Behavioral Energy Economics

Course on Energy Economics

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Motivation

- Why dig deeper to understand behavior?
- Our models often fail, even in well-functioning markets
- Challenge the notion of "rational" agents
- Concepts originally from psychology applied to economics

Topics in Behavioral and Energy Economics

- **Myopia** (short-sightedness)
- **Prospect Theory**
- **Rebound Effect**
- **Peer Effects**
- **Inattentiveness and Salience**
- **Social Norms**

Myopia (short-sightedness)

For non-myopic individuals:

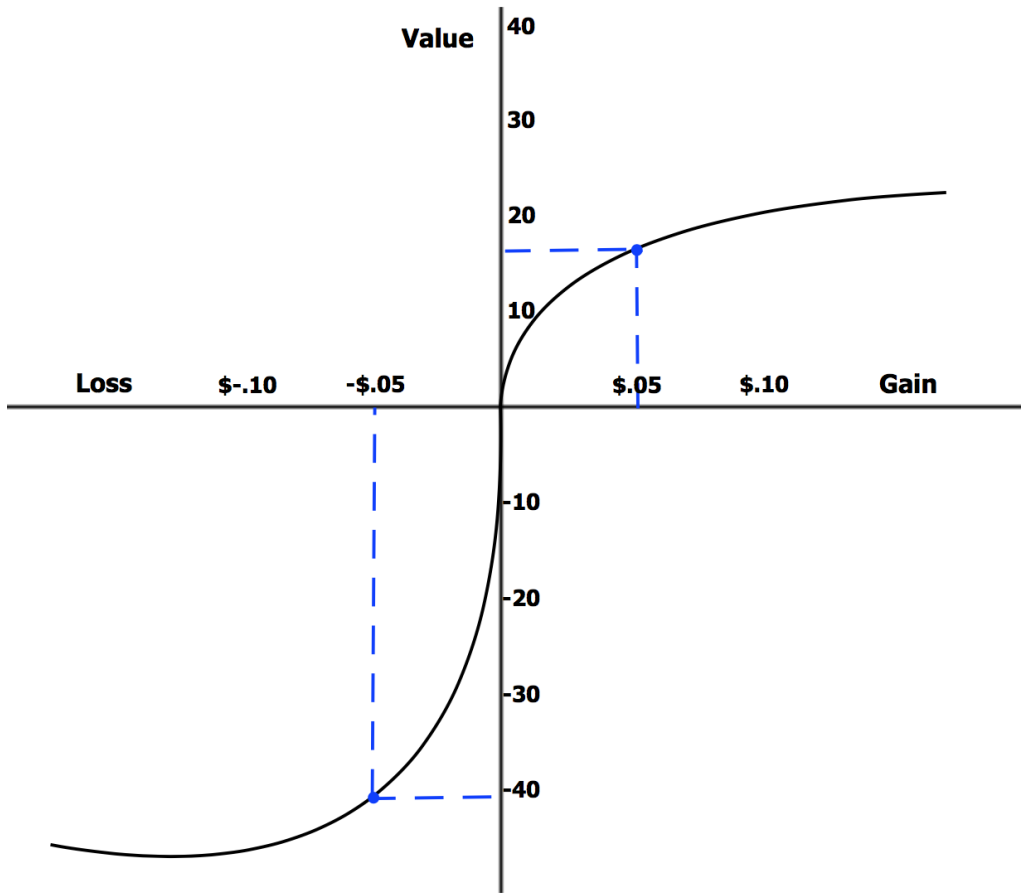
- *"an increase in the expected future usage cost of a durable good should not change consumers' total willingness-to-pay for the good"*
- *"if the usage cost component of the total cost rises, the up-front cost must fall by an equal amount"*

- "Are Consumers Myopic? Evidence from New and Used Car Purchases." Busse, Knittel, and Zettelmeyer (2013)
  - Find relatively small discount rates
  - implicit discount rates comparable to interest rates from car financing (not too myopic)

- "Consumer myopia, imperfect competition and the energy efficiency gap: Evidence from the UK refrigerator market." Cohen, Glachant, and Söderberg (2017)
  - Consumers underestimate future energy savings by 35%
  - Myopia increases energy use by only 9.2%

Prospect Theory

- "Prospect Theory: An Analysis of Decision under Risk." Kahneman and Tversky (1979)
  - Challenges expected utility theory: Individuals assess losses and gains asymmetrically
  - "Loss aversion"



Prospect Theory

- "Prospect theory and energy efficiency." Heutel (2019)
  - Test whether prospect theory explains consumers' investments in energy efficiency
  - Choice experiment
  - Finds a negative correlation between an individual's level of loss aversion and several energy efficiency investments

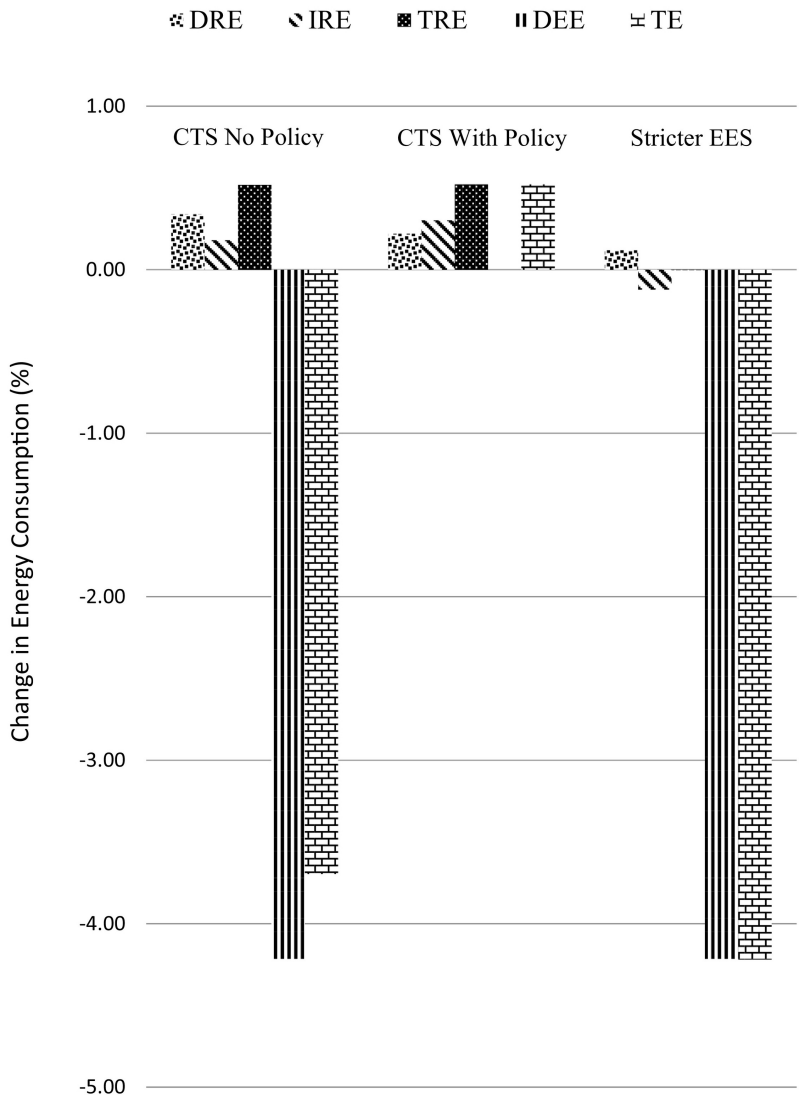
- Aside: Stated Preference vs. Revealed Preference

Rebound Effect

"Costs of energy efficiency mandates can reverse the sign of rebound." Fullerton and Ta (2020)

- Direct efficiency effect (DEE)
- Direct rebound effect (DRE)
  - people use the good more often or more intensely
- Indirect rebound effect (IRE)
  - e.g. energy efficiency frees up income used to purchase/use other energy goods

Rebound Effect



DRE: Direct Rebound Effect
IRE: Indirect Rebound Effect
TRE: Total Rebound Effect

DEE: Direct Efficiency Effect
TE: Total Energy

Peer Effects

"Peer Effects in the Diffusion of Solar Photovoltaic Panels." Bollinger and Gillingham (2012)

Table 9 First-Differenced Street-Level Model

	FD 1	FD 2
Number of previous installations on street	0.127	0.151
	(0.011)	(0.012)
Zip code installed base (100s)	0.074	Street-specific
	(0.046)	
Street-quarter effects	Y	Y
Month of year indicators	Y	Y
Street indicators interacted with month of year indicators	Y	Y
Street indicators interacted with zip installed base	N	Y
R-squared	0.275	0.327
N	7,585	7,585

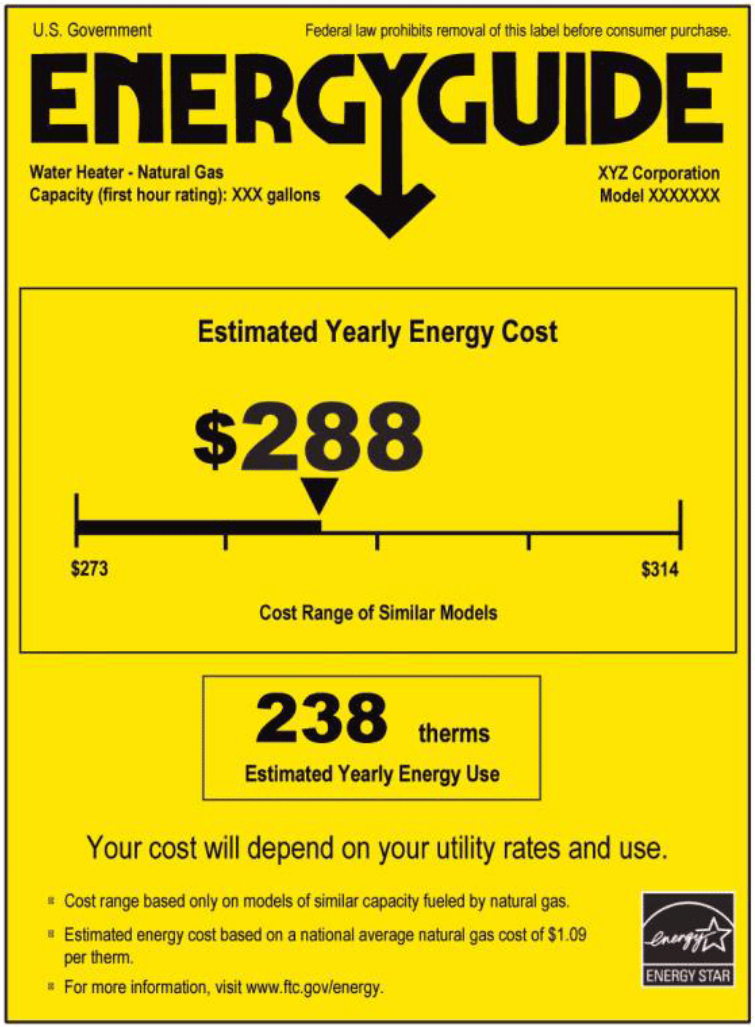
Notes. The unit of observation is zip code-month. Robust standard errors are in parentheses.

Inattentiveness and Salience

- "Are Home Buyers Inattentive? Evidence from Capitalization of Energy Costs." Myers (2019)
  - Strongly rejects that home buyers are unresponsive to energy costs

Inattentiveness and Salience

- "Does Better Information Lead to Better Choices? Evidence from Energy-Efficiency Labels." Davis and Metcalf (2016)



Social Norms

- Compare own energy usage to those of peers/neighbors
- Home energy reports (HER); standard residences:
  - Allcott (2011): Promote reduction of 2% of energy usage.
  - Allcott and Rogers (2014): Effects persist, decaying at 10-20% per year.
  - Brandon et al. (2017): 43-55% of savings persist, mostly attributed to physical capital investments.
- Campus Setting:
  - Delmas and Lessem (2014) compare private information vs. public displays (posters) of "bad" (above average) and "good" consumers. Large users reduced up to 20%, with most coming from heating/cooling.

An Application

"Social comparison nudges without monetary incentives: Evidence from home energy reports." Myers and Souza (2020)

Research Questions:

- Can behavioral nudges promote energy conservation in a campus setting?
  - When consumers do not (directly) pay for their energy?
  - Where they cannot make physical capital investments to their dwellings?
  - Specifically looking at heating/cooling.
  - How/why are the effects different from a standard residential context?

Conceptual Framework

"The Welfare Effects of Nudges: A Case Study of Energy Use Social Comparisons." Allcott and Kessler (2019)

$$\max_{x,e} U(\theta) = x + \hat{f}(e; \alpha, \gamma) + (m - \mu e)$$

$$\text{subject to: } y \geq x + e p_e$$

- x is a numeraire good; y is income
- $\hat{f}$ perceived utility from consumption of energy e
- α is consumer heterogeneity
- γ incorporates behavioral biases, inattention, or lack of information
- $(m - \mu e)$ is "moral utility"
- m is energy-independent (dis)utility from the nudges
- μ represents a "moral tax"
- p_e is price of energy

Conceptual Framework

- Budget Constraint:

$$y \geq x + ep_e \quad \text{(Standard residential)}$$

$$y - E \geq x \quad \text{(Campus housing)}$$

- First Order Condition:

$$f'(e; \alpha, \gamma) = \mu + p_e \quad \text{(Standard residential)}$$

$$f'(e; \alpha, \gamma) = \mu \quad \text{(Campus housing)}$$

- Equilibrium energy consumption:

$$\Rightarrow e^*(\alpha, \gamma, \mu) \geq e^*(\alpha, \gamma, \mu, p_e)$$

Experimental Design

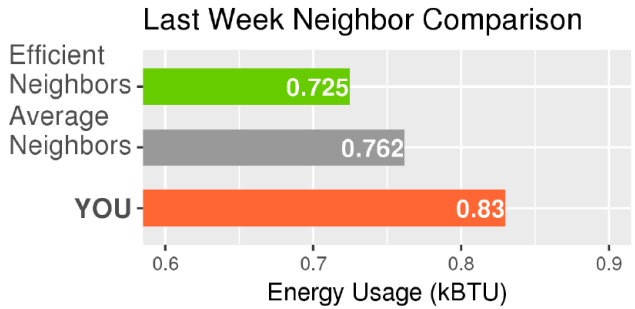
You used 8.95% more energy than average neighbors last week.

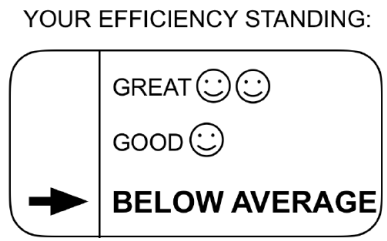
Heating/Cooling Energy Report [redacted]

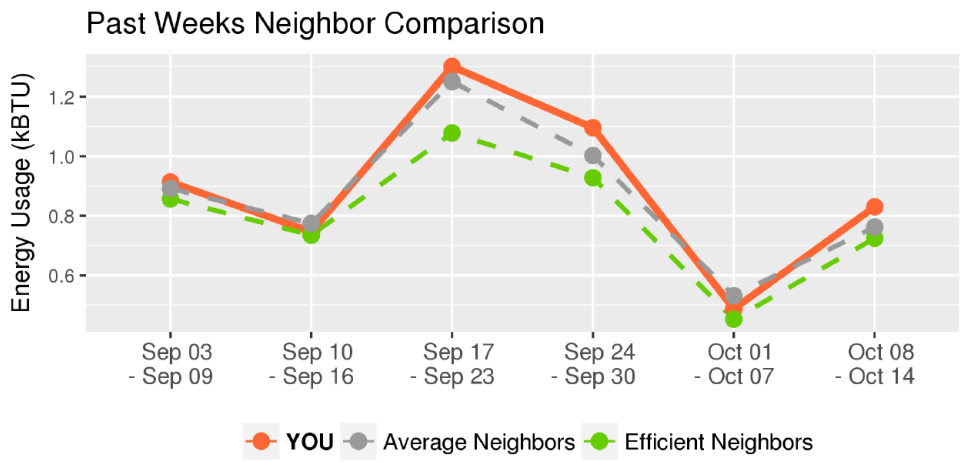
Sent [redacted]

To: [redacted]

The following reports are based on thermostat setpoints in your room.







Energy saving tips:

In **HOT** days, turn your thermostat **UP** before going to sleep or when you leave the room.

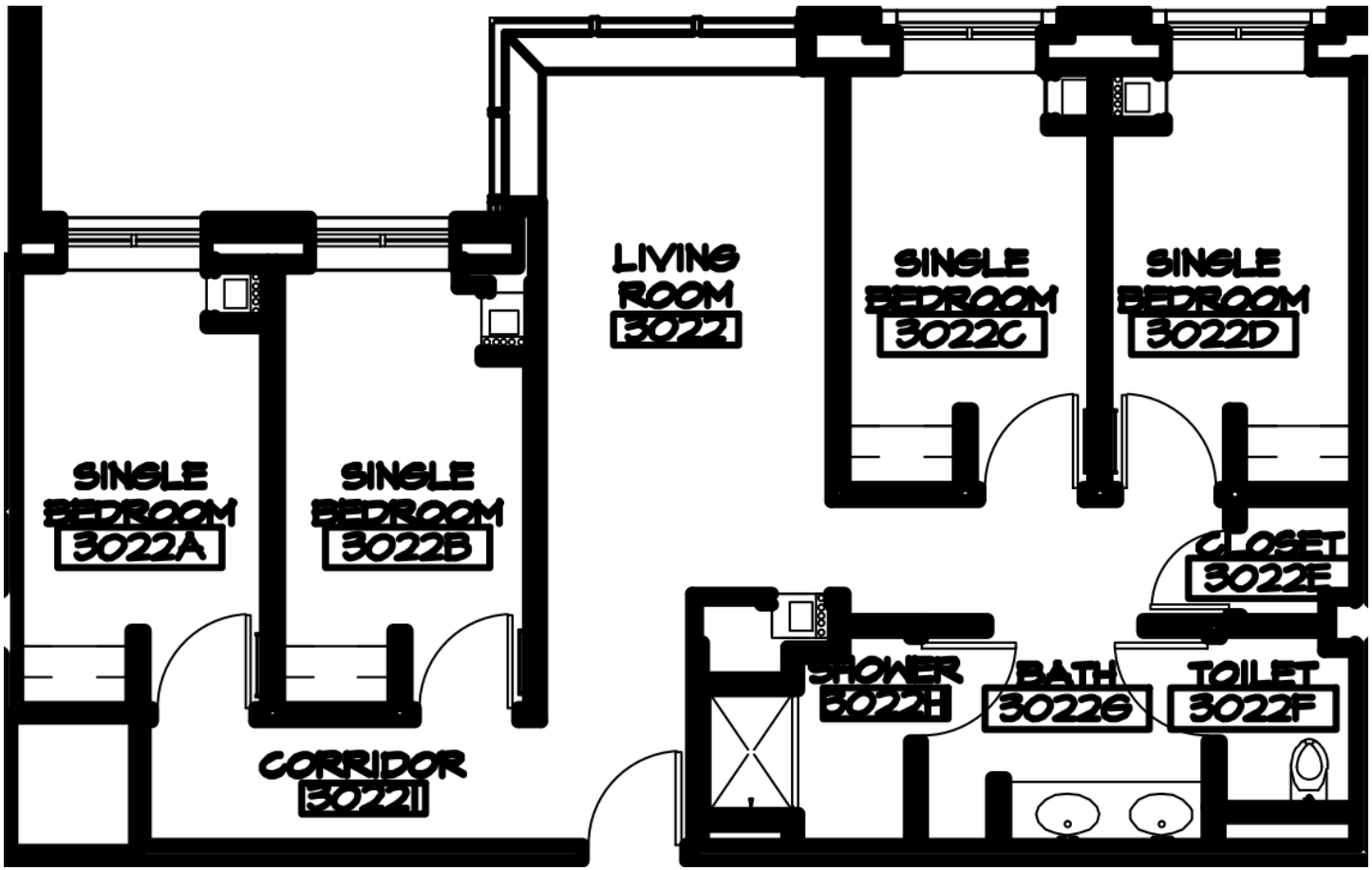
In **COLD** days, turn your thermostat **DOWN** before going to sleep or when you leave the room.

If you have any questions/concerns, or if you want to withdraw from this study, please contact [redacted]

Experimental Design

- Emails were sent every week (on Wednesdays)
- Scripts to automate the process of cleaning data, generating graphs, and sending out emails
- R was used to clean data and generate graphs
- Python was used to automatically generate and send emails

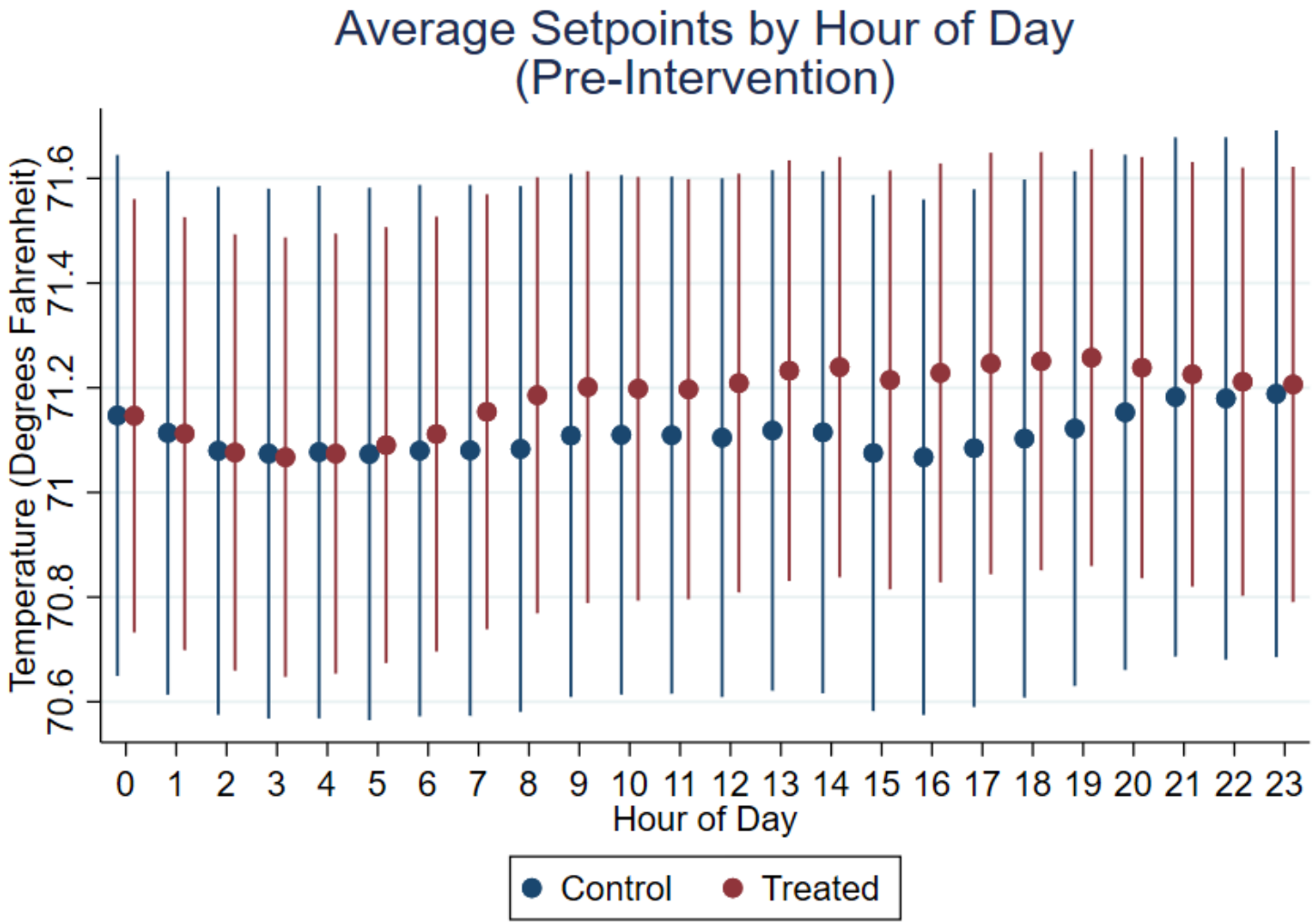
Experimental Design



Experimental Design

- $\Rightarrow$ simulated power calculation, with MDE of $0.75 - 0.8^{o}F$ (1%)
- $\Rightarrow$ opt-out selection into study
- $\Rightarrow$ 115 rooms in control, 105 in treat A, and 100 in treat B
- $\Rightarrow$ randomization by suite
- $\Rightarrow$ treat A received room-level info, while treat B received suite-level
- $\Rightarrow$ weekly reports of own vs. neighbors heating/cooling usage
- $\Rightarrow$ sample period: September 13th - December 15th
- $\Rightarrow$ high-frequency thermostat data (15-minute intervals)

Results from Main Trial



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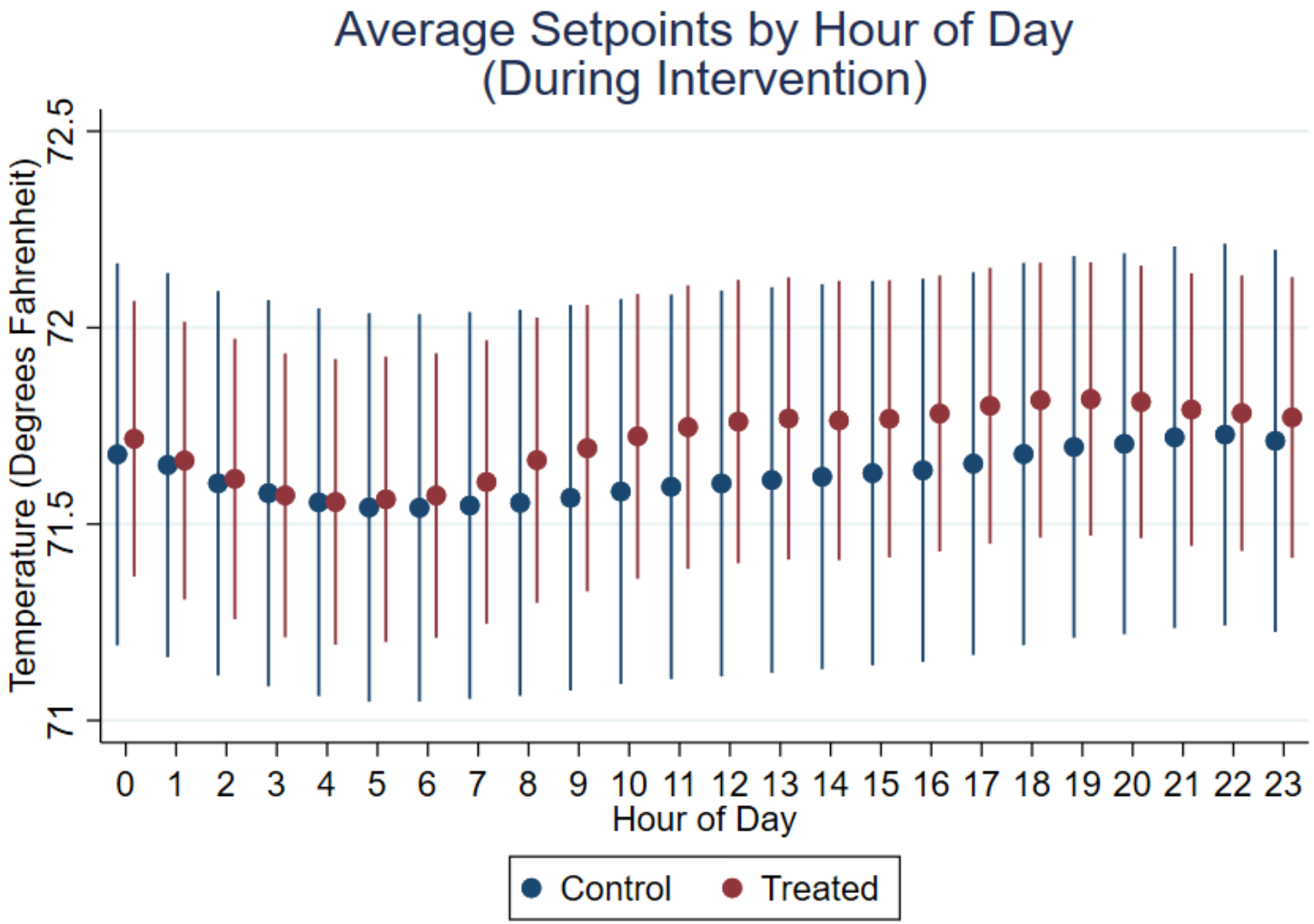
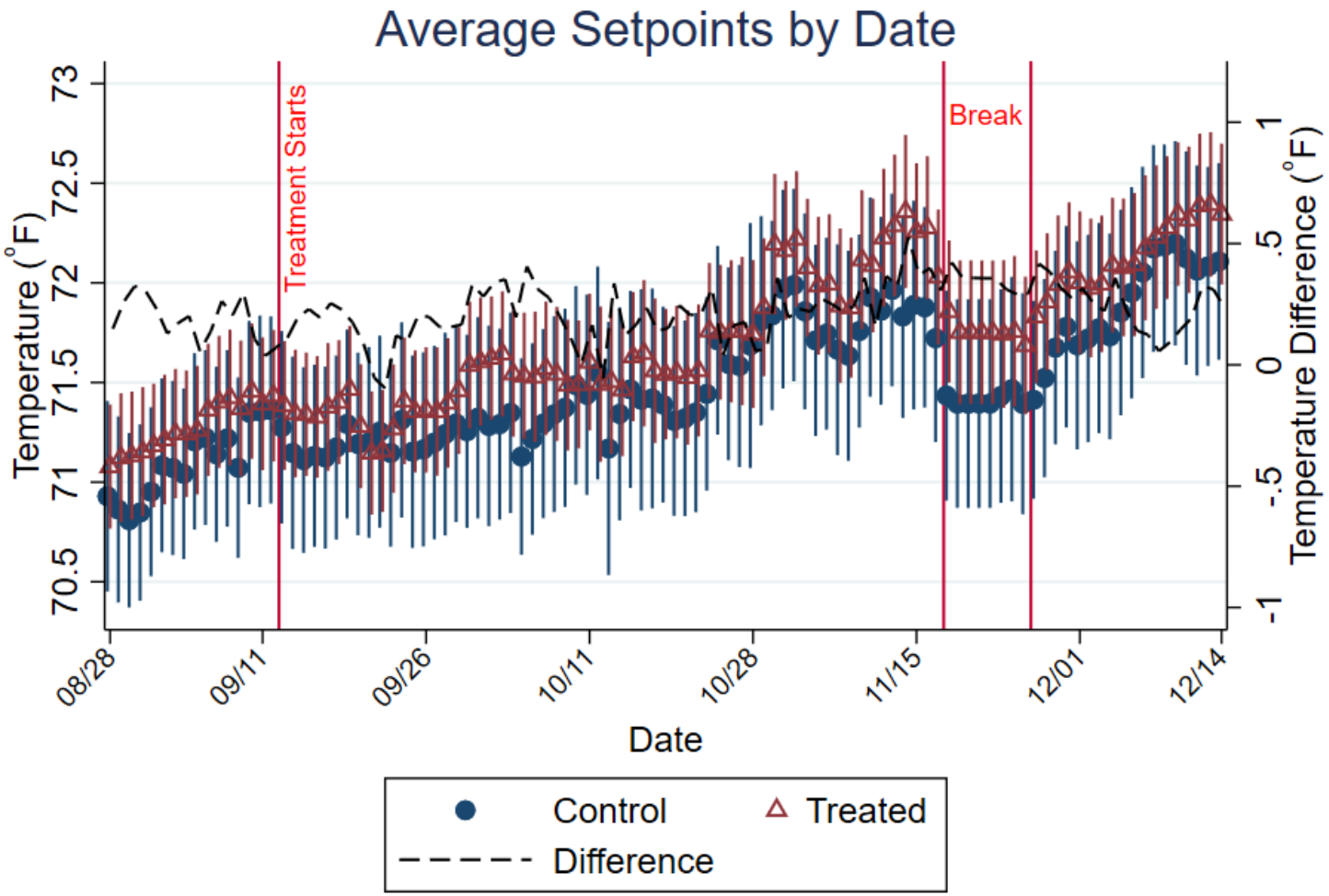


Results from Main Trial



Note: 95% confidence intervals based on room-level clustered standard errors

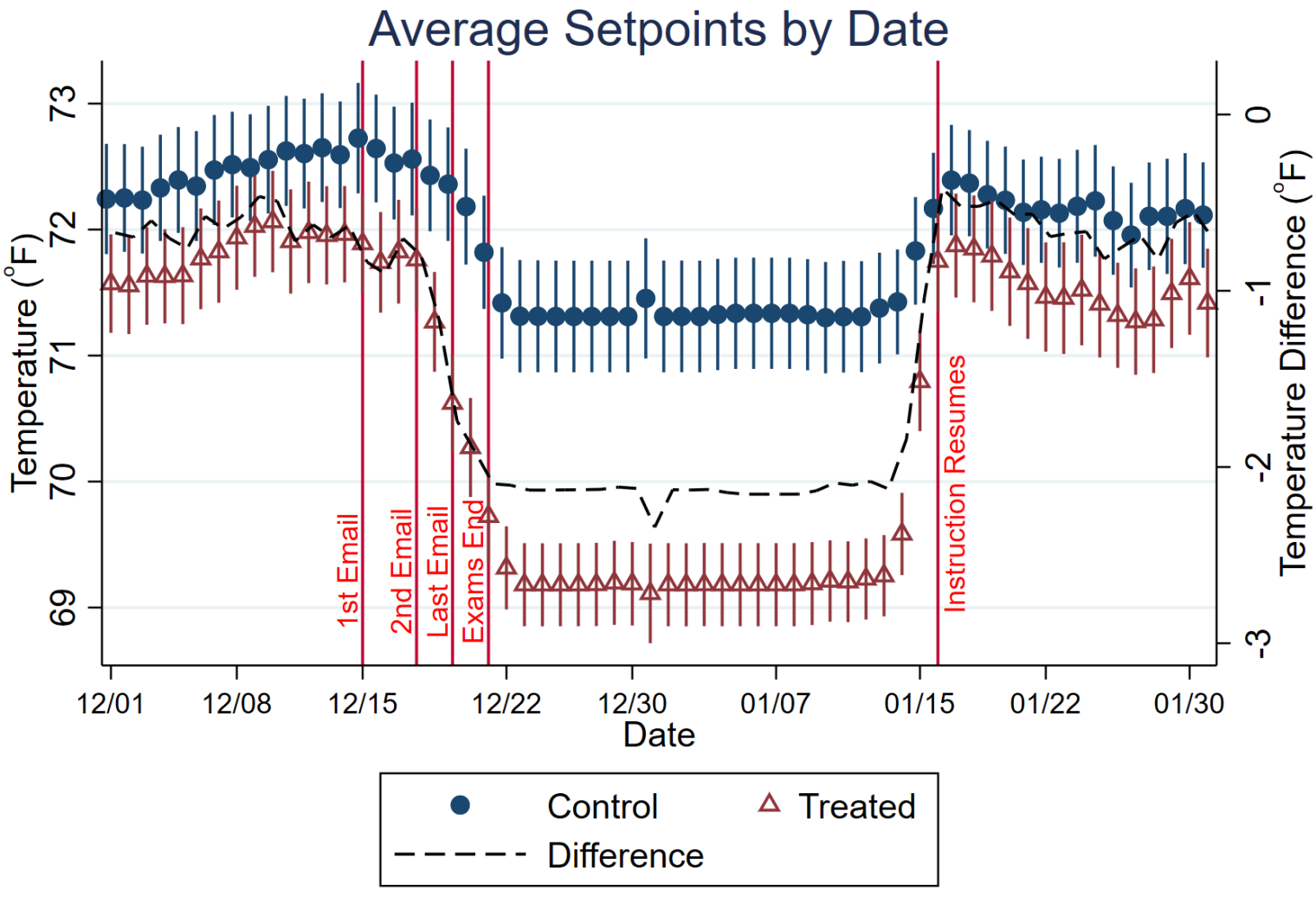
Results from Main Trial

	(I)	(II)	(III)	(IV)	(V)	(VI)
Treated	0.2320	0.2800	0.2791	0.2784	0.0993	
	(0.2908)	(0.2842)	(0.2845)	(0.2849)	(0.1555)	
	[-0.337 0.802]	[-0.277 0.837]	[-0.278 0.836]	[-0.280 0.836]	[-0.205 0.404]	
Treated × Post Sep.13						0.0665
						(0.1560)
						[-0.239 0.372]
Average Setpoint (^{o}F)	71.69	71.69	71.69	71.69	71.69	71.62
Average Within-Room SD	1.39	1.39	1.39	1.39	1.39	1.45
Observations	2,591,687	2,591,687	2,564,891	2,591,687	2,591,687	3,090,708
Controls:						
Room physical characteristics	No	Yes	Yes	Yes	Yes	No
Weather	No	No	Yes	No	No	No
Date/Time fixed effects	No	No	No	Yes	Yes	Yes
Avg. pre-treatment setpoint	No	No	No	No	Yes	No
Room fixed effects	No	No	No	No	No	Yes

Secondary Trial - Winter Break

- ⇒ 159 rooms were assigned to control, and 161 were assigned to treatment
- ⇒ treatment rooms received emails asking them to lower their thermostats before leaving for winter break

Results - Winter Break



Note: 95% confidence intervals based on room-level clustered standard errors.

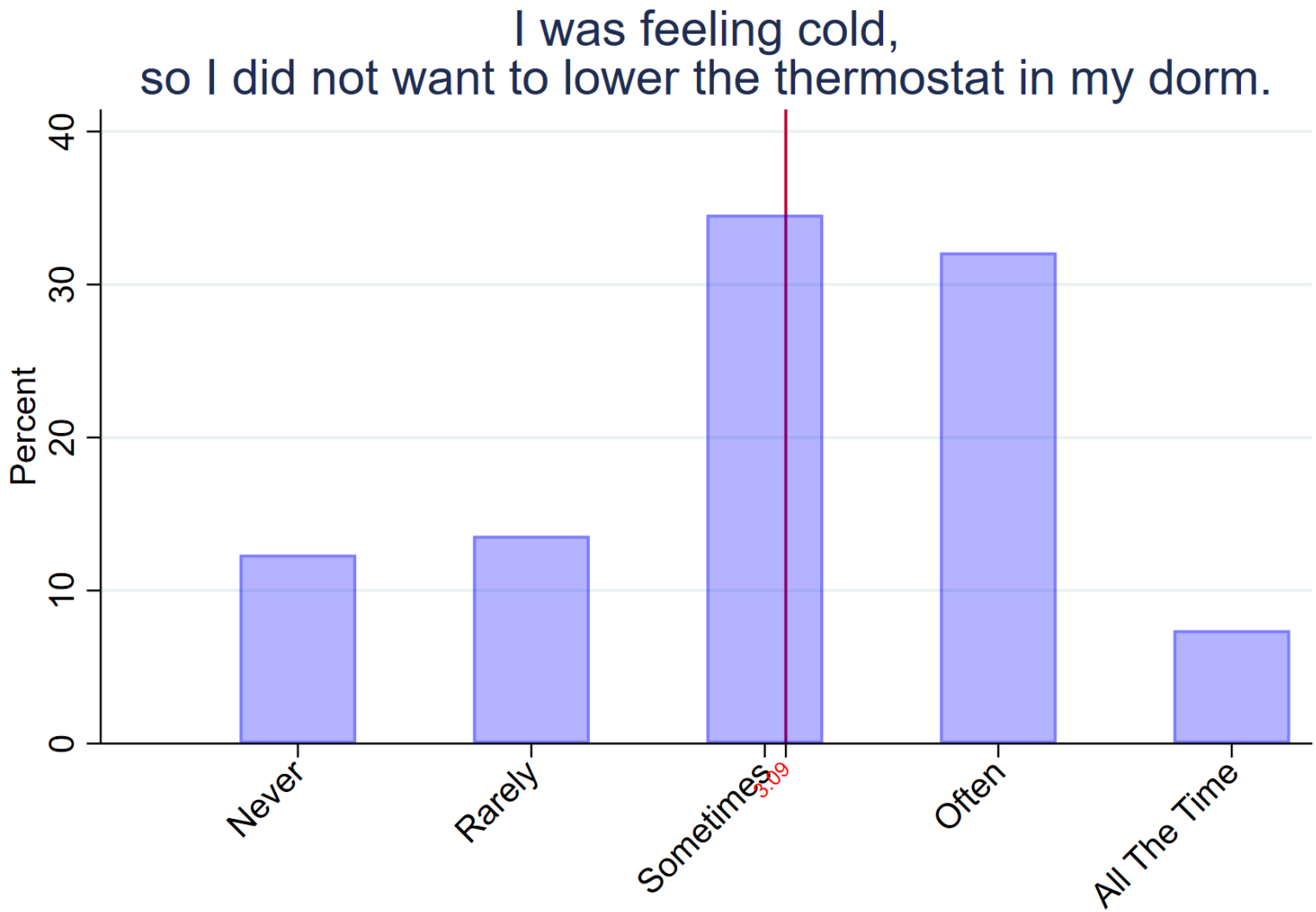
Results - Simple Nudges During Spring

Robustness: Do the simple nudges work when students are actually in the rooms?

	(I)	(II)	(III)	(IV)	(V)	(VI)
Spring Treatment	-0.1750	-0.0553	-0.0638	-0.0616	-0.1963	
	(0.3793)	(0.3774)	(0.3798)	(0.3812)	(0.1511)	
Spring Treatment × Post Jan. 31						-0.2403
						(0.1556)
Sample Average Setpoint (^{o}F)	72.14	72.14	72.14	72.14	72.14	72.17
Observations	1,386,111	1,386,111	1,361,355	1,386,111	1,386,111	1,677,513
Controls:						
Room physical characteristics	No	Yes	Yes	Yes	Yes	No
Weather	No	No	Yes	No	No	No
Date/Time fixed effects	No	No	No	Yes	Yes	Yes
Avg. pre-treatment setpoint	No	No	No	No	Yes	No
Room fixed effects	No	No	No	No	No	Yes

Post-treatment Survey

Why didn't subjects lower their thermostats?



Conclusion

- Home Energy Reports do not work in the absence of monetary incentives/potential capital investments
- However, simple messages to promote conservation in unused spaces are effective
- The timing of the nudges is crucial

Main References I

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