Behavioral Energy Economics

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Motivation

Why do we need “behavioral economics”?

- Standard models of economic behavior often fail, **even in well-functioning markets**
- Behavioral econ. challenges the notion of “rational” agents
- Builds on insights from psychology, with applications to economics

Topics in Behavioral and Energy Economics

Outline:

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

A Quick Poll

Consider these two scenarios:

Scenario:	A		B	
Net Gains/Losses (€):	100	50	100	-150
Probabilities:	50%	50%	90%	10%

Suppose that these scenarios represent investment portfolios.
Which one would you pick?
(imagine that you repeat the investment many times)

Expected Utility Theory

$$\mathbb{E}[U] = \mathbb{E}\left[\sum_{n=1}^{N} V_n \times P_n\right]$$

Scenario:	A		B	
Net Gains/Losses (€):	100	50	100	-150
Probabilities:	50%	50%	90%	10%
Expected Gains:	75		75	

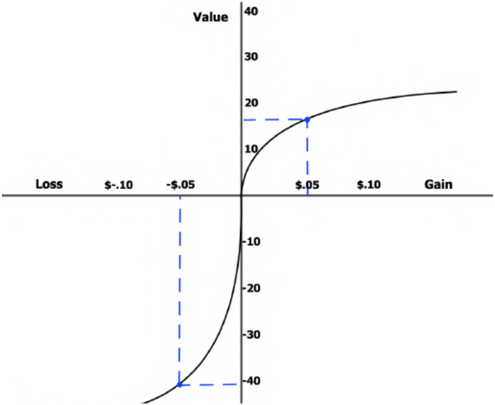
Expected Utility Theory poses that people should be indifferent between scenarios A and B.

Prospect Theory challenges this notion.

Prospect Theory

"Prospect Theory: An Analysis of Decision under Risk."
Kahneman and Tversky (1979)

- Individuals assess losses and gains asymmetrically
- Introduces concept of "Loss Aversion"
- Also, individuals tend to overweight small probabilities



"Prospect theory and energy efficiency." Heutel (2019)

- Survey (choice experiment) to measure levels of loss aversion

Table 1. Prospect theory lottery questions (from Tanaka etal., 2010).

Series 1				Series 2				Series 3			
Option A		Option B		Option A		Option B		Option A		Option B	
30%	70%	10%	90%	90%	10%	70%	30%	50%	50%	50%	50%
$8	$2	$13.60	$1	$8	$6	$10.80	$1	$25	–$4	$30	–$21
$8	$2	$15	$1	$8	$6	$11.20	$1	$4	–$4	$30	–$21
$8	$2	$16.60	$1	$8	$6	$11.60	$1	$1	–$4	$30	–$21
$8	$2	$18.60	$1	$8	$6	$12	$1	$1	–$4	$30	–$16
$8	$2	$21.30	$1	$8	$6	$12.40	$1	$1	–$8	$30	–$16
$8	$2	$25	$1	$8	$6	$13	$1	$1	–$8	$30	–$14
$8	$2	$30	$1	$8	$6	$13.60	$1	$1	–$8	$30	–$11
$8	$2	$37	$1	$8	$6	$14.40	$1				
$8	$2	$44	$1	$8	$6	$15.40	$1				
$8	$2	$60	$1	$8	$6	$16.60	$1				
$8	$2	$80	$1	$8	$6	$18	$1				
$8	$2	$120	$1	$8	$6	$20	$1				
$8	$2	$200	$1	$8	$6	$22	$1				
$8	$2	$340	$1	$8	$6	$26	$1				

“Prospect theory and energy efficiency.” Heutel (2019)

- Test whether loss aversion explains variation energy efficiency investments
- Survey also collected information about ownership of “Energy Star” (ES) rated appliances and fuel-efficient vehicles
- Regress the binary ES ownership indicator on loss aversion parameters, controlling for demographics and time preferences
- **Find that more loss aversion explains lower investment in efficiency**

Myopia (short-sightedness)

Do consumers "accurately" take into account the future usage costs of durable goods?

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"*

Myopia is intimately related to the concept of time preferences. The challenge is to distinguish between the two in practice.

Myopia (short-sightedness)

- "Are Consumers Myopic? Evidence from New and Used Car Purchases." Busse, Knittel, and Zettelmeyer (2013)
  - First step: reduced-form specification for the effect of gassoline prices on car sales prices
  - Second step: use their estimates within a structural model which allows changing assumptions (about miles traveled, future gas prices, car survival rates)
  - Implicit discount rates from 2.8% to 16.9%; comparable to interest rates from car financing (not too myopic)

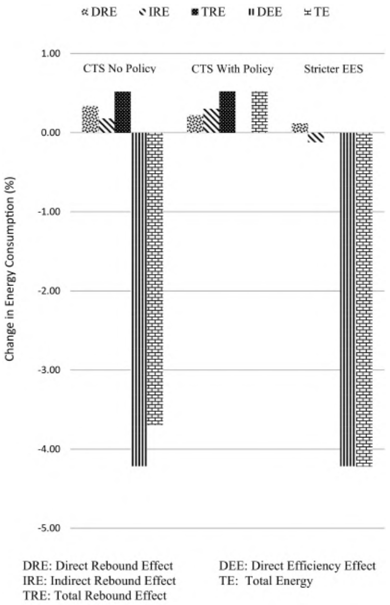
- "Consumer myopia, imperfect competition and the energy efficiency gap: Evidence from the UK refrigerator market." Cohen, Glachant, and Söderberg (2017)
  - Consumers underestimate future energy savings by 35%
  - Myopia *increases* energy use by 9.2%
  - Implicit discount rate of 11%
  - Imperfect competition *reduces* energy use by 4.2% (through reduced demand due to higher prices of dominant firms)

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



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.

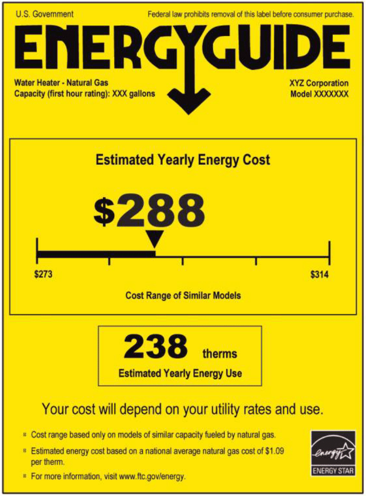
Inattentiveness and Salience

"Are Home Buyers Inattentive? Evidence from Capitalization of Energy Costs." Myers (2019)

- Has access to home transaction data from Massachusetts between 1990 and 2011
- Some homes are heated with oil, others with gas
- The "thought experiment" is to compare the sales price of two identical homes, that vary only in the fuel costs
- Main results suggest that an increase of oil costs relative to gas leads to a reduction in the sales prices of oil-heated homes
- Thus, in this setting, we strongly reject 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)

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

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

- 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:

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

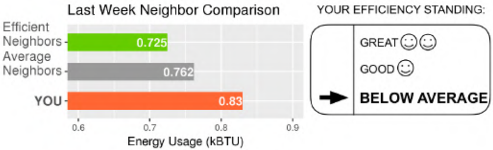
Experimental Design

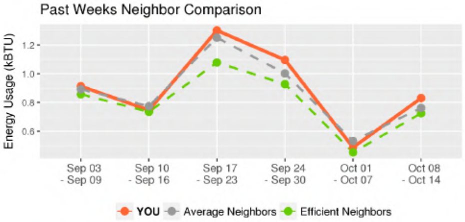
You used 8.95% more energy than average neighbors last week.

Heating/Cooling Energy Report [redacted]

Sent 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]

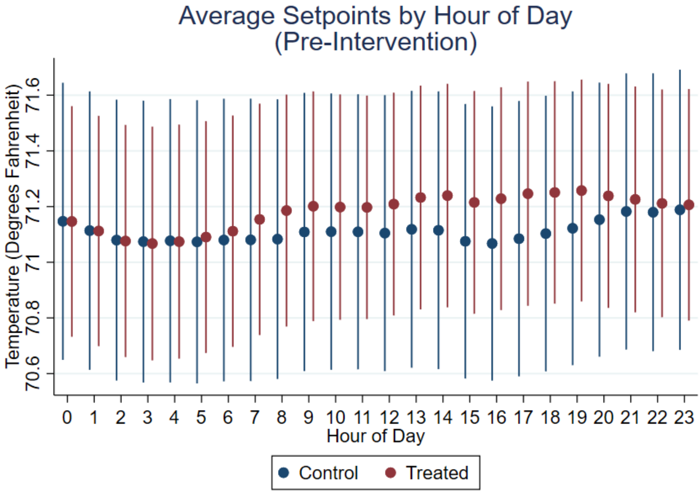
Experimental Design

- 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

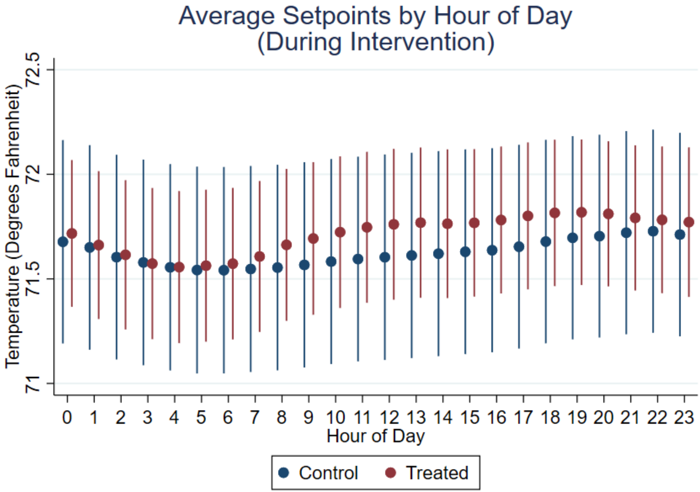
Experimental Design

- simulated power calculation, with MDE of $0.75 - 0.8^{o}F$ (1%)
- opt-out selection into study
- 115 rooms in control, 205 rooms in control
- randomization by suite
- treated suites received weekly reports of own vs. neighbors heating/cooling usage
- sample period: September 13th - December 15th
- high-frequency thermostat data (15-minute intervals)

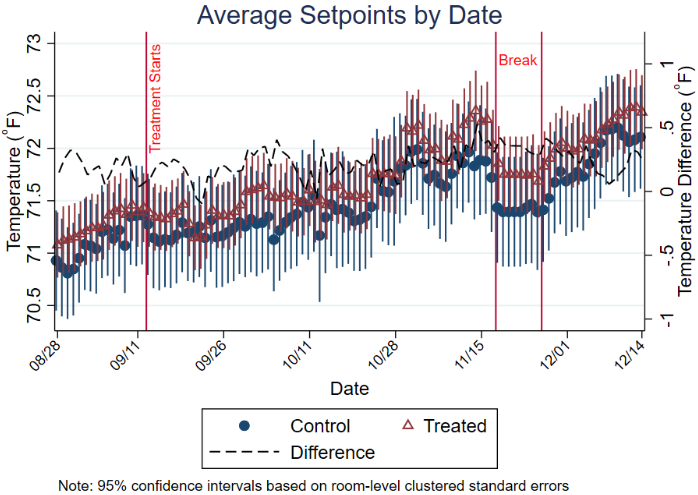
Results from Main Trial



Results from Main Trial



Results from Main Trial



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 $\times$ 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

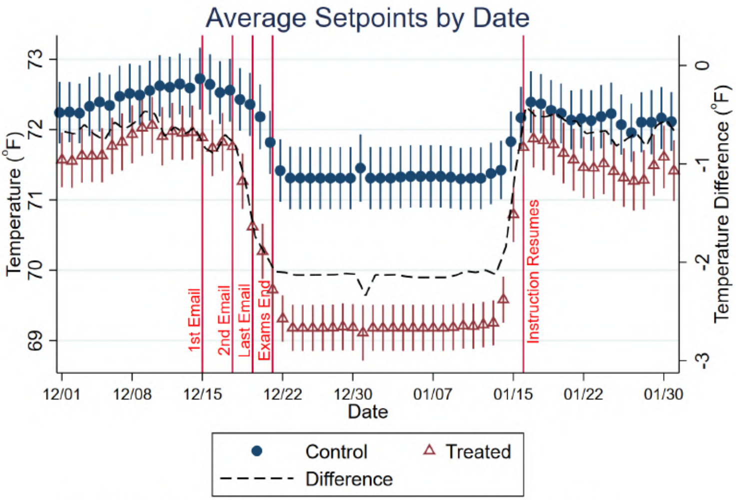
- 159 rooms were assigned to control, and 161 were assigned to treatment
- treatment rooms received emails asking them to lower their thermostats before leaving for winter break

Dear [redacted]

Please, remember to **lower your thermostat to 68 degrees** before leaving for Winter Break. This is a very simple task that can **help save a lot of energy!**

Thank You!

Results – Winter Break



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

Results – Simple Nudges During Spring

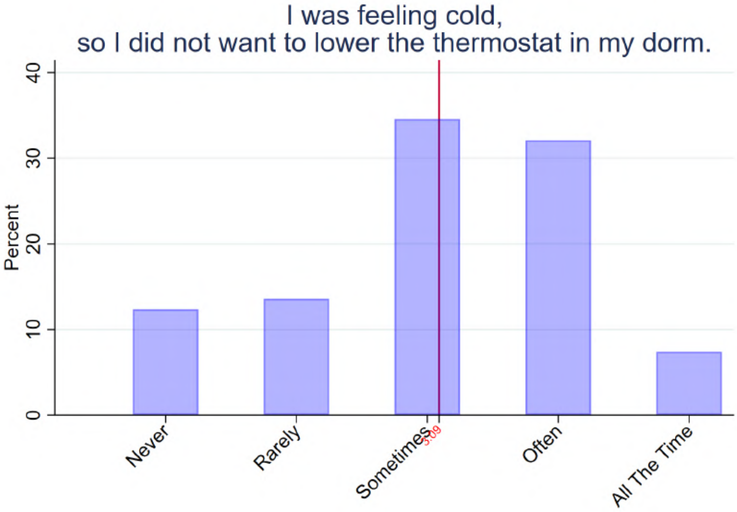
Robustness: Do the simple nudges work when students are actually in the rooms?

	(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 $\times$ 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?



Conclusions from this application

- 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

What we wish we had done differently:

- Another experiment where we actually give money to the students, which they could lose depending on their consumption levels
- This would create monetary incentives for them
- We would them be able to fully compare results with and without monetary incentives

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