Do the Effects of Social Nudges Persist? Theory and Evidence from 38 Natural Field Experiments

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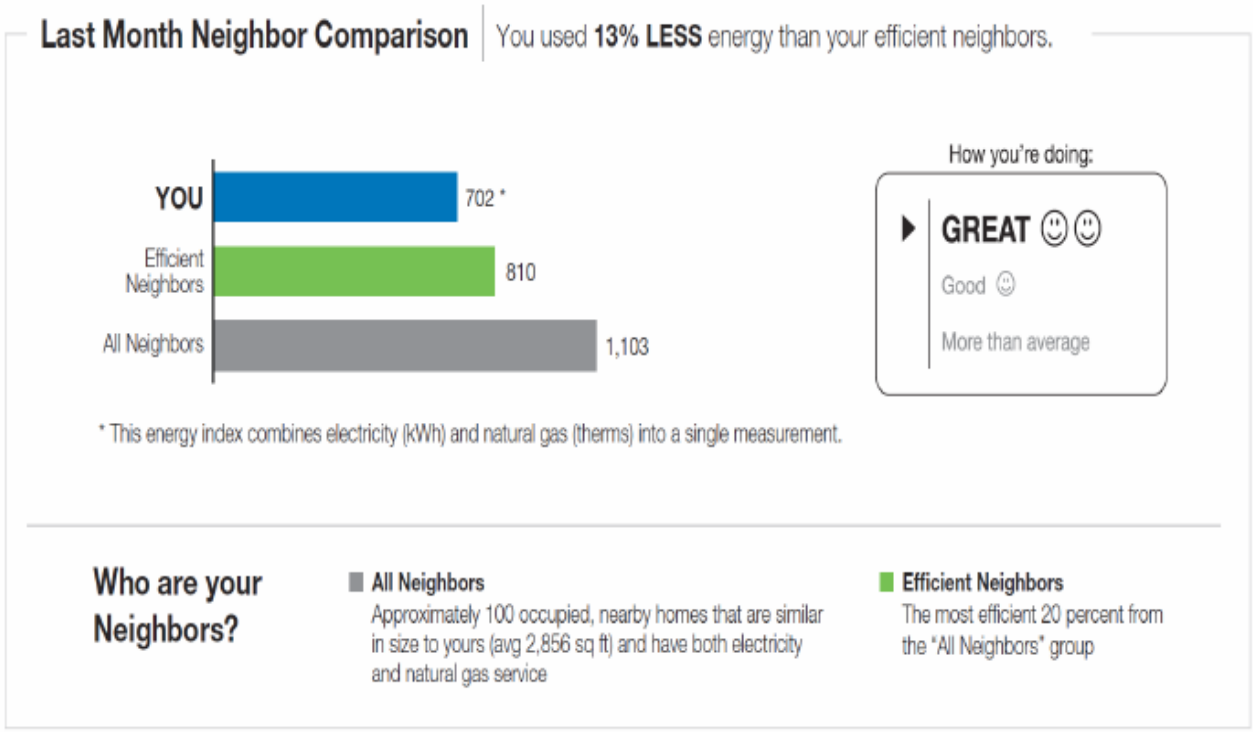
Why Social Comparisons?

- Problems with "traditional" solutions has spurned interest in behaviorally motived policies

- Popular approach is based upon social comparison theory
  - Use actions of similar others to evaluate what is appropriate
  - Provide households information on how their energy use compares to like neighbors

Opower…The Home Energy Report



Do Social Comparisons Work?

- Yes…social comparisons cause reductions in monthly energy and water use
  - Allcott (2011) finds approximate 1.4 to 3.3% reductions in monthly energy use
  - Ferraro and Price (2013) find approximate 4.8% reductions in monthly water use

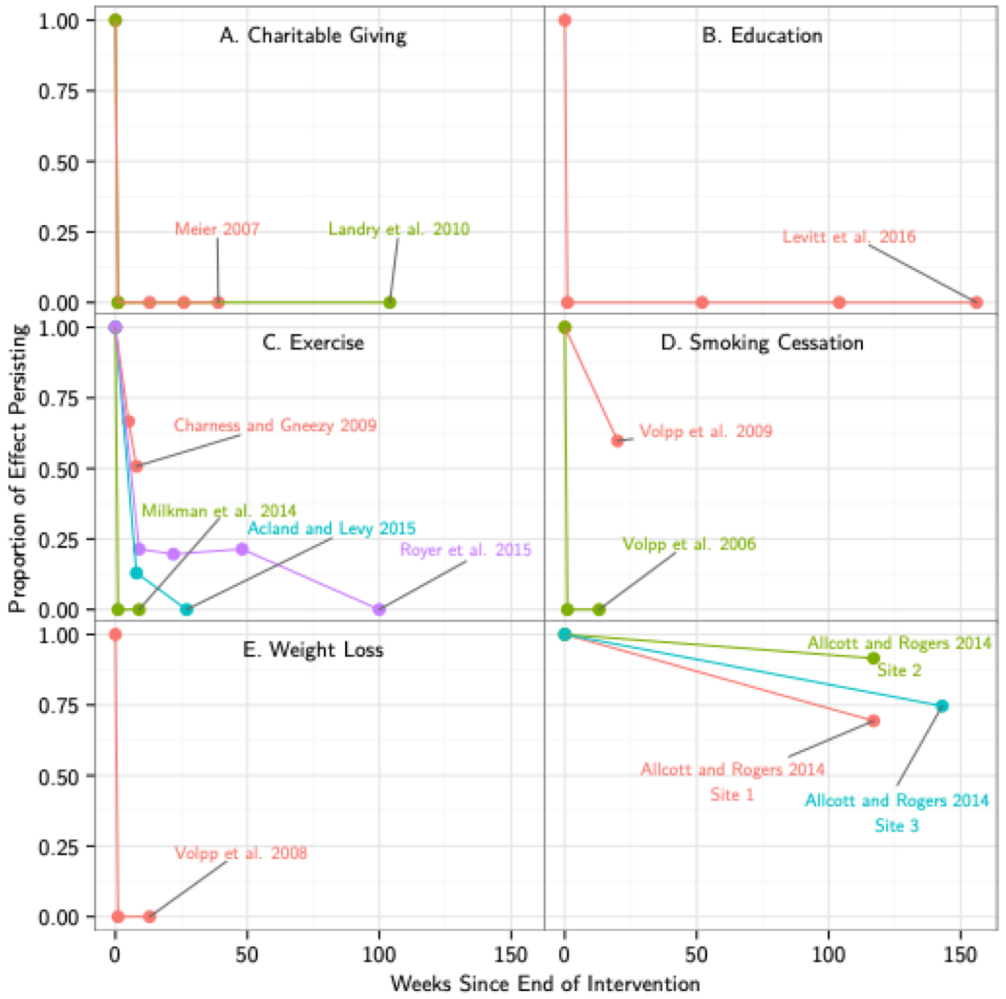
- Do the effects persist once "treatment" is removed?

The Bigger Picture…Creating Habits

- Array of important settings where utility from choices today are dependent upon past choices
  - Habits and Addiction
  - Tradition

- Limited evidence on ability to create new habits or break old habits using financial incentives
  - Impacts tend to wane over time
  - Behavior converges towards pre-intervention benchmarks

Persistence in Habit Formation Literature



Notes: Each point represents the proportion of the initial treatment effect that persists for a given amount of time since the end of a given intervention. All observations are based on point estimates presented in the corresponding studies with insignificance at the five percent level constituting persistence of zero.

The Basic Motivation…Creating Habits

- Remarkable exception…Opower's home energy report
  - Approximate 2-3% reductions in monthly use when receiving reports
  - Between 60-75% of the original treatment effect persists two years after treatment

- Is the home energy report a silver bullet?

The Fundamental Challenge…Mechanisms

- Number of reasons why the effects of the HER are persistent
  - Habit formation and better "use" of energy by customer
  - Technological change and changes in physical capital of home

- Our objective…disentangle the two effects to understand what drives persistence

Why Focus on Mechanisms?

- Positive perspective
  - Understand how best to model social comparisons and derive welfare effects
  - Test predictions of models of habit formation and understand how habits are formed

- Normative perspective
  - Allow policy-makers to identify "new" policy instruments and/or improve effectiveness of existing policies
  - Refine measures of cost-effectiveness and welfare by accounting for persistence/costs of investments

Our Approach…A Simple Roadmap

- Conceptual framework
  - Energy is intermediate good that is used to produce goods/services in the home
  - Show how receipt of HER impacts energy use…both direct (higher "price") and indirect effects (investments)

- Identification strategy…exploit administration of HER
  - Treatment is discontinued when original customer closes account
  - Opower continues to receive information on energy use at premise

Our Basic Innovation…Isolate Capital

- Identification strategy…shut down habitual behavior
  - Compare energy use across treated and control homes after move
  - Neither customer receives or has received HER…no role for habits

- But…if capital stock is impacted by treatment
  - Expect lower energy use in treated premises after move
  - Sheds light onto mechanisms through which HERs impact use

The Main Findings…A Quick Preview

- Receipt of HER leads to an approximate 2.4% reduction in monthly energy use
  - Effects fall within range of those observed in Allcott (2011)
  - Effects for households that eventually move are slightly lower than those observed for non-movers

- Customers that move into treated homes use 1 – 1.3% less than those that move into control homes
  - Persistence is increasing in exposure to treatment
  - No evidence that sorting explains persistence

Conceptual Framework…The Basics

$$\max_{c_\tau, e_\tau, I_\tau} \quad u(c_\tau) + v(z_\tau) - s_\tau$$

$$s.t. \quad m = c_\tau + p_I I_\tau + p_e e_\tau$$
$$z_\tau = f(e_\tau, k_\tau)$$
$$k_\tau = I_\tau + k_{\tau-1}$$
$$s_\tau = g(e_\tau, a_\tau)$$

Conceptual Framework…The Basics

- Optimal e_τ, I_τ given by

$$v'(z_\tau) f_e(e_\tau, k_\tau) = p_e + g_e(e_\tau, a_\tau)$$
$$v'(z_\tau) f_k(e_\tau, k_\tau) = p_I$$

- Takeaway: HER introduces a shadow tax…Households will reduce energy use *and* invest in new capital

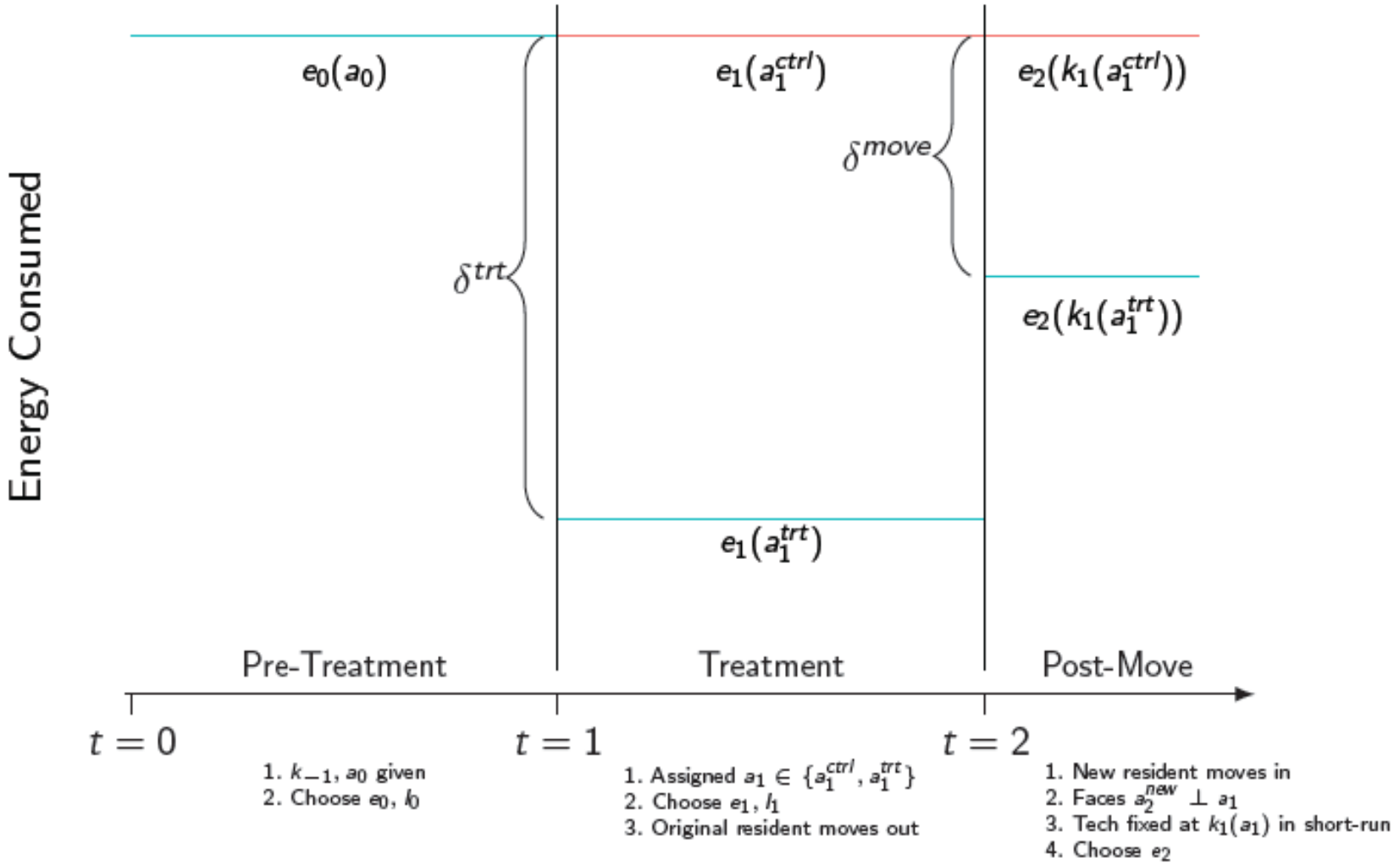
Conceptual Framework…Post-Move

- Households inherit capital stock of prior tenant and face same shadow price on energy…no HER's

- Energy consumption in post-move period
  - Consumption at control homes is unaffected…same price of energy and capital stock
  - Consumption at treated homes increases…lower shadow tax

- But…if HER triggered investment in $\tau = 1$ then should see lower use at treated premises

Conceptual Framework…A Summary



What Data Do We Observe?

- Observe data at the premise level
  - Date of first HER
  - Monthly use
  - Unique ID for account holder at premise

- Neighbor comparison based on use over 12-month period

Variation We Exploit…Movers

- Administrative quirk…changes in account holder
  - Treatment is discontinued so new tenant does not receive HER
  - Observe date when treatment is discontinued
  - Continue to observe monthly energy use at the premise

- Our approach…focus on comparison of treated and control ***premises*** in post-move period

The Data…A Summary

Table 1: Sample Overview

	Full	Non-Movers	Movers
Utilities	22	22	22
Waves	41	41	38
Households	2,785,457	2,527,553	257,904
Treatment Indicator	0.677	0.680	0.647
	(0.468)	(0.467)	(0.478)
Pre-Treatment Usage	1,191.45	1,202.55	1,082.73
	(639.57)	(641.58)	(608.89)
Pre-Treatment Observations			12.61
			(1.25)
Treatment and Pre-Move Observations			11.76
			(9.46)
Post-Move Observations			12.37
			(9.38)

Empirical Strategy...DiD

Difference-in-Differences (DiD) framework directly maps quantities from theory to data:

$$e_{ijt} = \beta^T T_i + \beta^H H_t + \delta^{trt} T_i H_t + \beta^M M_t + \delta^{move} T_i M_t + \omega_j + \tau_t + U_{ijt}$$

where $\theta = (\delta^{trt}, \delta^{move})$ are the parameters of interest:

- δ^{trt} captures the effect of treatment (social comparison letters) on initial occupants
- δ^{move} measures the persistent treatment effect after treated patrons moved out

Empirical Findings...DiD

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\hat{\beta}^T$	6.50***	7.01***	8.34***	6.35***	6.70***	6.50***	7.01***
	(2.05)	(0.48)	(2.37)	(2.05)	(2.09)	(2.05)	(0.62)
$\hat{\beta}^H$	-53.71***	-58.45***	-54.36***	-53.83***	-54.16***	-53.72***	-57.93***
	(1.72)	(1.45)	(2.04)	(1.73)	(1.77)	(1.72)	(1.73)
$\hat{\delta}^{trt}$	-24.98***	-22.69***	-25.63***	-24.93***	-24.48***	-24.97***	-22.64***
	(2.05)	(1.50)	(2.45)	(2.06)	(2.10)	(2.05)	(1.84)
$\hat{\beta}^M$	-148.30***	-131.10***	-154.40***	-149.14***	-149.13***	-148.30***	-136.24***
	(2.73)	(2.51)	(3.24)	(2.74)	(2.79)	(2.73)	(3.03)
$\hat{\delta}^{move}$	-11.35***	-12.73***	-11.18***	-11.25***	-11.41***	-11.35***	-13.14***
	(2.64)	(2.57)	(3.13)	(2.65)	(2.69)	(2.64)	(3.09)
Pre-Exp. Usage		0.80***					0.80***
		(0.00)					(0.00)
CDD			0.88***				0.89***
			(0.01)				(0.01)
HDD			0.14***				0.15***
			(0.00)				(0.00)
Vacancy Rate				-1.07***			-1.08***
				(0.16)			(0.11)
Env. Index					-0.28***		0.05**
					(0.03)		(0.02)
Green Party Donations						-0.05	0.21**
						(0.03)	(0.09)
R^2	0.216	0.444	0.232	0.216	0.217	0.216	0.453
N	9,350,745	9,350,725	6,127,816	9,247,833	8,921,649	9,350,642	5,821,922

Empirical Findings…A Summary

- Customers receiving HERs use approximately 25 kWh less (~2.4%) per month
  - Turning off two incandescent lightbulbs for 8 hours per day
  - Not using a high-end AC window unit (1500W) for 16 hours

- Previously treated homes use approximately 11 kWh less per month than previous control homes
  - Suggests that treatment induced investment in new capital
  - Substituting one incandescent with a CFL for 220 hours

Empirical Findings…A Summary

- Estimates imply persistence in range of 43 – 55%
  - Allcott and Rogers estimate persistence in range of 60 -75%
  - Calls into question importance of habits

- But…three main concerns
  - Large reductions in use for *all* homes in post-move period
  - Analysis ignores heterogeneity across RCTs
  - Alternate explanation…sorting into treated homes

Robustness Check…Low Use Months

- Exclusion rules
  - Homes for which post-move average use is two-standards deviations below pre-intervention average
  - First six months of post-move period
  - Any post-move month where use is less than 80% of smallest pre-intervention use
  - Any post-move month where use is less than 200 kWh
- Estimates on post-move indicator fall by 50 – 85%
- But…estimate persistence in range of 20 – 40 percent

Robustness Check…Heterogeneity

- Treat every wave-cohort as its own experiment
  - Waves denote unique experiment within a utility
  - Cohort defined by date of move and receipt of first HER

- Estimate DiD for each wave-cohort

- Estimate proportion of treatment effect that persists via inverse-variance weighted least squares

$$\delta_{jc}^{move} = \gamma \delta_{jc}^{trt} + W_{jc}$$

Robustness Check…Heterogeneity

	(1)	(2)	(3)
$\hat{\gamma}^{prst}_{total}$	0.3468***		
	(0.0495)		
$\hat{\gamma}^{prst}_{<1Yr}$		0.2632***	
		(0.0640)	
$\hat{\gamma}^{prst}_{\geq 1Yr}$		0.5295***	
		(0.0614)	
$\hat{\gamma}^{prst}_{<2Yr}$			0.3300***
			(0.0513)
$\hat{\gamma}^{prst}_{\geq 2Yr}$			0.5449***
			(0.0693)
Null Hypothesis (H_0)			
$\hat{\gamma}^{prst}_{<t} = \hat{\gamma}^{prst}_{\geq t}$, p-value		<0.01	0.02
R^2	0.000	0.162	0.147
N	654	654	654

Robustness Check…Heterogeneity

- Across all wave-cohorts, estimate persistence of 35%

- Estimated persistence increase in length of treatment
  - Persistence of 26% for cohorts with less than 1 year of HERs
  - Persistence of 53% for cohorts with more than 1 year of HERs

- Suggests fundamental difference in how HERs impact energy use over short- and long-run

Robustness Check…Sorting

- Develop partial equilibrium model of sorting and test predictions using proxies for housing market conditions

- Basic intuition…sort into homes with more capital if price of capital is low relative to price of investment

- Proxies for price of capital
  - Vacancy rates and ability to "price" capital into home value
  - Environmental attitudes and demand for better technology

Robustness Check…Sorting

Sort Variable (0-100)	Sorting Prediction	Estimates $\hat{\delta}^{trt}$	$\hat{\delta}^{trt} \cdot$ Sort	$\hat{\delta}^{move}$	$\hat{\delta}^{move} \cdot$ Sort
Vacancy Rate	[−]	-27.86***	0.39	-21.50***	1.16**
		(3.46)	(0.33)	(4.78)	(0.47)
Environmental Index (Annual)	[+]	-34.51***	0.20***	-11.68**	0.03
		(3.97)	(0.07)	(4.69)	(0.08)
Environmental Index (Lifetime)	[+]	-35.63***	0.23***	-13.21***	0.07
		(3.94)	(0.07)	(4.83)	(0.08)
Green Party Donations (District)	[+]	-33.36***	3.86*	-16.51***	2.32
		(4.89)	(2.05)	(6.21)	(2.59)
Green Party Donations (County)	[+]	-25.68***	0.16**	-11.88***	0.13
		(2.08)	(0.08)	(2.68)	(0.10)

So What…Broader Implications

- Persistence for cohorts with at least two-years of treatment similar to that observed in Allcott and Rogers
- Calls into question the importance of habits in prior work…behavioral policies are not "magic pill"
- Reassess cost-effectiveness…accounting for investment makes program less attractive than other policy options

Take Away Thoughts

- Develop a novel identification strategy to indirectly estimate capital investments using only energy use
- Find evidence that moral suasion induces both capital investments and behavioral adjustments
- Results are robust to variety of controls and exclusions
  - Selection into homes with better capital stock
  - Heterogeneity across cohorts

Take Away Thoughts

- Positive perspective
  - Rethink how to model moral suasion to include indirect effects on capital stock
  - Support prior work showing difficulty in forming habits through simple interventions

- Normative perspective
  - HERs are a less attractive policy option when account for costs of investment