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

Alec Brandon, University of Chicago
Paul Ferraro, Johns Hopkins University
John List, University of Chicago & NBER
Robert Metcalfe, Boston University & NBER
Michael Price, University of Alabama & NBER
Florian Rundhammer, Cornerstone Research

December 2018
Why Social Comparisons?

- Problems with “traditional” solutions has spurned interest in behaviorally motivated 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

### Last Month Neighbor Comparison

You used **13% LESS** energy than your efficient neighbors.

- **You**: 702 kWh
- **Efficient Neighbors**: 810 kWh
- **All Neighbors**: 1,103 kWh

*This energy index combines electricity (kWh) and natural gas (therms) into a single measurement.*

**How you’re doing:**

- **GREAT 😊😊**
  - Good 😊
  - More than average

### Who are your Neighbors?

- **All Neighbors**: Approximately 100 occupied, nearby homes that are similar in size to yours (avg 2,856 sq ft) and have both electricity and natural gas service.
- **Efficient Neighbors**: The most efficient 20 percent from the "All Neighbors" group.
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

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

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

- Optimal $e_\tau$, $I_\tau$ given by

\[
\nu'(z_\tau)f_e(e_\tau,k_\tau) = p_e + g_e(e_\tau,a_\tau)
\]
\[
\nu'(z_\tau)f_k(e_\tau,k_\tau) = p_l
\]

- 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

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

- $\delta^{trt}$ captures the effect of treatment (social comparison letters) on initial occupants
- $\delta^{move}$ measures the persistent treatment effect after treated patrons moved out
## Empirical Findings...DiD

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

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\hat{\gamma}_{total}^{prst}$</td>
<td>0.3468***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0495)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\hat{\gamma}_{&lt;1Yr}^{prst}$</td>
<td></td>
<td>0.2632***</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0640)</td>
<td></td>
</tr>
<tr>
<td>$\hat{\gamma}_{\geq1Yr}^{prst}$</td>
<td></td>
<td>0.5295***</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0614)</td>
<td></td>
</tr>
<tr>
<td>$\hat{\gamma}_{&lt;2Yr}^{prst}$</td>
<td></td>
<td></td>
<td>0.3300***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.0513)</td>
</tr>
<tr>
<td>$\hat{\gamma}_{\geq2Yr}^{prst}$</td>
<td></td>
<td></td>
<td>0.5449***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.0693)</td>
</tr>
</tbody>
</table>

Null Hypothesis ($H_0$)

$\hat{\gamma}_{<t}^{prst} = \hat{\gamma}_{\geq t}^{prst}$, p-value

<table>
<thead>
<tr>
<th>$R^2$</th>
<th>0.000</th>
<th>0.162</th>
<th>0.147</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>654</td>
<td>654</td>
<td>654</td>
</tr>
</tbody>
</table>
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

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