Using Incentives and Social Information to Promote Energy Conservation Behavior

Field Experiment

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Contents

Abstract

Improving the efficiency in the domestic energy consumption has become a showpiece of how behavioral economics can be applied to the field of

All the authors conceived and designed the study. M.B. implemented the field study and data collection. N.B. performed the data management and analysis of the data. All the authors contributed toward the interpretation of the results and the writing of the manuscript.

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environmental economics. This study builds upon the literature by providing subjects with individual and social energy performance information at group level in a controlled field experiment setting. We aim to test whether extrinsic incentives accentuate or crowd out the intrinsic motivation to save energy and how heterogeneity in environmental attitudes also impacts on electricity conservation. Besides, we test for the persistence of energy-saving habits after the information is removed. Results suggest that the provision of individual feedback and social information increase energy conserving behavior, with this being most effective among those who signaled in a previous stage preferences for pro-environmental and sustainable living. However, treatment variations indicate that subjects overall fail to maintain "good habits" once the intervention stops, with exception of pro-environmental subjects who continue to consume less electricity in the post-intervention phase. Furthermore, our findings indicate that rewarding groups in a competitive environment may create perverse long-run effects. While providing individual and social information could improve both consumer welfare and energy demand forecasting, the timescale, frequency, and mechanism undertaken require careful scrutiny and planning if these potential benefits are to be maximized and undesirable side effects prevented.

Keywords

Behavioral nudging · Social norms · Extrinsic motivation · Field experiment · Group coordination · Sustainability · Environmental economics

JEL Classifications

Q4 · Q56 · H31 · L94

Introduction

Improving the efficiency of domestic energy consumption has become a showpiece of how behavioral economics can be applied to the field of environmental economics. The use of behavioral "nudges," which are non-price interventions grounded in psychology and behavioral economics, has been proven to be an effective tool that improves consumption awareness and instill positive environmental habits (Allcott 2011; Kunreuther and Weber 2014).

Student residences in a UK university campus could be a good setting for assessing the effectiveness of such nudging. One reason is that students are relatively unfamiliar with understanding their patterns of energy usage as compared with the average population; hence, they are more receptive to behavioral adaptation. Moreover, the rent of student residences is typically predefined and inclusive of utility bills. This means that throughout the study trial, no financial advantages are made (by the participant) if the students become more energy-efficient. It could be assumed that any behavioral change stems from an intrinsically motivated response to the imposed treatment.

In our experimental study, we nudge students to be more energy-efficient by providing them with information about their electricity consumption. Specifically, students were informed of their absolute (i.e., individual information) and relative to others' (i.e., social information) energy usage via a weekly email between January and May 2017. The study explores whether (a) individual feedback and social information creates a fall in consumption per se, (b) conservation behavior persists once the information stimulus is removed, and (c) the introduction of an extrinsic motivation in a form of rewards heightens or offsets the desire to make energy savings.

Our results imply, and in line with relevant literature, that a small (4–8 percentage points) yet significant reductions can arise when subjects are provided with individual and social comparative energy consumption information. In fact, treated students exhibited a decrease in their energy consumption from an above-average consumption to a below-average one relative to their building-level cohort. When exploring the second and third research questions, the study identifies some novel insights which are potentially useful from both a social and policy-based standpoint. Regarding the persistence of conservation behavior, it seems that most subjects quickly lose any "good habits" (and return to pretreatment levels of energy consumption) once the email intervention ceases and the information stimuli are removed. Interestingly, this pattern is not seen among students who self-signaled as environmentally friendly in a previous stage prior to this study. They not only decrease their consumption during the intervention period but also continue to exhibit lower levels of energy usage in the post-intervention period. Regarding extrinsic motives, the added incentive to win a prize appears to accentuate energy conservation behavior. However, once the prize allocations are determined, these conservation habits come to a halt, and subjects within this sub-treatment group exhibit significantly higher energy usage in the post-intervention phase.

These findings therefore issue a mixed message for the energy policy field. On the one hand, the results show that providing individual and social information can constitute an effective environmental nudge and lead to efficiency gains. However, the time frame and type of mechanism employed require careful planning if one is seeking to optimize societal benefits and indeed if unwanted (or inefficient) consumption patterns are to be avoided in the long run.

The rest of the paper is structured as follows: Section "Background of the Study" outlines the literature on environmental nudging in the energy sector; Section "Experimental Design and Procedures" describes the study experimental design and procedures; Section "Behavioural Predictions" presents the behavioral predictions; Section "Analysis and Results" provides the results and associated data analyses; Section "Discussion" proceeds with some further discussion; and section "Conclusion" concludes and recommends some future steps for research and policy in the field.

Background of the Study

Research has shown that people on suboptimal energy tariffs are not persuaded to act even when provided with information on the possible financial savings they could make by switching to a more convenient deal offered by the same or another service provider (Giulietti et al. 2005). Domestic energy constitutes around 27% of the UK's demand for fuel (DECC 2015), wherein associated savings derived from the improved awareness on energy consumption could be substantial both for individuals and at aggregate levels. Research also indicates that many people overconsume energy and the only dissemination of the advantages of energy efficiency rarely results in any significant behavioral adaptation. False perceptions play a major role here, where users could hold untrue or incorrect weighted ideas on the relative energy requirements of domestic appliances (Attari et al. 2010; Allcott 2011a). The impact of this is that individuals often undertake "energy-saving behavior" that creates financial savings that fall short of their expectations (HM Government 2006). Undoubtedly, the introduction of personal energy usage interfaces and the associated move to make these freely available (www.smartenergygb.org) could combat this effect. However, it is important to highlight that uptake is voluntary and thus the likelihood of a self-stimulated action is projected to be less extensive in consumer areas where widespread disengagement exists.

The combination of effects mentioned above, which contributes to the deterioration of energy conservation, has created an intense research field seeking to establish whether behavioral economics and psychology can successfully address people's unwillingness to act (Abrahamse et al. 2005; Allcott and Mullainathan 2010; Croson and Treich 2014). The studies also assess the relative success of using alternative tools to engage consumers in a more pro-environmental behavior.

In this sense, "nudges" (Thaler and Sunstein 2009) have been shown to be a successful tool to influence decision-making in diverse settings, including the energy sector (see, for example, Abrahamse et al. 2005; Allcott and Mullainathan 2010; and Croson and Treich 2014). A leading mechanism used by behavioral economists is to test the role of social comparisons (Bault et al. 2008; Allcott 2011b; Czajkowski et al. 2014; Dasgupta et al. 2016). The associated theory is that people tend to react oversensitively to their performance or status relative to their peers. Thus, explicitly showing individuals how they perform in comparison to their peers could increase levels of energy efficiency leading to reductions in consumption and improving of their energy standing. These social comparisons have been implemented in many ways. Popular techniques have fused percentile statistics with a diagrammatic trigger, for example, a happy or sad face (Allcott 2011b) or "green stars" (Costa and Kahn 2013). The belief is that the latter element reinforces comparative performance. Other studies provide an explicit ranking breakdown, which illustrate precisely where a subject lies in relation to their peers (Delmas and Lessem 2014; Alberts et al. 2016). The results from these studies are encouraging, implying energy consumption can fall by a magnitude between 0 and 10 percentage points (Allcott 2011b; Delmas and Lessem 2014).

Gains from nudging have been even greater in other areas of environmental economics, including the promotion of recycling and reduction of food wastage (Convery et al. 2007; Kallbekken and Sælen 2013).

Studies have typically believed that the greatest reductions arise from the initially poor performers, although counterarguments have also been reported in recent studies. Indeed, social comparisons may create a "discouragement effect" which disincentivizes weaker participants (Hargreaves et al. 2013; Alberts et al. 2016) under certain conditions. On the other hand, Delmas and Lessem (2014) concluded from their study that alongside incentivizing the worst performers, relative information also heightens the efficiency of already high performers. They attribute this to such respondents wanting to maintain a high status. This in turn defies the "Jevons paradox" (Alcott 2005), which would predict that as one is identified as a relatively strong performer, one should react by *raising* their energy consumption. This heterogeneity implies that "targeted" dissemination (regarding both how the information is presented and to whom) could be crucial when seeking to ensure environmental gains can be made from such an intervention (Allcott and Rogers 2014; Alberts et al. 2016).

A difficult aspect within this type of research is to unravel the motives that drive an individual's behavioral change. This is particularly tasking because energy efficiency provides a "win-win" situation for the environment and the agents given that, by decreasing their electricity consumption, it also produces (at times substantial) financial private gains (Kallbekken and Sælen 2013). Consequently, energy conservation contains attributes akin to an impure public good (see, for example, Kotchen 2009), and so disentangling the effects produced by the stimuli, and determining the incentives that influence decision-making, is a tall order.

Using student accommodation in a controlled field experiment does partially alleviate this problem (Delmas and Lessem 2014; Alberts et al. 2016) as most university residences offer rental contracts that are inclusive of utility bills. Moreover, prices are set prior to residency and remain fixed throughout tenancy, which eliminates any financial advantages to students in relations to the amount of energy they consume. Thus, if adjustments in energy usage are witnessed once subjects are provided with performance information, this gives a clearer indication that actions are driven by an intrinsic desire to improve their standing or to act pro-socially. In this respect, the study setting is "cleaner." Furthermore, there is evidence that in this context, subjects are typically more receptive to behavioral adaptation (Giuliano and Spilimbergo 2009). This is one of the reasons why some experimenters believe student cohorts are less representative of the wider population although some existing studies prove otherwise (Druckman and Kam 2009). Nonetheless, we apply an air of caution regarding the extent to which any findings could be fully applicable to a wider population. This is one motive for offering a subset of students the opportunity to win a prize in this study. By doing so, their consumption levels are compared with others within the trial to further explore the motivational conundrum exhibited by students. We could also potentially provide findings that may be applicable to the domestic residential market where both intrinsic and extrinsic incentives exist.

This project also builds upon the existing literature in other domains. The first is that information is provided to *groups* of respondents who share a living space (hereon in referred to as “flats”). Findings from both laboratory and field experiments indicate that groups exhibit stronger tendencies for pro-social action than when people act as individuals (Mancur Olson 1965; Fehr and Schmidt 1999; Frank 2003). This pattern is observed across public good games, voluntary actions, waste reduction, and environmental affiliation. The notion is also supported by the subjective well-being literature, stating that “interconnectivity” and feeling part of something bigger than oneself instill a stronger societal construct and level of psychological happiness (Putnam and Alone 1995; Diener and Biswas-Diener 2011). This in turn facilitates instances of altruism (Andreoni 1990), reciprocity (Sugden 1984), or positive social action (Czajkowski et al. 2014). Alternatively, it could be argued that groups could bring about greater energy conservation through the competitive atmosphere it imposes. Indeed, when presented as a “team,” respondents frequently react more fiercely in order to improve their standing relative to rival groups (Terry et al. 1999; Baik 2008; Konrad 2009; Nitzan and Ueda 2009). Regardless of the disposition that motivates them, disseminating information to a group seeks to understand if (and to what extent) this adjusts the scale of behavioral change.

In this study, we also attempts to understand whether and how those who indicated to be committed to an environment of sustainable living react to comparative information. Therefore, we seek to explore to which extent self-reported positive environmental attitudes are also reflected in actual energy-efficient performance. Past literature shows evidence of a positive relationship between self-reported pro-environmental habits and concrete eco-efficient actions (see for example Urdiales et al. 2016).

To test this, we analyze the behavior of a subset of our treatment flats, which are part of a long-standing movement at the university, known as “The Green Flats Project.” These students, when completing their accommodation application form, indicated their preference to reside with other people that share the same pro-environmental attitudes and also wish to live in a sustainable way. Including this treatment affords the chance to study whether “Green Flat” residents (i) hold “below-average” baseline usage *prior* to information dissemination, (ii) are more or less responsive to the comparison data, and (iii) display a different consumption trajectory across the study period.

We also want to study how extrinsic motivations could affect the behavior of participants. To analyze this, around half of the treatment flats enter into a competition for prizes, with the winners being those flats who consume the least energy per student during the intervention period. The literature here suggests two possible impacts from implementing this treatment. On one hand, contests typically create incentives for an overprovision of effort relative to the socially optimal level. Such “over-dissipation” (Konrad 2009) is accentuated in experimental settings, where the extent to which respondents engage in the contest consistently exceeds the thresholds predicted by theory (Davis and Reilly 1998). This is exacerbated in instances where prizes are distributed proportionally (Cason et al. 2010), or when the prize quality is high (Doraszelski and Markovich 2007), there is a heightened "desire to win" (Lugovskyy et al. 2010) and when we see a greater degree of homogeneity among contestants (Clark and Riis 1998; Baik 2008). In contrary, opposing literature shows empirical and experimental examples (Bergstrom et al. 1986; Pellerano et al. 2017) where such extrinsic incentives offset (or "crowd out") the innate or intrinsic motive to act in a pro-social way. Based on this crowding-out literature, it is suggested that paying people for an activity may help in the short run but reduce their intrinsic motivation to perform the task in the long run once the incentives are removed. An overview of the evidence surrounding this area is provided by Cerasoli et al. (2014), and it is certainly an aspect that is both interesting and highly policy-relevant to consider.

Finally, there is often disagreement in this research domain as to how persistent habits are once a "nudge" is removed. For associated policy, understanding the long-term benefits of an intervention is crucial for forecasting the impact(s) and estimating the financial outlay required in order to achieve a successful outcome. Existing evidence in this domain varies, with some studies suggesting that behavioral habits can partially persist into medium to long term (Abrahamse et al. 2005; Allcott and Rogers 2014), while others indicate that pro-social actions quickly dissipates once the intervention disappears (Dolan and Metcalfe 2013). Intrinsically motivated individuals tend to persist longer in pro-social actions, principally because by acting in that way, they get reinforced their self-image and status (Cerasoli et al. 2014).

To test this, we stop sending emails to a subset of our student groups halfway through the trial period. Half of those subset of students were part of the "Green Flats Project," while the other half were not. By comparing their consumption against those who obtain the ranking email for the whole intervention time frame, the question on habit persistence can be further explored.

By imposing these new elements onto an existing research framework, this study looks not only to confirm and reinforce some of the current beliefs on how non-financial stimuli can incentivize behavioral change but also to examine how such an action might be influenced by facets of persistence, extrinsic motivation, and prior attitudes toward sustainability.

Experimental Design and Procedures

The experiment ran between January and May 2017 at the University of East Anglia (UEA), Norwich, UK. Fourteen flats were selected for the study that involved 140 students. An overview of the flats and their attributes is given in Table 1. Before the trial began, participants were informed that the energy they used in residences would be logged and that this (anonymized) data would be sent to them through a weekly email. This would show their absolute usage and how this is compared to the other residences which partook in the study. It was made explicitly clear that relative efficiency would not lead to a change in accommodation fees.

Including the "Green Flats" afforded a unique opportunity to see if those who signaled a preexisting preference for a pro-environmental lifestyle deviated from the

Table 1 The monitored flats and their characteristics

Flat name	Number of students	Email stopped after 6 weeks	Green	Prize
AA17	12			✓
BB17	8	✓	✓	
CC17	10			✓
DD17	10			✓
EE17	10	✓		
FF17	10	✓		
GG17	10		✓	✓
HH17	10			✓
II17	11		✓	✓
JJ17	11	✓	✓	
KK17	11			
LL17	9			✓
MM17	9			✓
NN17	9			

main cohort. Possible differences could be anticipated in relation to the general (base) usage or how individuals and comparative information influenced energy performance. While the “Green Flats Project” has existed at the UEA for a number of years, no direct obligation or onus is placed upon the students regarding sustainability when they live in the flat through the academic year.

In order to test the role of persistence, four of the flats in the study would (without warning) stop receiving the emails, yet their usage continued to be logged and ranked. The monitoring of energy usage also continued beyond the information dissemination period for all flats, in what is later described in the results and discussion sections as the “post-intervention” time frame. Table 2 shows that following 10 weeks of emails, the Spring Semester was bisected with 4 weeks of an Easter break. Students returned, and for a period of 6 weeks, the monitoring continued. However, email communications stopped after 4 of these weeks, affording a chance to see if (short-run) habits persisted in the absence of a reminder for the remaining ten flats. For the four flats mentioned above, emails stopped in week 8 of the timeline given in Table 2.

When exploring the role of the extrinsic motivation, the selection of the prize had to be chosen carefully. Instead of offering direct monetary incentives, the prizes students were competing for including (i) a three-course meal and drinks at one of the on-campus restaurants and (ii) lunch vouchers for the same establishment. These prizes present positive advantages. Firstly, given that readings were taken at group level, it reinforced an idea of cohesion within flats, which brings about the notion of working as a team and being rewarded in the same way. Secondly, this prize was perceived as something that students would value with greater equity than monetary equivalents given the diversity in the students’ financial backgrounds.

Each flat was fitted with a monitor that isolated, logged, and stored energy usage data. Meter readings were taken at the same time of each week, and students were t:1 **Table 2** Timeline of the study

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Pretrial		Semester Part 1 (email sent)										Easter (emails not sent)				Semester Part 2 (email sent)				Posttreatment (emails not sent)	

t:2

Energy Monitoring Research Project

Week **8**

Your Flat Code **DD17**

This Week

Rank	Team	Usage
1	BB17	10.56
2	NN17	11.16
3	HH17	15.49
4	KK17	15.55
5	GG17	16.97
6	MM17	18.00
7	CC17	18.44
8	EE17	18.78
9	LL17	19.93
10	FF17	21.94
11	**DD17**	**22.31**
12	II17	23.55
13	JJ17	25.55
14	AA17	26.81

Running Total

Rank	Team	Usage
1	BB17	917.63
2	HH17	1182.96
3	MM17	1236.00
4	NN17	1300.90
5	GG17	1306.33
6	KK17	1351.52
7	EE17	1472.60
8	CC17	1598.00
9	**DD17**	**1720.00**
10	LL17	1761.65
11	FF17	1764.80
12	AA17	2374.04
13	II17	2402.80
14	JJ17	2432.79

Weekly Performance

Week	Rank
1	7th
2	9th
3	11th
4	9th
5	11th
6	11th
7	7th
8	11th
9	
10	
11	
12	
13	
14	

To opt out at any time, email michael.brock@uea.ac.uk

Fig. 1 A sample email

emailed on the following day of each week. Figure 1 shows that information was disseminated to students through three tables. One showed weekly usage and the associated rankings across all competing groups. A second gave the same information for overall usage and ranking since the beginning of the intervention period. The final table provided a “ranking timeline” for the course of the trial period.

Behavioral Predictions

In this section, we present our behavioral predictions that are derived from the relevant literature reviewed in section "Background of the Study" and motivate our experimental design described in section "Experimental Design and Procedures". In this study, and as discussed previously, we are interested to analyze the effect of individual and social information on electricity consumption and whether there is a persistent effect of that information once the feedbacks are removed. Furthermore, we aim to study whether and in which extent extrinsic incentives have an effect on energy conservation. Lastly, we want to analyze whether subjects who self-signaled to have a pro-conservation or "green" identity respond in a greater magnitude to the information compared to those who did not identify themselves as being environmentally friendly.

Role of Information

H1: Students receiving individual and comparative feedback increase energy conservation.

This hypothesis is built on the notion that receiving both individual and social information in the form of a league table will stimulate efforts to lower per-student usage over time. This is grounded in the notion that the league table incites competitive tendencies and a desire for flats to improve their relative standing in the league.

Role of Persistence

H2: Those who stop receiving feedbacks increase their electricity consumption as compared with those who keep receiving information.

This second hypothesis follows the notion that the students in flats where the email stopped halfway through the trial are likely to have a higher energy usage than those who continue to receive emails. At the very least, we would expect the former group to be returning to prior intervention levels as they revert to their original habits in the absence of individual and social energy information. This provides one measure of persistence.

Role of Prizes

H3a: The existence of extrinsic incentives will increase conservation efforts.
H3b: Once the rewards are given, subjects return to the pretrial level of consumption.

This is the conjecture that extrinsic rewards stimulate respondents in the "prize" treatment to reduce energy usage to a greater extent. A related hypothesis is that this group will adjust their consumption more rapidly over time in their desire to win the prize than those who are in the "non-prize" group. However, once the prizes are given at the end of the intervention period, subjects do not maintain their low levels of consumptions, but return quickly to their baseline level of energy usage. Indeed, extrinsic incentives may work in the short term but might reduce the intrinsic motivation to perform the pro-environmental action once the incentives are removed.

Role of Green Identity

H4a: *Self-signaled pro-environmentally friendly individuals react stronger to the feedbacks by reducing the electricity consumption more than the nonself-identified "green" subjects.*

H4b: *Self-signaled pro-environmentally friendly individuals persist in their conservation habits after the feedbacks are removed.*

The first hypothesis revolves around the idea that students who have expressed prior preferences to act sustainably will have a lower energy usage on average as compared to those who have not made this commitment. If this effect is accentuated by reputation, we would also expect the gap between these two groups to widen overtime during the intervention period. Furthermore, we expect these subjects to maintain their good habits even after the information is removed. Indeed, once individuals experience the positive aspects of being more energy-efficient, their positive self-image and status improve reinforcing their intrinsic motivation for behaving pro-environmentally. This will further encourage them to maintain their conservation habits even after the intervention period is over.

Analysis and Results

In this section, we are presenting the results from our analysis over aggregate and heterogeneous behaviors using uniquely generated experimental data. Our research questions are addressed in the subsections below, and accordingly, we assess whether our results validate or reject our behavioral predictions.

The Role of Information

One of the major aims of this research was to identify whether the provision of energy information impacted upon subsequent behavior. In order to assess this usage against that of those students not in the study, the University Estates Division was able to provide aggregated monthly energy usage for the associated residential buildings covering the study period. These buildings comprise entirely of student accommodation, meaning the two data-sets are comparable across the experiment's

Table 3 A comparison of flat usage against the building baseline

	Average weekly usage [building (KwH)]	Average weekly usage [study flats (KwH)]	Difference (%)	t-statistic *(p)*
January	19.65	20.47	+ 4.14**	2.43 *(0.01)*
February	20.38	20.93	+ 2.69*	1.63 *(0.051)*
March	16.07	15.74	— 2.03*	—1.3 *(0.09)*
April	12.75	12.55	+1.64	—0.079 *(0.21)*
May	13.99	14.36	+2.64*	1.47 *(0.07)*

*$p < 0.1$, **$p < 0.05$

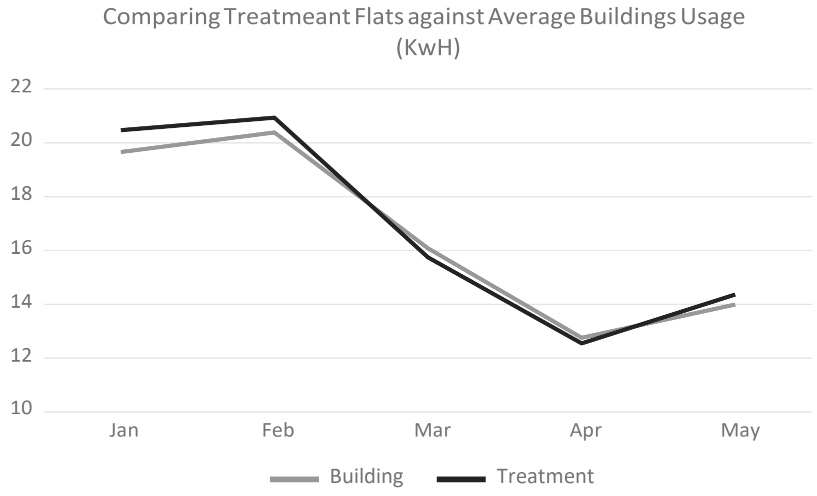

Fig. 2 Comparing treatment flat and building usages

time frame. The results identify a clear pattern of energy conservation behavior for the treatment groups relative to the “building-level” baseline.

Table 3 and Fig. 2 confirm that students living in the treatment flats consumed more than the average level from within their respective buildings during the initial phase of the study. However, the identified gap significantly erodes overtime. Indeed, after approximately 2 months of disseminating information through emails, the average electricity consumption of treated flats is lower compared with others within their respective buildings, validating *H1*. This means that, and as hypothesized, dissemination of individual and social information in a form of league table incites the competitive spirit in our subjects increasing their conservation efforts. The magnitude of this effect is consistent with previously cited field research and indicates the potential gains that could be derived by raising the visibility of energy usage via social comparisons. This reinforces the positive contribution that behavioral interventions could play in facilitating tangible adaptations in how people behave. While this trend is aligned to previous works conducted at the same

Table 4 Linear regression model for the log weekly usage per student clustering by independent observations (teams)

	(1)
Variables	Log weekly usage per student
No email stop	*Ref*
Yes email stop	—0.00130
	(0.154)
Weeks	—0.0264***
	(0.00654)
Constant	2.970***
	(0.0859)
Observations	294
Number of number of teams	14

Robust standard errors in parentheses

****p* <0.01, ***p* <0.05, * *p* <0.1

university (Brock 2016), this is still something that could be highly prioritized in future work to affirm the robustness of this result.

Although only a crude measure of persistence, the fall in efficiency between April and May serves as an initial warning about how subjects respond to information over time and how this relates to their behavior. Emails stopped in early May, and by the end of the month, the average usage of energy among the treatment flats return to above the building level (although not fully returning to the pre-intervention disparity). Two possible conjectures arise from this. The first is that good habits may erode quickly once a nudge is no longer explicitly imposed upon individuals – this is something that shall be considered further in the next subsection. The other is that by the time students were exposed to many weeks of emails, the novelty or interest in the project disappears. Both of these conjectures hold a strong policy relevance and indicate that extreme care needs to be paid to the frequency, format, and timeline of delivering such information in order to maximize and retain user engagement.

The Level of Persistence

Figure 2 implies that there may be some questions regarding how long-lasting an information stimulant may be. As shown in Table 1, we test this aspect by including a subset of flats who stopped receiving emails after a period of just 6 weeks. Nonetheless, these flats' readings were still taken for the full 22 weeks of the study allowing their usage patterns to still be seen for a full 3 months after the email termination date.

Table 4 confirms that no significant differences occurred between the two treatment groups, which in principle gives us little support for *H2*. However, upon closer inspection, it appears that this result may have been driven by the wide heterogeneity

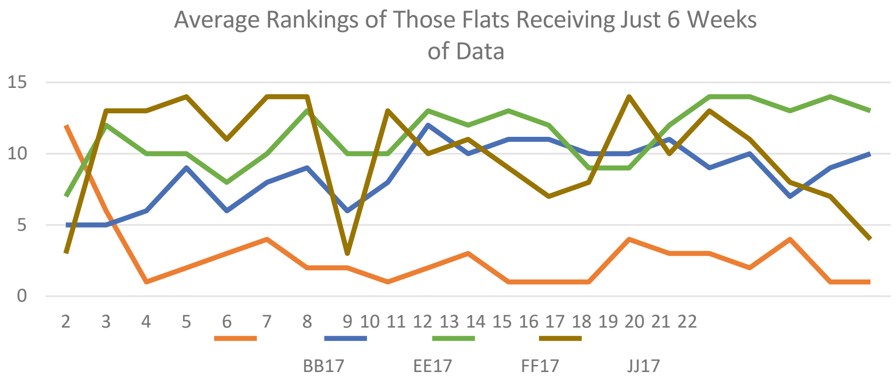

Fig. 3 The ranking trends of the four flats where emails stopped after 6 weeks

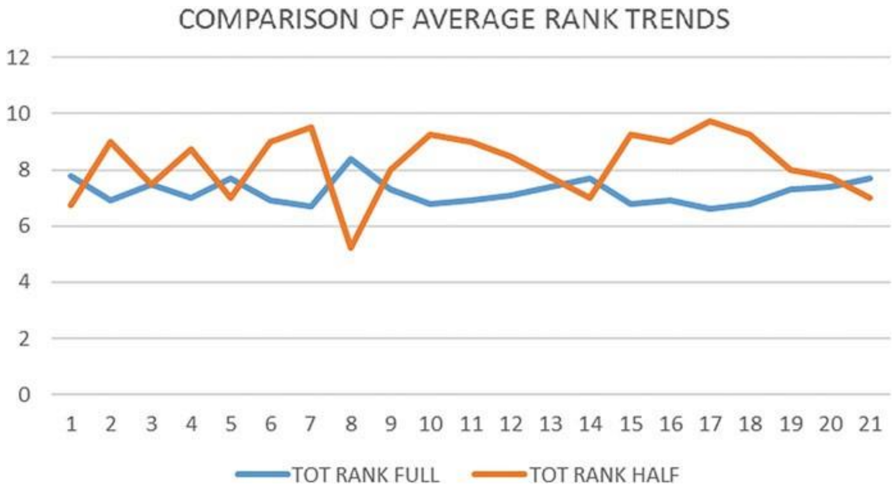

Fig. 4 Comparing ranking trends between those receiving emails for only 6 weeks against those receiving emails for the full study period

in the performances of the four “6-week” sub-treatment flats. Exemplified through Fig. 3, we see that Flat “BB17” was an extremely strong performer (hence low ranking) throughout the study period, perhaps because this group already acquired preexisting energy efficiency habits and constantly practices them. For both Figs. 4.2 and 4.3, the crucial stage is Week 8, which was the time emails stopped for the “6-week” groups. With the exception of Flat “JJ17,” Fig. 3 shows an apparent upward trend (and thus worsening rank) following this period. When aggregated in Fig. 4, this seems most pronounced in the initial weeks after the email stopped.

Furthermore, when inspecting Fig. 4, it is noteworthy to look at the slight increase in the rankings of those within the “full information” treatment after week 19. This is the time when the information disseminating emails stopped. The trends seen in weeks 9–11 for our “6-week subsample’ and in weeks 19–21 for the remaining

Table 5 Linear regression model for the log weekly usage per student clustering by independent observations (teams)

	(1)
Variables	Log weekly usage per student
Non-prize	*Ref*
Prize	0.0888
	(0.111)
Weeks	—0.0264***
	(0.00654)
Constant	2.918***
	(0.103)
Observations	294
Number of number of teams	14

Robust standard errors in parentheses

***p <0.01, **p <0.05, *p <0.1

groups imply that it is the immediate time period after stopping an information interjection that creates the most severe reactions in behavior.

University accommodation contracts ceased from "week 22," which explains why further monitoring did not occur. However, assessing these patterns in future work could be easily achieved by simply bringing forward the treatment start date or by using a set of subjects (e.g., postgraduate students or domestic residents) who live in their accommodation for a full calendar cycle.

The Impact of Offering a Prize

Another key aim is to see what impact (if any) extrinsic incentives have on the subjects' decrease of their energy consumption. As previously stated, two strands of competing literature exist here. The first argues that the added competition should heighten the desire to improve one's standing, leading to an even greater reduction in energy consumed. However, an opposing (theoretical and experimental) literature shows evidence that extrinsic motivations can offset (or "crowd out") intrinsic desires or motivation of pro-environmental behavior.

The results of this study are mixed. Table 5 observed no significant differences in energy consumption. This result arises when formal econometric testing is used to compare those in the "prize" versus "non-prize" treatment groups. This suggests that the opportunity to reap additional extrinsic benefits through a strong relative performance does not translate into greater instances of energy-saving behavior.

However, by delving a little deeper, a couple of interesting and policy-relevant patterns emerge from those flats who were given the chance to win a prize.

The first of these results arises if we segment the results into three stages: before, during, and after the intervention period. Table 6 provides the average consumption

Table 6 A comparison of energy usage differences between prize and non-prize groups

	Pre-intervention usage (KwH/week)	Intervention period usage (KwH/week)	Post-intervention usage (KwH/week)
Prize cohort	14.99 (5.59)	16.85 (6.96)	14.22 (4.21)
Non-prize cohort	12.1 (3.76)	16.92 (6.89)	14.03 (5.68)

for the two groups across these periods. It shows us that within the "pre-intervention" phase, those in the "prize" treatment group consumed on average 23.9% more energy each week than those in the "non-prize" treatment. This means the "prize" subsample were relatively poor performers at the time the emailing began.

However, the gap not only shrunk but reversed through the intervention period wherein the "prize" treatment groups consumed a marginally lower level of energy on average per week than the remaining set of participants. The difference (0.07KwH) is marginal and statistically insignificant, but given the pre-intervention consumption levels, this implies that the potential for additional reward could represent some form of stimulus to respondents. This result validates our *H3a*. Indeed, as it was anticipated, the existence of an extrinsic motivation makes "prize" groups to make an extra effort in their electricity conservation. Regarding the post-intervention figures, we see the levels of energy usage from the "prize" groups almost return to their pre-intervention threshold. Yet the magnitude of this return is by no means as substantial as for the "non-prize" cohort, suggesting that perhaps there are some lasting effects from the extrinsic prize.

While this first effect seems promising, a second finding reveals that in the post-intervention period, the average usage of the "Prize" subsample rose by 22% compared with the final week when emails were sent. Combined with statistics in Table 6, this implies that the "prize" flats exhibited a more pronounced downward trajectory in usage during the intervention period itself than "non-prize" counterparts. However, a rapid rise in the energy consumption was observed once prizes had been allocated, which validates our *H3b*. For individuals that are extremely competitive, this makes intuitive sense. Through the intervention period, they are likely to be very conscious of the amount of energy they were using, particularly in the weeks prior to the selection of the winning teams because of their strong desire to claim a prize. However, once the prizes were allocated, the strong impulse to be energy-efficient disappears, leading them to quickly reverting back to a pattern of higher usage. It is noteworthy to highlight that this post-intervention pattern was not witnessed for flats within the "non-prize" treatment. This result is consistent with the "crowding-out" literature, which suggests that extrinsic incentives may work in the short term but might reduce the intrinsic motivation to perform the pro-environmental action once the incentives are removed.

Informal evidence of this is given in Fig. 5. This illustrates the ranking of the leading "prize" flats over the duration of the study. Note that winners were determined by week 17. The graph shows that the four leading flats in the prize treatment

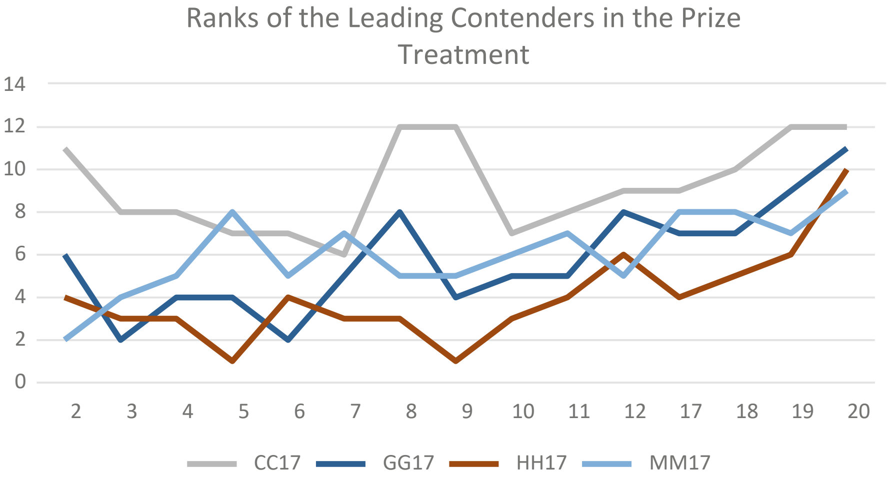

Fig. 5 Ranks of the leading contenders in the prize treatment

Table 7 A comparison of energy usage differences between Green and Non-Green Flats

	Pre-intervention usage (KwH/week)	Intervention period usage (KwH/week)	Post-intervention usage (KwH/week)
Green Flats	16.33 (7.71)	18.34 (8.41)	11.91 (5.73)
Non-Green Flats	12.73 (3.38)	16.42 (6.36)	15.65 (4.55)

had maintained a steady rank throughout the intervention period but these quickly rose (meaning they were now performing relatively badly) once the announcement is made. When considering the design and nature of implementing some form of extrinsic motivation, this type of result is undoubtedly poignant for policy-makers and energy providers alike, particularly if their objective is to improve the long-term consumption and stability of energy demand.

The Impact of Residing in a Green Flat

One of the novel elements of this study is its ability to have a subset of the subject pool from a “Green Flat.” Recall that these participants expressed a desire, far before the study begins, to live in an environmentally sustainable setting. It offers an opportunity to examine whether they have a lower level of energy usage and, of equal interest, whether they respond differently when are presented with individual and social information.

A really surprising result here is that “Green Flats” residents actually consume more energy than those in standard residencies during the “pre-intervention” phase.

Table 7 confirms this point, showing that Green Flat occupants on average consume 29% more energy each week than their peers. This finding echoes previous experimental work (Brock 2016) and seems to indicate that in the context of energy consumption, there is a clear discourse between the intentions of a person and their behavior in the absence of a mechanism for them to monitor or uphold their stated ambitions.

Nevertheless, this trend of overconsumption disappears over the intervention period and significantly reverses by the time the post-intervention period is reached. These two results validate our *H4a* and *H4b*. As we expected, these subjects react positively to the information disseminated and maintain their good habits even after the information is removed. Unfortunately, we have no way of disentangling whether this occurs because of the information channels in themselves or instead through a desire to defend a previously stated reputation. In any case, this finding is intriguing, especially for one who is looking to design techniques that will get consumers committing to longer-term pro-social activity.

The trends in Table 7 offer a second insight that is observed from the green flat treatment groups. In just the same way as with the post-intervention consumption patterns of “prize” respondents, the average consumption of those living in Non-Green Flats increases by 19.1% relative to the final weeks where the intervention took place. However, for the Green Flats over this same period, there is a continued fall in usage by an average magnitude of 23%. Linking this finding to the notions of behavioral habits and persistence, this offers the conjecture that long-term energy conservation habits may only materialize if an individual expressed a predisposition to embrace environmental attitudes.

Discussion

While these results are encouraging and complement findings of previous studies, we acknowledge that they could be significantly strengthened through repeated tests to check for their reliability and robustness. Furthermore, to do so with a larger cohort would be also very valuable. Nonetheless, this work contributes to the literature by assessing experimentally the roles of persistence, extrinsic motivation, and attitudes to sustainability on energy consumption.

It appears that the degree to which “good behavior” persists is highly dependent upon a range of factors, including prior attitudes of those receiving the information or the way in which an intervention interacts with other motives, be these extrinsic or intrinsic. With these intricacies put aside for one moment, it is clear that there are clearly potential advantages for gathering and disseminating information on energy usage. Our results imply that savings from imposing a competitive framework could offer a 5–10 percentage point reduction in energy consumption over a fairly short period of time. On aggregation, this could be translated into significant financial savings by making domestic energy users more sustainable. Moreover, this could also benefit energy suppliers through the establishment of more consistent and predictable trends in energy demand.

Nevertheless, a significant heterogeneous response arises through this study, which suggests that policy-makers need to identify and seize opportunities to target information to the various population groups that share similar characteristics. This is something that the energy industry is already aware of through aforementioned studies in relation to performance (Abrahamse et al. 2005), political ideology (Costa and Kahn 2013), and demographic status (Giulietti et al. 2005). However, this study explicitly demonstrates this, considering how both prizes and "green" individuals reveal disparate patterns of behavior.

Conclusion

This study builds upon a burgeoning literature that seeks to identify whether relatively cost-free behavioral nudging can influence people's energy consumption. To test this, students living in student residences at a UK university were provided with (absolute and relative) energy usage data through a weekly email. The study introduced new insights, firstly by issuing energy information at a flat (apartment) level and secondly by splitting this cohort to explore aspects relating to extrinsic motivation, persistent behavior, and preexisting environmental attitudes. This sought to assess (a) whether responses differ when data is provided through a group dynamic and (b) whether these imposed subtreatments create a range of consumption trends as a consequence.

The results imply that issuing ranking information can incite behavioral change. The treated flats involved in the study reduced their usage by a magnitude which make them jump from an above-average consumption to a below-average one relative to their building-level cohort. Interestingly, students in the "Green Flats" proved to be good performers through the intervention period. This result suggests that those students have a greater positive response to individual and comparative performance information with respect to non-"Green Flats" students. Importantly, this effect persists over time in the post-intervention even when the information is removed.

While no evidence hints toward the crowding out effect of extrinsic motivations on intrinsic ones, there are serious questions regarding the long-term impact of offering such additional reward, particularly from the point after a promised incentive is issued. Finally, "good consumption habits" seem to erode quickly for those who receive the prize, and at multiple junctures in the study, an almost immediate upward trajectory in consumption is observed once emails ceased and information is removed.

These findings appear highly relevant for the field of energy and environmental economics. We advocate extending and expanding upon these experimental beginnings in order to strengthen the evidence for these early conjectures. The main implication is that policymakers, industries, and consumers alike must consider the role of nonfinancial stimuli in inciting small and yet significant changes to behavior. A motivation to change may exist, yet how long does this desire remains is highly debatable. Moreover, this project implies that the success of an intervention may crucially hinge on the way that it is imposed. This relates both to its frequency and its target group's characteristics (i.e., demographic, socioeconomic, and psychological). It suggests that an ability to nurture (or indeed even establish) a desire for behavioral change in an environmental field such as energy usage will require a well-crafted and thoroughly planned scheme if the anticipated benefits are to fully materialize.

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References

Abrahamse W, Steg L, Vlek C, Rothengatter T (2005) A review of intervention studies aimed at household energy conservation. J Environ Psychol 25(3):273–291

Alberts G, Gurguc Z, Koutroumpis P, Martin R, Muûls M, Napp T (2016) Competition and norms: a self-defeating combination? Energy Policy 96:504–523

Alcott B (2005) Jevons' paradox. Ecol Econ 54(1):9–21

Allcott H (2011a) Consumers' perceptions and misperceptions of energy costs. Am Econ Rev 101(3):98–104

Allcott H (2011b) Social norms and energy conservation. J Public Econ 95(9–10):1082–1095

Allcott H, Mullainathan S (2010) Behavior and energy policy. Science 327(5970):1204–1205

Allcott H, Rogers T (2014) The short-run and long-run effects of behavioral interventions: experimental evidence from energy conservation. Am Econ Rev 104(10):3003–3037

Andreoni J (1990) Impure altruism and donations to public goods: a theory of warm-glow giving. Econ J 100(401):464–477

Attari SZ, DeKay ML, Davidson CI, De Bruin WB (2010) Public perceptions of energy consumption and savings. Proc Natl Acad Sci 107(37):16054–16059

Baik KH (2008) Contests with group-specific public-good prizes. Soc Choice Welf 30(1):103–117

Bault N, Coricelli G, Rustichini A (2008) Interdependent utilities: how social ranking affects choice behavior. PLoS One 3(10):e3477

Bergstrom T, Blume L, Varian H (1986) On the private provision of public goods. J Public Econ 29(1):25–49

Brock M (2016) Is the Monster Green-Eyed, or just Green? Assessing the impact of group cohesion and environmental attitudes on energy conservation habits (working paper)

Cason TN, Masters WA, Sheremeta RM (2010) Entry into winner-take-all and proportional-prize contests: an experimental study. J Public Econ 94(9–10):604–611

Cerasoli CP, Nicklin JM, Ford MT (2014) Intrinsic motivation and extrinsic incentives jointly predict performance: a 40-year meta-analysis. Psychol Bull 140(4):980

Clark DJ, Riis C (1998) Competition over more than one prize. Am Econ Rev 88(1):276–289

Convery F, McDonnell S, Ferreira S (2007) The most popular tax in Europe? Lessons from the Irish plastic bags levy. Environ Resour Econ 38(1):1–11

Costa DL, Kahn ME (2013) Energy conservation "nudges" and environmentalist ideology: evidence from a randomized residential electricity field experiment. J Eur Econ Assoc 11(3):680–702

Croson R, Treich N (2014) Behavioral environmental economics: promises and challenges. Environ Resour Econ 58(3):335–351

Czajkowski M, Hanley N, Nyborg K (2014) Social norms, morals and self-interest as determinants of pro-environment behaviours. Working paper 2014-03, Department of Geography and Sustainable Development, University of St Andrews. Available through http://www.stir.ac.uk/management/research/economics/working-papers/. Working paper 2014-06

Dasgupta P, Southerton D, Ulph A, Ulph D (2016) Consumer behaviour with environmental and social externalities: implications for analysis and policy. Environ Resour Econ 65(1):191–226

Davis DD, Reilly RJ (1998) Do too many cooks always spoil the stew? An experimental analysis of rent-seeking and the role of a strategic buyer. Public Choice 95(1–2):89–115

Delmas MA, Lessem N (2014) Saving power to conserve your reputation? The effectiveness of private versus public information. J Environ Econ Manag 67(3):353–370

Department for Energy and Climate (DECC), Cabinet Office (2015) Energy Consumption in the UK. https://www.gov.uk/government/uploads/system. Accessed 15 July 2016

Diener E, Biswas-Diener R (2011) Happiness: unlocking the mysteries of psychological wealth. Wiley, New York

Dolan P, Metcalfe R (2013) Neighbors, knowledge, and nuggets: two natural field experiments on the role of incentives on energy conservation. CEP discussion papers, CEPDP1222. Centre for Economic Performance, London School of Economics and Political Science, London

Doraszelski U, Markovich S (2007) Advertising dynamics and competitive advantage. RAND J Econ 38(3):557–592

Druckman JN, Kam C D (2009) Students as experimental participants: a defense of the 'narrow data base'. SSRN eLibrary

Fehr E, Schmidt KM (1999) A theory of fairness, competition, and cooperation. Q J Econ 114(3):817–868

Frank SA (2003) Repression of competition and the evolution of cooperation. Evolution 57(4):693–705

Giuliano P, Spilimbergo A (2009) Growing up in a recession: beliefs and the macroeconomy (no. w15321). National Bureau of Economic Research, Cambridge, MA

Giulietti M, Price CW, Waterson M (2005) Consumer choice and competition policy: a study of UK energy markets. Econ J 115(506):949–968

Hargreaves T, Nye M, Burgess J (2013) Keeping energy visible? Exploring how householders interact with feedback from smart energy monitors in the longer term. Energy Policy 52:126–134

HM Government (2006) UK Climate Change Programme 2006. The Stationery Office, London

Information on the SMART Meter rollout in the UK in 2020. https://www.smartenergygb.org/en/smart-future/about-the-rollout. Accessed 05 Jan 2018

Kahneman D, Knetsch JL (1992) Valuing public goods: the purchase of moral satisfaction. J Environ Econ Manag 22(1):57–70

Kallbekken S, Sælen H (2013) 'Nudging' hotel guests to reduce food waste as a win–win environmental measure. Econ Lett 119(3):325–327

Konrad KA (2009) Strategy and dynamics in contests. OUP Catalogue, Oxford

Kotchen MJ (2009) Voluntary provision of public goods for bads: a theory of environmental offsets. Econ J 119(537):883–899

Lugovskyy V, Puzzello D, Tucker S (2010) An experimental investigation of overdissipation in the all pay auction. Eur Econ Rev 54(8):974–997

Nitzan S, Ueda K (2009) Collective contests for commons and club goods. J Public Econ 93(1–2):48–55

Olson MJ (1965) The logic of collective action: public goods and the theory of groups. Harvard University Press, Cambridge

Pellerano JA, Price MK, Puller SL, Sánchez GE (2017) Do extrinsic incentives undermine social norms? Evidence from a field experiment in energy conservation. Environ Resour Econ 67(3):413–428

Putnam R, Alone B (1995) America's declining social capital. J Democr 6:65

Steg L, Lindenberg S, Keizer K (2016) Intrinsic motivation, norms and environmental behaviour: the dynamics of overarching goals. Int Rev Environ Resour Econ 9(1–2):179–207

Sugden R (1984) Reciprocity: the supply of public goods through voluntary contributions. Econ J 94(376):772–787

Terry DJ, Hogg MA, White KM (1999) The theory of planned behaviour: self-identity, social identity and group norms. Br J Soc Psychol 38(3):225–244
Thaler RH, Sunstein CR (2009) Nudge: improving decisions about health, wealth, and happiness. Penguin
Urdiales MP, Lansink AO, Wall A (2016) Eco-efficiency among dairy farmers: the importance of socio-economic characteristics and farmer attitudes. Environ Resour Econ 64(4):559–574
Weimann J (1994) Individual behaviour in a free riding experiment. J Public Econ 54(2):185–200

Index Terms: