389)	(-0.112)	(0.703)
Structural winner (TOU)	0.343	0.344	0.346	0.341	0.332
		(-0.133)	(-0.145)	(0.411)	(1.14)
My Account	0.425	0.43	0.442	0.432	0.419
		(-0.78)	(-0.974)	(-1.26)	(0.591)
My Account logins	6.71	7.09	7.14	6.82	6.35
		(-0.823)	(-0.428)	(-0.249)	(0.565)
Paperless	0.209	0.209	0.204	0.208	0.193
		(0.128)	(0.351)	(0.286)	(2.01)
Low income	0.194	0.196	0.21	0.2	0.2
		(-0.247)	(-1.13)	(-1.38)	(-0.697)
Households	45,839	9,190	846	12,735	2,407

◀ Return to Average Effects

Cost-Benefit Analysis

Table 6: Cost-effectiveness

	Benefits		Costs				Benefits - Costs
	Avoided Capacity	Avoided Energy	One-time Fixed Costs	One-time Variable Costs	Recurring Annual Total Costs	10-year NPV	
CPP opt-in	44.0	0.9	1.4	31.0	0.9	36.5	8.4
CPP opt-out	92.1	2.1	1.4	21.0	3.1	38.8	55.4

Notes: Table estimates cost-effectiveness of each treatment group. All figures in millions of dollars and assume the program is scaled to SMUD's whole residential customer base and run for 10 years. See Appendix section 5 for details.

Return to ITT Estimates

Derivation of LATE Estimators for Complacents and Always Takers

Assumptions

- Unconfoundedness
- Stable unit treatment effect
- Exclusion restriction
- Instrument monotonicity

Average consumption by assignment

$$E\left[Y_i|\text{ Control}\right] = \pi^{NT} E\left[Y_i(0)|NT\right] + \pi^{C} E\left[Y_i(0)|C\right] + \pi^{AT} E\left[Y_i(0)|AT\right]$$
$$E\left[Y_i|\text{ Opt-in}\right] = \pi^{NT} E\left[Y_i(0)|NT\right] + \pi^{C} E\left[Y_i(0)|C\right] + \pi^{AT} E\left[Y_i(1)|AT\right]$$
$$E\left[Y_i|\text{Opt-out}\right] = \pi^{NT} E\left[Y_i(0)|NT\right] + \pi^{C} E\left[Y_i(1)|C\right] + \pi^{AT} E\left[Y_i(1)|AT\right]$$

LATE estimates

$$LATE^{AT} = E\left[Y_i(0) - Y_i(1)|AT\right] = \frac{1}{\pi^{AT}}\left(E\left[Y_i|\text{Control}\right] - E\left[Y_i|\text{Opt-in}\right]\right)$$
$$LATE^{C} = E\left[Y_i(0) - Y_i(1)|C\right] = \frac{1}{\pi^{C}}\left(E\left[Y_i|\text{Opt-in}\right] - E\left[Y_i|\text{Opt-out}\right]\right)$$

Return to Default Option Comparison

Institutional Background

- Smart Grid Investment Grand program (SGIG)
  1. Goal: fund studies of time-based rate programs.
  2. Requirement: RCTs.
- Sacramento Municipal Utility District (SMUD)
  1. 530,000 households in Sacramento, California.
  2. Demand response programs existed before SGIG, but low participation.
  3. Invested in a smart grid in the past, wants to reap benefits.
- Eligible population
  1. Smart-meter installed one year prior to June 2012.
  2. No participation in existing demand response programs.
  3. 170,000 eligible households.