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Abstract

The aim of demand response is to make energy consumption more flexible during peak periods. Using a contextualised CPR framework, we study energy consumption choices. Subjects decide the consumption level of five activities during 10 periods. The total consumption of these activities is the CPR contribution, and payoffs depend on own consumption and the amount consumed by the group. In the nudge treatment, subjects are nudged towards the socially optimal level of consumption using injunctive norms. The average consumption observed in the nudge treatment is used to calculate the price implemented in the price treatment. The objective is to quantify the nudge via an equivalent price. The main hypotheses are: consumption choices will be lower in the treatment groups compared to the control groups; when the price level is fixed according to the nudge result, consumption choices in the price treatment will be equivalent to those in the nudge treatment. Across all 10 periods, consumption is significantly lower in the nudge treatment, and higher for control groups. In the price treatment, consumption remains between the two at or slightly above the target. We conclude that the nudge treatment performs as well as an equivalent price without the implied loss of welfare. When comparing decisions under the nudge and price treatments to the control groups, the consumption decisions are significantly different from period 2 for the nudge and, consistently different from period 7 for the price. We conclude that the nudge is understood and integrated into subjects' decision making quicker than an equivalent price.

JEL Classifications: C91, C92, D62, D91, H21

Keywords: common pool resource, demand response, laboratory experiment, incentives, nudge, price

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1 Introduction

In the last two decades, we have seen an increase in the share of renewable energy and in distributed power generators (REN21 2016). This phenomenon calls for new strategies in the management of the electricity grid in order to maintain power supply reliability and quality, particularly at times when intermittent energy sources constitute a significant part of total system capacity. This need is all the more important given that the European Union has set ambitious targets to reduce greenhouse emissions and to increase the share of renewable energy sources in the production mix by 2030 (European Commission 2014).

Reliable management of the electricity system requires a perfect balance between supply and demand in real time. Given the increase in renewable energy sources, this balance is harder to achieve as supply and demand levels can change rapidly and unexpectedly, in particular on high demand days when natural conditions are unfavourable for the use of renewable energy sources. Moreover, the power generation infrastructure is highly capital intensive, such that demand side management may be one of the cheaper tools available for balancing supply and demand. Given the greater difficulty of producing peak electricity, there is a need to have a more flexible residential energy demand, particularly during peak periods. Demand response programs, defined as the changes in electricity usage by end-use consumers from their normal consumption patterns in response to signals, are certainly the main tool used or experimented in the management of the electricity grid (Balijepalli et al. 2011).

Current methods used to incentivise households to lower their energy demand include dynamic tariff structures, informational incentives, or nudge-based incentives. Under certain tariff structures consumers face financial incentives to reduce their energy demand as during certain hours or on days when demand is particularly high, the price of electricity is greater than at off-peak times. This increased price is designed to induce lower electricity use at times with high wholesale market prices or when system reliability is jeopardised (Borenstein et al. 2002; Faruqui et al. 2010a; Faruqui et al. 2010b; Hargreaves et al. 2010; Raw and Ross 2011). Informational incentives involve providing the household with increased information on their consumption to allow them to make a more informed decision. Such incentives include information on how personal consumption compares from one day to another, or on a weekly or a monthly basis (Benders et al. 2006; Houde et al. 2013; Mizobuchi and Takeuchi 2013; Schleich et al. 2013; Carroll et al. 2014; Schultz et al. 2015). Nudge based incentives go beyond simple information by changing the way the information is presented in order to exploit behavioural biases (Schultz et al. 2007; Thaler and Sunstein 2008; Allcott 2011; Ayres et al. 2012).

Our main research hypothesis is that the management of end-use consumers in peak periods is similar to the management of agents that use a common pool resource (CPR). Here, the CPR is the limited renewable energy sources which are sustained so long as electricity consumption does not exceed power capacities. Such an approach allows us to explore, in an experimental setting, the impacts of demand response tools on consumers' behaviour when they are placed in the social dilemma due to the need to balance supply and demand. This dilemma is the conflict between the personal interest of consuming electricity without constraint and the collective interest of maintaining power supply reliability.

The principal objective of the present experiment is to use a contextualised CPR game to compare the effect of nudges and prices on subjects' consumption choices in order to give a monetary value to the nudges. The secondary objective is to compare subjects' choices of which appliances to use and which electricity-consuming activities to take part in when faced with a need to reduce their demand. In doing so, we hope to respond to the following questions: Which interventions are more likely to increase socially optimal behaviour? What is the "equivalent price" of the nudge? How do people respond to nudges and prices in an energy consumption context? What trade-offs do they make in terms of which electric appliances to use or not use?

The remainder of this paper is set out as follows, the second section discusses literature related to the research questions, the third section sets out the theory behind the CPR game used in the experiment, and the fourth section describes the experimental design. The fifth section gives the results and the final section discusses and concludes

2 Related literature

Our paper is particularly related to experiments which study the effect of monetary incentives, and nudges or non-monetary incentives on behaviour in experiments. In addition, due to its contextualisation, our experiment is further related to field experiments on electricity consumption. We discuss each of these areas of literature below.

2.1 Monetary interventions

In laboratory experiments, taxes are found to be a first best policy when it comes to managing behaviours which result in negative externalities (Ballard and Medema 1993). In experimental games with negative externalities, studies have shown that subjects perform at near optimal levels (Plott 1983; Cochard et al. 2005). Yet, taxes are seldom accepted by the public. This can be explained by a preference for the status quo (Cherry et al. 2014), by tax aversion; individuals feel that negative incentives, such as taxes, impede their free-will and are controlling ; by framing; acceptance for taxes increases when the mechanism behind them is explained (Kallbekken et al. 2011; Heres et al. 2013).

Given that monetary interventions such as taxes, and dynamic pricing in the context of electricity consumption (Alexander 2010), can be politically difficult to implement as well as costly, policy makers have also used non-price interventions to influence households to reduce their energy consumption, such as nudges.

2.2 Studying nudges in the laboratory

A nudge is defined as a change to a choice setting which alters individuals' behaviour without removing any of the choices available to them nor affecting their economic incentives. Nudges are designed to incentivise individuals to pick an option that is in their best interest, an option which they would not necessarily choose for themselves (Thaler and Sunstein 2008). While the idea of nudges is not recent, the term has certainly seen an increased level of interest in recent years. The nudge intervention used in our experiment relates to both information on suggested play as the feedback is based upon the optimal level of consumption, and on social approval as we add an element of whether an individual's consumption behaviour is approved of or not.

2.2.1 Suggested play

Experiments using suggested play recommend a course of action to subjects concerning their contribution to a public good or their extractions from a common pool resource. In a threshold public good game, Marks et al. (1999) and Croson and Marks (2001) find that suggesting a fair contribution to subjects before they decide on their contribution only results in the provision of the public good when preferences are heterogeneous. Dal Bó and Dal Bó (2014) find that suggested play works only under the addition of an element of moral suasion; the idea in a public good game that increasing your contribution to the maximum amount benefits everyone.

In a CPR game, Delaney and Jacobson (2015) suggest to groups what they should do to increase their payoffs using both informative and normative messaging and compare this to a subsidy. They find that the subsidy is the most effective, resulting in a 27.34% reduction in CPR extraction compared to no incentive. Their nudge treatments (information and normative messaging) result in a 0.55% and a 5.233% reduction, respectively. The authors note that it is unusual that the normative messaging treatment results in a small reduction in extraction level when compared to information alone given that previous research has found significant effects on energy and water consumption reduction through the use of normative messages (Schultz et al. 2007; Allcott 2011; Ayres et al. 2012; Ferraro and Price 2013). They suggest that the non-significant difference in the results may be due to small sample sizes (n=15). However, it may also be due to a certain level of overlap between the two treatments, as the information treatment also contains normative language. The two treatments, information and normative messaging should perhaps instead be viewed as a weak normative message and as a strong normative message, respectively.

Boun My and Ouvrard (2017) explore the impact of recommended play, or a nudge, and taxes on contributions to a public good for reducing pollution. They hypothesise that reaction to a nudge is greater when subjects are more sensitive to environmental issues. After measuring environmental sensitivity, subjects' are split into groups according to whether they are more or less environmentally sensitive than average and are then faced with either a nudge; a statement of the socially optimal contribution to the public good, or a tax; a linear tax based upon the optimal contribution.

The tax treatment shows the greatest increase in contributions for both high and low sensitivity groups, a 45% and 34% increase in contributions, respectively. Interestingly, they find that the nudge divides subjects according to their environmental sensitivity; with the least sensitive reducing their contribution by 29% compared to the baseline, and the most sensitive increasing their contribution by 14%. In their set-up, Boun My and Ouvrard (2017) create groups of either all highly environmentally sensitive subjects, or of less environmentally sensitive subjects. This is perhaps not entirely reflective of the situations where individuals interact with people of differing levels of environmental sensitivity.

2.2.2 Social approval

In addition to suggested play, the nature of the nudge used in our experiment provides social approval or disapproval of an individual's behaviour in the game. The rationale is that social approval increases optimal behaviour in public good and CPR games as subjects perceive utility (disutility) from social approval (disapproval) (Rege and Teller, 2004). There is mixed evidence as to whether social information and approval increases or decreases optimal behaviour in collective action games. It has been shown both theoretically (Holländer 1990; Fehr and Schmidt 1999) and experimentally that such social norms can increase contributions in collective action games (Cialdini 2003; Rege and Telle 2004; Spraggon et al. 2015). In other experiments, social approval has been shown to reduce optimal behaviour (Noussair and Tucker 2007; Brent et al. 2017).

In a one-shot public good game, Rege and Telle (2004) find that when there is indirect social approval of a subject's contribution (subjects reveal their contribution to the group), contributions are of the order of 73% on average, much higher than the 34% contribution in the base game and the theoretical prediction of 0 contributions. Noussair and Tucker (2007) run a similar experiment to Rege and Telle (2004). They find that social approval of subjects' decisions does not have a significant effect on contributions in both a one-shot game and a repeated game. Indeed, in the repeated game, the possibility for social approval or disapproval leads to lower contributions than in the absence of approval.

Gächter and Fehr (1999) find that such social approval, created by publically disclosing all contributions to all subjects at the end of a 10 period game, only has a significant effect when subjects are allowed to create a group identity. When subjects are complete strangers, the revelation of their contributions has a weak positive effect on contributions. In a CPR game, making public the decisions of subjects has been shown to have a negative effect on optimal behaviour. When faced with heterogeneous levels of extraction in a CPR game, Brent et al. (2017) find that the use of social approval by observing individuals' actions increases the level of resource extraction.

The social approval used in our experiment does not come from the other subjects, but from the regulator who informs subjects via a happy or sad face whether they are consuming more or less than the optimal amount.

2.3 Electricity field experiments

The different incentives described above have also been tested independently in field experiments in different geographical locations but have not often been compared within the same experiment, under the same conditions. Mizobuchi and Takeuchi (2013) compare a financial incentive (comparable to a peak-time rebate) to the same financial incentive combined with socially comparative information. They find that the additional information on a household's consumption relative to their neighbours does not result in a significantly larger reduction in consumption. In an Irish study, Carroll et al. (2014) test a combination of financial incentives and informative and comparative nudges and as such the effects of each cannot be separated.

In electricity consumption field experiments, social norms are used to incentivise a reduction in electricity consumption. Households are told how much they consume compared to the average consumption of their neighbourhood. However, Schultz et al. (2007) found evidence of a boomerang effect; upon being told that they are consuming below the average of their group, low-consuming households increased their consumption. There was a tendency to converge towards the average level of consumption.

In pilot studies using Opowers Home Energy Report, a combination of both social norms, a description of a household's consumption compared to the average of their neighbourhood, and injunctive norms, the addition of a smiley face to the bills of those who consume less than average to promote social approval of this behaviour, are used to incentivise households to lower their electricity demand. Such information is found to have an effect of around 2% on average (Allcott 2011).

While taxes, or changes in prices, and nudges have been tested previously in both laboratory and field experiments, few papers, to the authors' knowledge, have directly compared subjects' behaviour using clearly defined treatments (bar Delaney and Jacobson (2015) and Boun My and Ouvrard (2017)). The present paper adds to the research by exploring demand side management via a contextualised CPR game: subjects are incentivised to reduce their consumption during a peak period taking into account the negative externalities resulting from overconsumption. In addition, the experimental design asks subjects to decide whether to use, or not, various electrical equipments which determines their consumption for the peak period.

3 Theory

Ostrom (1990) defines a common pool resource as a stock of a natural or man-made resource system from which a flow of resource units can be withdrawn. The stock of CPR is renewable and so the stock can be sustained so long as average withdrawal rates do not exceed average replenishment rates. The social dilemma of CPRs is that individuals would like to withdraw more than the sustainable amount resource units from the stock and as such there is a conflict between personal interest and collective interest.

Electricity can be thought of as a CPR; the electricity network (power stations, distribution centres, transmission lines) represents the resource system and the resource units are the kilowatt hours. In the short run, we can consider that this system provides a stock electricity units available to households. The stock of electricity is renewable in the sense that once electricity has been consumed it must be immediately reproduced in order to maintain supply and demand balance. There is equally a problem of overuse: on days of extreme weather, or when renewable energy resources supply electricity, there is risk of demand outstripping supply which implies a need to reduce the demand of electricity (Bäckman 2011).

3.1 Common pool resource game

A group of n players share a common resource. They each have an endowment e which can be used to invest in the extraction of the common resource. The amount invested in resource extraction by individual i is x_i with Σx_i the amount invested by the group. Extraction of the resource earns each player a for every unit extracted personally, minus b for every unit extracted by the group regardless of who extracts it. The cost of investing in the extraction of the resource is c. Each player's profit depends on his own investment in extraction as well as the group investment:

$$\pi_i = e - cx_i + x_i(a - b\Sigma x_i)$$

A rational, self-interested player invests an amount x_i which maximises their profit:

$$max_{x_i}\pi(x_i, \Sigma x_i) = e - cx_i + x_i(a - b\Sigma x_i)$$

The first order condition is:

$$-c + a - bx_i - b\Sigma x_i = 0$$

Supposing that all agents are equal, a symmetric Nash equilibrium can be found such that $x_i = x_j = x$ for all players i, j.

$$x_i = \frac{(a - c)}{b(n + 1)}$$

The socially optimal investment in resource extraction is the amount x which maximises the collective profit. Assuming symmetry, the player maximises:

$$max_x n\pi(x) = n[e - cx + x(a - bnx)]$$

The first order condition is:

$$-cn + an - 2bn^2x = 0$$

which gives an optimal investment where:

$$x_i = \frac{(a-c)}{2bn}$$

The Nash equilbrium results in a higher level of extraction than the socially optimal amount, hence the social dilemma. One option, to align the private earnings with the social optimum, is to increase the cost of extraction c such that the Nash equilibrium and socially optimum levels of extraction are equal. The cost of extraction c is increased by an amount d and its value is found by equating the Nash equilibrium and the socially optimal solutions[1]:

$$\frac{a-c-d}{b(n+1)} = \frac{a-c}{2bn}$$
$$d = \frac{(a-c)(n-1)}{2n}$$

4 Experimental Design

This section details the experimental design beginning with a description of the participants and the procedure, followed by the parametric protocol and the different experimental treatments. Finally, we present the hypotheses to be tested.

4.1 Participants and Procedure

The experiment took place during 12 sessions[2] in March and April 2017 at the Grenoble Applied Economics Laboratory (GAEL). Each session involved 20 subjects (240 subjects in total) and lasted for one and a half hours. Table 1 shows the number of sessions, subjects and groups per treatment. The experiment was programmed using zTree software (Fischbacher 2007). Individual earnings ranged from 17€20 to 28€00 with average earnings across sessions of 22€30 (including a 10€ show-up fee). The majority of subjects were undergraduates students in various disciplines, 59% of were female subjects, and the average age across subjects was 22 years (see table 2).

Each session began with instructions being read aloud by the experimenter and displayed on two screens at the front of the room. Subjects were told that the experiment would include several phases. The first phase of the experiment was the CPR game. The second phase involved a risk aversion test (Holt and Laury 2002). In the third and

[1]In the context of electricity consumption d is the higher price of electricity during peak periods.

[2]During the 8th session a technical problem occurred and so the results of this session are excluded from the analysis. The excluded session would have been in the price treatment.

final phase, subjects completed three questionnaires: the General Ecological Behaviour Scale (Kaiser 1998), an altruism questionnaire (Costa and McCrae 1992) and finally a demographic questionnaire [3]. We include a questionnaire on altruism as the nature of the game requires making a decision that affects other people. We wish to control for altruistic tendancies in our analysis. Additionally, we measure risk attitudes as, consumption context aside, in CPR games there is a risk to investing in the CPR as the outcome depends on others' choices and is not certain. Thus individuals who are risk averse may invest less in the CPR (Delaney and Jacobson 2015).

The instructions for each phase were read aloud then the subjects completed the phase before listening to the instructions on the following phase. Before the beginning of the CPR game phase, subjects completed a questionnaire to determine their understanding of the game. Subjects were informed of any wrong answers and had to correct them before advancing to the first period of the game.

Table 1: Number of subjects per treatment

Treatment	Number of sessions	Number of subjects	Number of groups
Nudge	5	100	25
Price	4	80	20
Control	3	60	15
Total	12	240	60

Table 2: Description of subjects

Male	Undergraduate	Average age
42.5%	67%	22

4.2 Experimental parameters

In the experiment, subjects form groups of four ($n = 4$) for 10 periods ($t = 10$). Subjects remain in the same groups for the duration of the experiment. At the start of each period, subjects receive an endowment $e = 100$ ECU[4] which they can use to consume electricity (measured in energy units (EU)). In the control and nudge treatments each EU costs 1 ECU ($c = 1$). The cost of each EU changes in the price treatment ($c = 3$) as discussed below. Any ECU that the subject does not use to consume electricity is kept by the subject and included in their profit function. For every EU consumed, the subject receives $a = 13$ and every EU consumed costs $b = 0.1$ for all subjects in the group regardless of who consumed it. Subjects' profit function is as follows :

[3]Following Boun My and Ouvrard (2017), we use a shorter version of the GEB scale including 28 items. See Appendix A and Appendix B for details of the GEB and altruism questionnaires.

[4]ECU = Experimental Currency Units. The exchange rate is communicated to all subjects during the instruction phase and is 150 ECU = 1€.

$$\pi_i = 100 - cx_i + x_i(13 - 0.1\Sigma x_i)$$

Individually, subjects maximise their profit at the Nash equilibrium, $x^{NE} = 24$ for an individual profit of 158 ECU. Collectively subjects should each consume $x^{SO} = 15$ for an individual profit of 190 ECU.

At the beginning of each session, subjects randomly choose a subject number and a computer post. Once the subjects are seated, the experimenter reads aloud all instructions. These are also displayed on two screens at the front of the room which all subjects can see. After general instructions concerning confidentiality, anonymity of data and the code of conduct are given, the experimenter describes the context of the game.

The game concerns electricity consumption during 10 peak periods when the demand can be greater than production. The subjects are placed into the same group of 4 for the duration of the experiment. This group makes up an electricity consumption system of four households. In this context the demand response challenge is represented as a repeated CPR game.

In each period, subjects must decide how much of their endowment to spend on consuming electricity by choosing whether or not to use five different electrical items. Table 3 details the different levels of consumption that subjects can choose from. Subjects are told that their electricity consumption brings them comfort (via a monetary gain) of 13 ECU for every unit consumed and that the total consumption of their group leads to a reduction in personal comfort (a monetary cost). The greater the total consumption of the group, the greater the reduction in comfort.

Table 3: Electricity consumption choices

Item	Consumption levels	Consumption amount (EU)
Electric heating	Unchanged	15
	1°C reduction in heating	10
	2°C reduction in heating	5
Electric water heater	On	5
	Off	0
Washing machine/ dishwasher	On	10
	Off	0
Cooking equipment	On	10
	Off	0
Television/ Computer	On	5
	Of	0

Given the levels of consumption available, subjects can only choose to consume energy units in increments of 5. As such the Nash equilibrium is $x_i = 25$ EU and the social optimum is $x_i = 15$ EU. To assist subjects in deciding how many EU to consume, a simulator[5] is available as well as a printed profit table. At the end of each period, subjects see how much they have consumed and their profit for the period.

4.2.1 Nudge treatment

In the nudge treatment, in addition to the above, subjects are told that one way to avoid power cuts is to ask consumers to lower their consumption during peak periods. This implies a lower level of comfort (as the individual may lower their heating or use their washing machine at a different time, for example) but allows all individuals, including oneself, to avoid a much lower comfort level, i.e. a power cut, or a reduction in the quality of electricity distribution.

At the end of each period, subjects receive additional feedback on their consumption. If their choice of consumption is less than or equal to the level of consumption which minimises the reduction in comfort for the group, i.e.: the socially optimal level, they see a picture of a smiley face. If their consumption is greater than this level, then they see a sad face.

4.2.2 Price treatment

In the price treatment, subjects are told that power cuts can be avoided by incentivising consumers to consume less during peak periods by increasing the price of electricity. The price for this treatment is calculated with respect to the average levels of consumption observed in the nudge treatment. Subjects are told that each energy unit consumed during the peak period costs 3 ECU which is three times more expensive than in a normal period[6]. The goal is to compare whether the price results in the same level of consumption as the nudge when that is its objective. Below in the results section, the average level of consumption observed in the nudge treatment is 19.07 across all periods. Given that subjects can only choose consumption in increments of 5, the price is calculated such that the Nash equilibrium consumption level in the price treatment is $x_i^{NE,P} = 20$.

$$\begin{aligned} \frac{a-c-d}{b(n+1)} &= 20 \\ \frac{13-1-d}{0.1(4+1)} &= 20 \\ d &= 2 \end{aligned}$$

The price increase required to incentivise subjects to consume 20 EU is equal to 2. The price of electricity for subjects in the price treatment is thus equal to 3 ECU.

[5]The simulator is described to subjects during the explanation of the game phase. Slides of the presentation of the game are available in French by request to the corresponding author.

[6]This is comparable to current tariffs proposed by EDF. According to the tariffs available at the time of experimentation, the highest peak price is approximately 3.5 times the standard tariff (EDF 2016).

In this treatment the subjects maximises:

$$max_{x_i}\pi(x_i, \Sigma x_i) = 100 - 3x_i + x_i(13 - 0.1\Sigma x_i)$$

The feedback given at the end of each period is the same as above; the subject's level of consumption and their earnings for that period.

4.3 Hypotheses

Under the assumption that subjects are rational and self-interested, we would expect them to choose the Nash equilibrium consumption amount in all treatments, i.e.: 25 in the control and nudge treatment, and 20 in the price treatment. Such players would not be influenced by the nudge described above.

Previous experiments have shown that suggesting a course of action has a positive influence on socially optimal behaviour (Dal Bó and Dal Bó 2014; Delaney and Jacobson 2015; Boun My and Ouvrard 2017). Other experiments have found that aligning the Nash equilibrium with the social optimum via the use of a tax (framed as a price increase in our experiment) is a first best policy for dealing with social dilemmas in public good and CPR games (Plott 1983; Ballard and Medema 1993; Cochard et al. 2005). However, such interventions are not always well-received by the public. In the context of electricity consumption, varying price structures or dynamic pricing also has its opponents (Alexander 2010). This leads to our main hypotheses:

Hypothesis 1: *Consumption choices in the nudge treatment will be lower than in the control treatment.*

Hypothesis 2: *Consumption choices in the price treatment will be lower than in the control treatment.*

Hypothesis 3: *When the price level is fixed according to the nudge result, consumption choices in the price treatment will be equivalent to those in the nudge treatment.*

Furthermore, the positive impact of suggested play or a nudge is increased when an element of social approval or disapproval is included (Dal Bó and Dal Bó 2014), as such we expect the following:

Hypothesis 4: *Subjects who receive 'happy face' feedback will not change their consumption in following period (those who consume the optimal amount or less).*

Hypothesis 5: *Subjects who receive 'sad face' feedback will lower their consumption in following period (those who consume more than the optimal amount).*

It has been shown in a previous experiment (Boun My and Ouvrard 2017) that subjects reaction to a nudge in an environmental setting depends on their environmental sensitivity. This leads us to formulate the following hypotheses:

Hypothesis 6: *More environmentally sensitive and altruistic subjects will consume less than less environmentally sensitive and altruistic subjects in all treatments.*

Hypothesis 7: *More environmentally sensitive subjects will consume less in the nudge treatment than in the price treatment.*

5 Results

We begin this section with a description of the results of the questionnaires used at the end of the experiment and of consumption decisions by type as identified by the questionnaires. We then describe the results of the experimental game, beginning with descriptive statistics and a graphical analysis of group level consumption decisions, followed by non-parametric testing and regression analysis. Next the individual choices of subjects are analysed, for all treatments and specifically for the nudge treatment according to the message received. Finally, we consider the equipment choices made by subjects.

5.1 Questionnaire results

In this section we detail the results of the questionnaires completed after the CPR game regarding envionmental sensitivity, altruism and risk attitudes.

5.1.1 General Ecological Behaviour

The GEB questionnaire is used to measure subjects' environmental sensitivity following Boun My and Ouvrard (2017). In their public good experiment, the authors find that subjects react to a nudge depending on their level of environmental sensitivity. Of the 28 items, the mean score per item is 3.34 (std. dev. = 0.22). Cronbach's $\alpha = 0.73$[7]. The GEB scale is therefore acceptable.

The average environmental sensitivity level of subjects overall, and per treatment is presented in table 4a, followed by the between treatments tests in table 4b. While the average level of environmental sensitivity appears to be similar between treatments, the p-values tell us that the levels are not statistically different from one another between only the nudge and the price treatments.

Table 5a shows the average consumption decisions of individuals in each treatment according to their sensitivity to the environment. High environmental sensitivity is classed as greater than the average of the sample [8]. As can be seen from the table,

[7] Boun My and Ouvrard (2017) found a Cronbach's $\alpha = 0.74$.

[8] In the nudge, price and control groups, 58%, 55% and 52% of subjects have high environmentally sensitivity, respectively.

Table 4: Generalised Ecological Behaviour Scale

(a) Average environmental sensitivity

Nudge	Price	Control	Overall
108.8	106.5	107.1	107.6
(10.25)	(10.64)	(9.61)	(10.00)

Standard deviations are in brackets.

(b) Between treatment p-values

	Price	Control
Nudge	0.0001	0.0000
Price		0.7534

in the nudge and control groups, more environmentally sensitive subjects choose to consume less than less environmentally sensitive subjects across all treatments. The differences in individual consumption by environmental sensitivity are only statistically significant in the nudge treatment as seen in table 5b. While more environmentally sensitive subjects choose to consume less across all treatments, the nudge treatment makes best use of environmental sensitivity to separate the consumption decisions of different subject types. Indeed, the difference in average consumption is only significant in the nudge treatment.

Table 5: Average individual consumption by treatment and by environmental sensitivity

(a) Average individual consumption

Treatment	Low	High	Total
Nudge	20.68	17.90	19.07
Price	21.38	20.86	21.09
Control	24.14	22.88	23.49
Total	21.85	20.04	

(b) Between treatment p-values

		High		
		Nudge	Price	Control
	Nudge	0.0000		
Low	Price		0.2036	
	Control			0.1770

5.1.2 Altruism Questionnaire

The altruism questionnaire is used to measure how altruistic subjects are. The mean score per item is 3.28 (std. dev. = 0.33). Cronbach's α is 0.68. The altruism questionnaire is moderately acceptable.

The average altruism scores are reported in table 6a across all subjects and by treatment and the associated p-values in table 6b. The average scores on the altruism tests are significantly different across the nudge and price, and the nudge and control treatments. They are not significantly different between the price and control treatments.

Table 7a shows the individual consumption decisions by treatment according to each subject's level of altruism and table 7b the associated non-parametric tests. High altruism is greater than the average of the sample[9]. In the nudge treatment highly altruistic individuals choose to consume less than less altruistic individuals. The levels

[9]In the nudge, price and control groups, 58%, 55% and 52% showed a high altruism level, respectively.

Table 6: Altruism questionnaire results

(a) Average individual altruism score

Nudge	Price	Control	Overall
32.89	31.76	32.35	32.38
(4.35)	(4.56)	(3.44)	(4.24)

(b) Between treatment p-values

	Price	Control
Nudge	0.0000	0.0000
Price		0.5779

are similar across altruism types in the control groups, and the opposite is observed in the price treatment. With regard to statistical significance, the differences are only significant in the nudge treatment. As with environmental sensitivity, it appears that a nudge based policy can separate subjects based upon their level of altruism.

Table 7: Average individual consumption

(a) Average consumption by altruism level and treatment

Treatment	Low	High	Total
Nudge	20.57	17.97	19.07
Price	20.88	21.27	21.09
Control	23.66	23.34	23.49
Total	21.51	20.32	

(b) Between treatment p-values

		High		
		Nudge	Price	Control
Low	Nudge	0.0000		
	Price		0.6936	
	Control			0.6117

5.1.3 Risk attitudes

In the second phase of the experiment, subjects completed a Holt and Laury (2002) test of aversion to risk. As expected, the majority of subjects are risk averse. In the nudge and price treatment, 80% of subjects are risk averse. In the control groups, there is a greater percentage of risk takers compared to the two other treatments[10].

Table 8 provides the average individual consumption choices by treatment, and table 9 the associated p-values. In the nudge treatment, there is little difference in the average consumption choices by risk attitude and as reflected in the p-values, these differences are not significant. In the price treatment, risk averse subjects consume less than risk neutral subjects and risk takers. The differences are significant ($p<0.05$).

5.2 Average consumption at the group level

The dynamics of average group consumption by treatment for each period is represented in fig. 1. We see that as the game progresses, consumption is consistently lower in the nudge treatment compared to the control groups who show the highest level of

[10]20% are risk takers in the control treatment versus 8% and 16% in the nudge and price treatments, respectively

Table 8: Average individual consumption choices by risk attitude

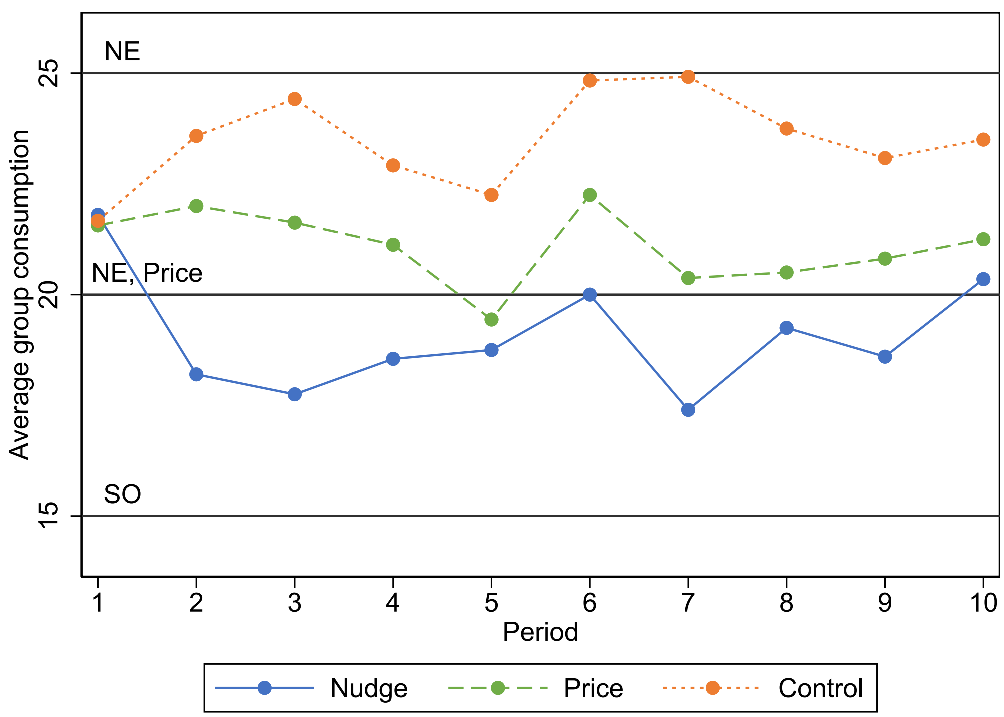
	Averse	Neutral	Taker	Total
Nudge	19.10	19.18	18.56	19.07
Price	20.48	24.80	22.62	21.09
Control	23.00	27.00	22.79	23.49
Total	20.42	22.96	21.70	

Table 9: Average individual consumption choices by risk attitude (p-values)

	Nudge		Price		Control	
	Neutral	Taker	Neutral	Taker	Neutral	Taker
Averse	0.9483	0.6076	0.0000	0.0012	0.0009	0.7141
Neutral		0.6429		0.1172		0.0013

average consumption. In the price treatment, consumption remains between the two, at or slightly above its objective, the Nash equilibrium amount of 20.

Figure 1: Dynamics of average consumption by treatment



The average group consumption by treatment across all 10 periods is summarised in table 10. In the absence of any policies, groups consume 23.49 on average. When the price is increased such that consumers are incentivised to consume 20, the average group level consumption is 21.09. The use of a nudge results in the lowest level of consumption of 19.07. This is to be expected given that the objective of the nudge is to encourage subjects to the optimal level of consumption of 15. Across all 10 periods, consumption across the three treatments is significantly different (Kruskal-Wallis test, $p<0.001$).

Table 10: Mean group consumption by treatment

Treatment	Period 1	Period 2	Overall
Nudge	21.80	18.20	19.07
	(4.43)	(3.08)	(4.45)
Price	21.56	22.00	21.09
	(3.71)	(3.17)	(3.66)
Control	21.67	23.58	23.49
	(3.67)	(4.11)	(4.18)
N (groups)	25	20	15
Wilcoxon rank-sum test (Between treatment *p*-values)			
Nudge = Price	0.9083	0.0004	0.0046
Nudge = Control	0.9216	0.0005	0.0001
Price = Control	0.9194	0.2027	0.0035
Kruskal-Wallis test			
Nudge = Price = Control	0.9899	0.0001	0.0001
Wilcoxon signed-rank test (Within treatment *p*-values)			
Nudge = Social optimum (15 EU)			0.0000
Nudge = Nash equilibrium (25 EU)			0.0000
Control = Social optimum (15 EU)			0.0007
Control = Nash equilibrium (25 EU)			0.0355
Price = Nash equilibrium (20 EU)			0.0057

Standard deviations in brackets

Between treatment *p*-values are *p*-values of Wilcoxon rank-sum tests.

Within treatment *p*-values are *p*-values of Wilcoxon signed rank tests.

To further analyse the results, we perform non-parametric tests on average group level consumption between treatments and within treatments compared to the corresponding Nash equilibrium and to the social optimum. The second part of table 10 summarises these results.

Groups in the nudge and price treatments have an average level of consumption that is significantly different from the control groups ($p<0.001$ for the nudge treatment and $p<0.05$ for the price treatment). Moreover, the average consumption observed in the nudge treatment is significantly different from that observed in the price treatment ($p<0.05$).

In table 10 we also report the average consumption in period 1 and 2 as this is pre and post initial feedback. We see that after feedback, the average consumption decreases in the nudge treatment. This is also visible in fig. 1. In the first period, all treatments start at a similar level of average consumption[11]. Given that in the nudge treatment, subjects do not receive feedback until after having made their consumption decision, it is to be expected that average group consumption in the first period be similar between the nudge and control groups. From period 2, there is a significant and permanent effect of the nudge policy as the consumption decisions under the nudge treatment are different to those of control groups.

In the price treatment, subjects are aware of the price change prior to any decision making. We would therefore expect there to be a significant difference between consumption decisions in the price treatment compared to control groups in the first period, but this difference is not significant. However, the average group consumption is only consistently and significantly different from the seventh period, it is also significantly different in periods 3 and 5 ($p<0.05$). This suggests that it takes several periods for the subjects to integrate the price increase into their decision making and that it was not until the seventh period that the price was fully integrated into their decision making process.

Given that the price increase is designed to incentivise subjects to consume the amount observed under the nudge treatment, we do not expect to see significant differences between the average group consumption decisions from the second period onwards between the nudge and price treatments. However, we see significantly different levels of consumption in periods 2 and 3 ($p<0.001$ and $p<0.05$, respectively), again suggesting that subjects do not immediately integrate the price increase into their decision making.

In both the nudge treatment and the control groups, the observed average levels of consumption are significantly different from both the Nash equilibrium of 25 and the social optimum of 15 ($p<0.05$). When average consumption per period is tested, average consumption in the control group is not significantly different from the NE in all but 3 periods. In periods 1, 5 and 9, average consumption is at its lowest and significantly different from 25 for the control groups ($p<0.05$).

In the price treatment, while average consumption across all periods is significantly different from 20 (the objective of the price), from period 3 onwards, average consumption is not significantly different from 20 (except in period 6[12]).

The results described in this section are robust to panel data estimation as shown in table 11 which presents regression estimates of treatment effects. The models have been estimated using panel data random effects estimation. Panel data methods are used as there are n subjects making a consumption decision in t periods. Random effects estimation is preferable to OLS or fixed effects estimation as it allows for heterogeneous subjects and is more efficient than fixed effects estimation. In addition, given that we have used a between-subject design, random effects estimation allows us to model the

[11]This difference is insignificant as tested non-parametrically using the Kruskal-Wallis test.

[12]Across all treatments in period 6, average consumption increases. It could be that as period 6 begins the last half of the game, subjects decided to increase consumption in a bid to earn more.

time-invariant treatment variables (Moffatt 2015).

The value of the constant represents the average group contribution controlling for different variables. All specifications show a clear significant effect of both the nudge and price treatments compared to the control groups. In models 2 and 4, a period variable is included to control for variation during the game, however, the coefficient is non-significant. In models 3 and 4, dummy variables are added to specify whether the group under or over consumed compared to the optimal consumption in their treatment[13]. At the group level, there is no significant effect on consumption due to under- or over-consuming in the previous period.

Table 11: Average group consumption (random effects estimation)

	(1)	(2)	(3)	(4)
Nudge	-4.427***	-4.427***	-4.740***	-4.731***
	(0.830)	(0.830)	(0.807)	(0.808)
Price	-2.398***	-2.398***	-2.272**	-2.254**
	(0.702)	(0.703)	(0.716)	(0.718)
Period		-0.018		0.058
		(0.052)		(0.055)
Group under consumed (t-1)			-0.757	-0.744
			(0.683)	(0.681)
Group over consumed (t-1)			0.288	0.340
			(0.590)	(0.609)
Constant	23.492***	23.588***	23.415***	23.015***
	(0.607)	(0.670)	(0.795)	(0.935)
Observations	600	600	540	540

Standard errors in parentheses

Robust standard errors clustered by group

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

5.3 Average consumption at the individual level

Table 12 shows the regression estimates of random effects models of treatment and covariates on individual consumption choice. Model 1 shows a significant treatment effect for both the nudge and the price treatment at the individual level. In even numbered

[13]The share of each type of group (under, optimal or over-consuming) is shown in table 14 in Appendix C

models, profit in *t-1* is included and has a significant but small positive effect on average individual consumption. As the amount earned in *t-1* increases, subjects increase their consumption in *t*. Models 3, 4 and 7 show that individuals who under-consumed in *t-1*, reduce their consumption in *t* compared to optimally consuming individuals. Those who over-consume in *t-1* continue to do so compared to optimally consuming individuals. Once individual consumption type is controlled for, the significant effect of the price treatment falls out as the price treats all individuals equally and does not differentiate according to how an individual consumes (under, optimally, or over).

Finally, in models 5-7, we include variables concerning subjects sensitivity towards the environment, their level of altruism and their risk attitude. Highly environmentally sensitive individuals consume less. There is no significant effect of altruism on consumption choice. Those individuals who are risk averse tend to consume less than those who are risk neutral.

We also examine the effect of the message received in the nudge treatment on individual consumption decisions. The estimates are shown in table 13. Subjects who under consume receive a smiley face message and subjects who over consume receive a sad face message. Compared to optimally consuming groups, these messages have the effect of reinforcing an individual's behaviour in t-1. At the individual level in the nudge treatment, environmental sensitivity and level of altruism have a significant effect on consumption choice. More environmentally sensitive and altruistic individuals consume less compared to less environmentally sensitive and altruistic individuals [14].

[14] These variables did not show significant effects in regression on full dataset and so were not included in the above tables

Table 12: Average individual consumption (random effects estimation)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Nudge	-4.427***	-5.655***	-3.899***	-4.802***	-4.125***	-5.340***	-3.709***
	(0.829)	(0.952)	(0.720)	(0.840)	(0.798)	(0.905)	(0.687)
Price	-2.398***	-1.799*	-0.843	-0.062	-2.114**	-1.499	-0.667
	(0.701)	(0.901)	(0.636)	(0.872)	(0.725)	(0.899)	(0.638)
Profit in t-1		0.033***		0.037***		0.032***	
		(0.005)		(0.007)		(0.005)	
Individual under consumed (t-1)			-2.091***	-1.619**			-1.998***
			(0.584)	(0.572)			(0.573)
Individual over consumed (t-1)			3.589***	3.342***			3.494***
			(0.496)	(0.483)			(0.497)
High Environmental sensitivity					-1.545*	-1.450*	-1.312*
					(0.630)	(0.640)	(0.535)
High Altruism					-0.982	-0.744	-0.602
					(0.648)	(0.647)	(0.522)
Risk taker					-1.749	-1.842	-1.708
					(1.267)	(1.335)	(1.139)
Risk averse					-2.451**	-2.754**	-2.119**
					(0.924)	(0.990)	(0.815)
Constant	23.492***	18.682***	21.294***	15.785***	26.781***	22.037***	24.095***
	(0.606)	(1.189)	(0.672)	(1.494)	(1.081)	(1.499)	(1.109)
Observations	2400	2160	2160	2160	2400	2160	2160

Standard errors in parentheses

Robust standard errors clustered by group

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 13: Effect of message on individual consumption in nudge treatment

	(1)	(2)
Under consumption :-) (t-1)	-2.317**	-2.241**
	(0.791)	(0.792)
Over consumption :-((t-1)	4.067***	3.753***
	(0.765)	(0.846)
High Environmental sensitivity		-2.453***
		(0.673)
High Altruism		-1.732*
		(0.846)
Constant	17.203***	19.770***
	(0.408)	(1.021)
Observations	900	900

Standard errors in parentheses

Robust standard errors clustered by group

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

5.4 Equipment Choices

This section looks at the hypothetical choices of subjects with regard to which electricity consuming activities they are willing to shift during peak periods. The consumption choices available to subjects are presented above in table 3. Figures 2 to 6 show the percentage of subjects choosing each level of consumption by equipment type[15] in each period.

In fig. 2 we can see that the majority of subjects were willing to lower their heating by at least 1°. In the nudge treatment, after feedback has been received, there is an increase in the number of subjects choosing to lower their consumption by 2°from 47% to 59%. The same can be observed for control groups but to a lesser extent. Of the subjects who choose to keep their heating at the same temperature, a greater percentage are present in the control groups and fewer in the nudge treatment.

Figure 3 shows that when deciding whether to use their water heating we can see that in the first period, there is a larger percentage of subjects who decide to turn it on (approximately two-thirds of subjects). Once subjects have received feedback on their overall consumption (from period 2 onwards), we see an increase in the number of subjects who choose to turn off their water heater. Particularly in the nudge treatment.

[15] By equipment type, we mean heating, water heating, cooking equipment, washing equipment and entertainment equipment. The level of consumption for heating is the same, 1°cooler, or 2°cooler. For

Figure 2: Dynamics of water heating choice by treatment

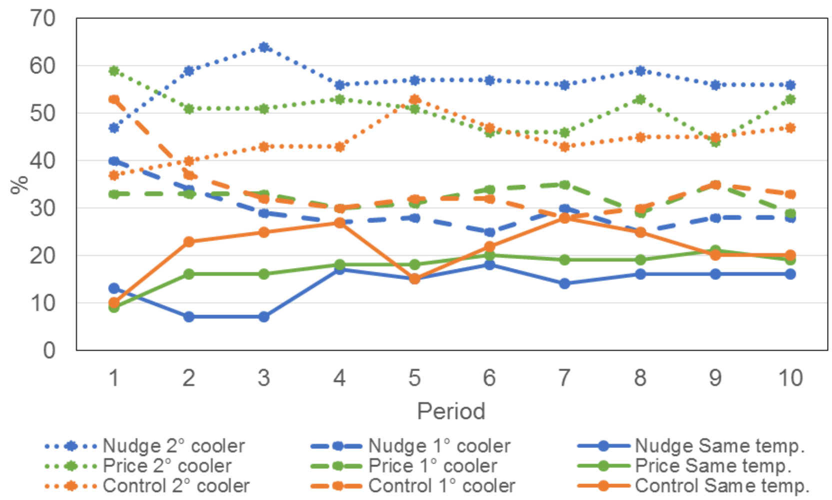


Figure 3: Dynamics of water heating choice by treatment

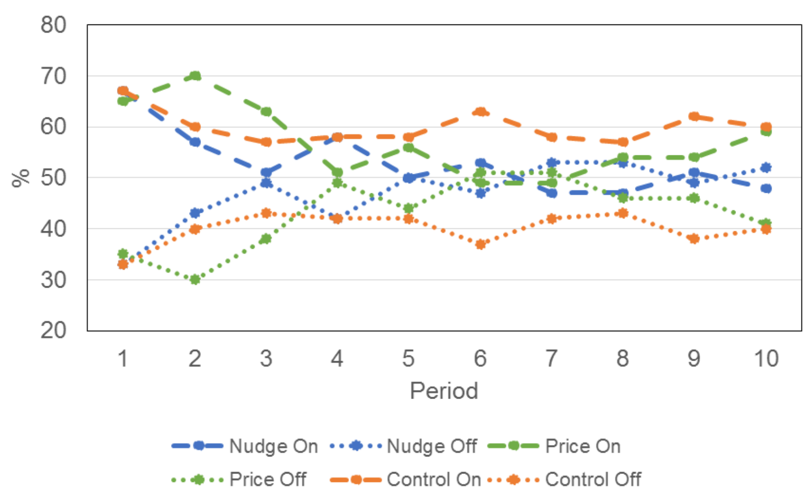


Figure 4: Dynamics of cooking equipment choice by treatment

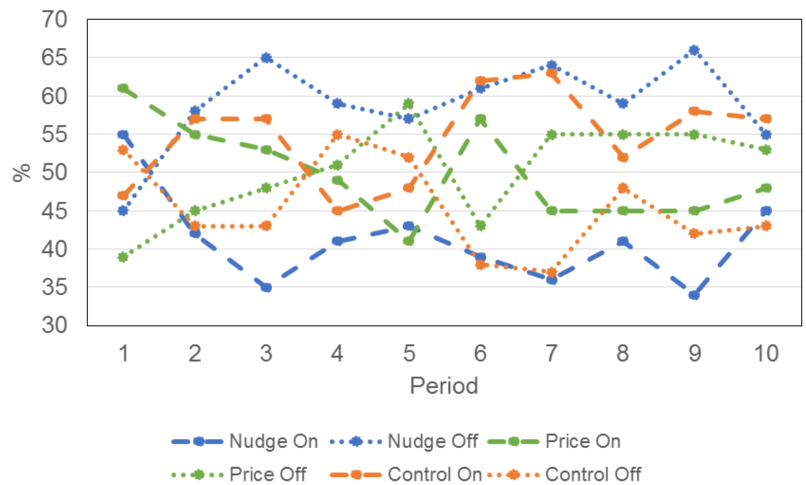
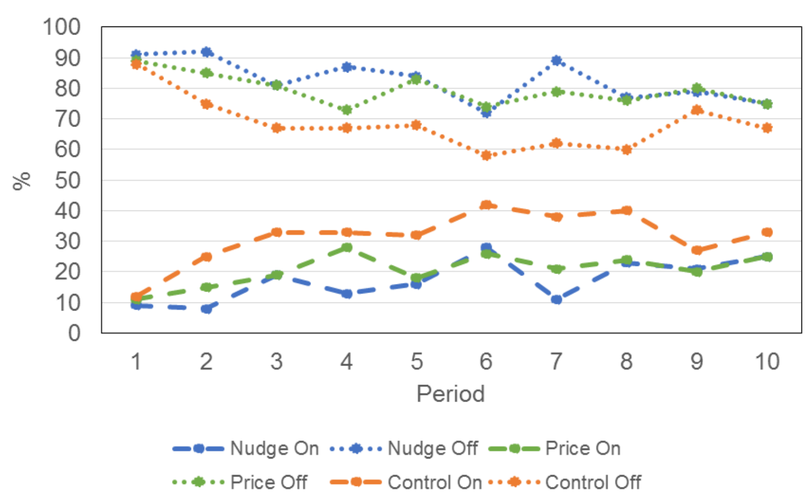


Figure 4 presents the choices of subjects as to whether to use their cooking equipment. Subjects willingness to shift cooking habits is less clear. From period 1 to 2, we can see an increase in the share of subjects who shift their use of cooking equipment in the nudge treatment. The share of subjects willing to shift such consumption remains around the 66% mark in the nudge treatment. In the price treatment, the willingness to shift cooking consumption for the majority of subject is visible from period 4. Subjects in control groups appear less willing to shift their use of cooking equipment.

Figure 5: Dynamics of washing equipment choice by treatment



From fig. 5 we can see that the use of a washing machine or dishwasher is the activity that subjects are most willing to shift. Across the 10 periods of the game, just

all others, it is either on or off.

under 80% of subjects choose to turn off these machines across treatments. This share is slightly hire for the nudge and price treatment compared to control groups. There appears to be a small effect of treatment on washing equipment use as in the control groups we can see an increase in subjects who decide to use such equipment during the course of the game.

Figure 6: Dynamics of entertainment equipment choice by treatment

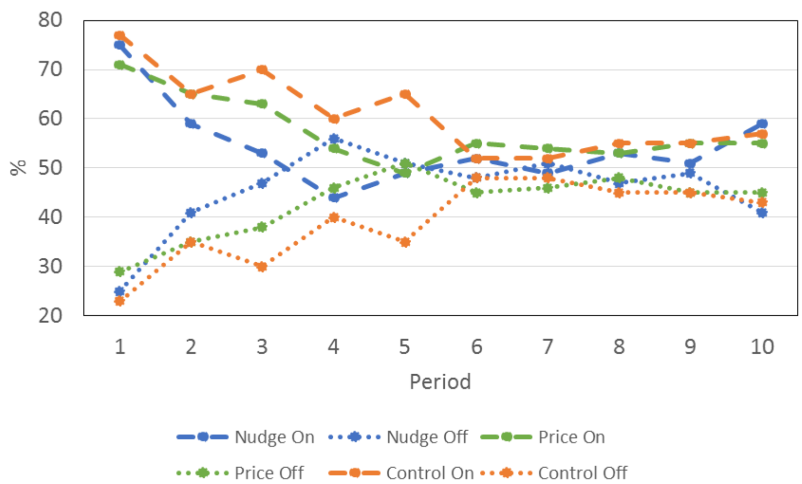


Figure 6 shows electricity consuming entertainment activities to be the activity that subjects are least willing to shift, at least initially with three-quarters of subjects choosing to turn on their televisions and computers in the first period. In periods 1-3, across treatments, more subjects choose to use their entertainment equipment than to turn it off. For the rest of the game, subjects are split fairly evenly as to their decision of whether to use their entertainment equipment or not.

6 Discussion and conclusion

The experiment described in this paper explored subjects responses to price and nudge-based interventions in a contextualised CPR game. The experimental design allows for comparison of behaviour under a nudge and an equivalent price increase. In particular, the experimental design provides an opportunity to examine subjects' consumption choices regarding the use of different appliances. The results of the experiment may be of interest to policy makers when considering the implementation of a nudge or a price based intervention designed to reduce households energy consumption during peak periods.

The principal result of the experiment is that both treatments, nudge and price increase result in a reduction in consumption compared to when no intervention is present. The nudge results in a reduction in consumption equal to 18.8%, and the price, 10.2% compared to the consumption of controls groups. Both hypothesis 1 and 2 are validated. Subjects consume the lowest amount in the nudge treatment. This is to be expected as the nudge target is a consumption of 15 EU, whereas the price is designed to incentivise a consumption level of 20 EU. The design of the experiment allows for an evaluation of the economic value of the nudge compared to its equivalent price. While both the nudge and the price increase lead to a reduce in comfort due to the reduction in consumption, we conclude that that our nudge in itself is not sufficient to achieve the social optimum, but that it performs as well as an equivalent price increase without the loss of welfare implied by an increase in price.

Given that the price is designed based upon the mean level of consumption observed in the nudge treatment, we expect subjects to consume the same level as under the nudge treatment from the start of the game. However, from the results we see that the level of consumption in the nudge and price treatments are significantly different in the first three periods and are not significantly different from period 4 onwards. We conclude that the price increase takes longer than the nudge to achieve the desired outcome as subjects take longer to integrate the price increase into their decision making than they do for the feedback in the nudge treatment. The hypothesis that consumption will be similar in the nudge and price treatments is partially accepted.

With regard to the feedback received by subjects in the nudge treatment, we find that both hypotheses 4 and 5 are rejected, as rather than nudging subjects towards the socially optimal level of consumption, the nudge employed in this experiment reinforces subjects' existing behaviour. Subjects who under or optimally (over) consume in the previous period tend to decrease (increase) their consumption in the present period. The magnitude of the change in consumption is greater for those who over consumed previously. This suggests that while the nudge shows a decrease in average consumption at the group level, at the individual level the nudge may serve to reinforce behaviours that are already present. This is turn could lead to a situation where low-consuming households are further reducing their consumption and high-consuming households continue to over-consume. While we have obtained this result in a hypothetical consumption game, it is worth consideration when implementing such nudges in the field.

Similarly to Boun My and Ouvrard (2017), we evaluated subjects level of environmental sensitivity. While in all treatments, more environmentally sensitive subjects consumed less than less environmentally sensitive subjects at an individual level, the difference is only statistically significant in the nudge treatment. In line with Boun My and Ouvrard (2017), we can also conclude that subjects' behaviour in response to a nudge depends on their level of environmental sensitivity. When comparing behaviour under each treatment by level of environmental sensitivity we see that in the nudge treatment, subjects consume less than in the price treatment. This difference is greater for more environmentally sensitive subjects. We also assessed subjects' level of altruism. More altruistic subjects consumed less in the nudge treatment; subjects' behaviour in response to the nudge also depends on their altruism. Interestingly, in the price treatment highly altruistic subjects consumed more than less altruistic subjects. This might suggest that the presence of the price increase crowds out subjects' willingness to reduce their consumption. However the difference is only significant in the nudge treatment. This provides evidence to confirm hypothesis 6 in the nudge treatment. Hypothesis 7 is also confirmed.

Finally, we also consider which appliances subjects are willing to not use in order to reduce their consumption. We find that subjects are most willing to turn off their washing appliances and prefer to continue to use their entertainment devices. Subjects are also willing to lower their heating in order to reduce their total consumption.

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A General Ecological Scale Questions (Kaiser 1998)

1. I use energy-efficient bulbs.
2. If I am offered a plastic bag in a store, I take it.
3. I kill insects with a chemical insecticide.
4. I collect and recycle used paper.
5. When I do outdoor sports/activities, I stay within the allowed areas.
6. I wait until I have a full load before doing my laundry.
7. I use a cleaner made especially for bathrooms, rather than an all-purpose cleaner.
8. I wash dirty clothes without pre-washing.
9. I reuse my shopping bags.
10. I use rechargeable batteries.
11. In the winter, I keep the heat on so that I do not have to wear a sweater.
12. I buy beverages in cans.
13. I bring empty bottles to a recycling bin.
14. In the winter, I leave the windows open for long periods of time to let in fresh air.
15. For longer journeys (more than 6h), I take a plane.
16. The heater in my house is shut off late at night.
17. I buy products in refillable packages.
18. In winter, I turn down the heat when I leave my house for more than 4 hours.
19. In nearby areas, I use public transportation, ride a bike, or walk.
20. I buy clothing made from all-natural fabrics (e.g. silk, cotton, wool, or linen).
21. I prefer to shower rather than to take a bath.
22. I ride a bicycle, take public transportation, or walk to work or other.
23. I let water run until it is at the right temperature.
24. I put dead batteries in the garbage.
25. I turn the light off when I leave a room.

26. I leave the water on while brushing my teeth.
27. I turn off my computer when I'm not using it.
28. I shower/bathe more than once a day.

B Altruism Questions (Costa and McCrae 1992)

1. Some people think that I am selfish and egotistical.
2. I try to be courteous to everyone I meet.
3. Some people think of me as cold and calculating.
4. I generally try to be thoughtful and considerate.
5. I'm not known for my generosity.
6. Most people I know like me.
7. I think of myself as a charitable person.
8. I go out of my way to help others if I can.

C Group type (under, optimal or over-consuming)

Table 14: Number of groups by consumption level (across all periods)

		Group consumption			
		Under	Optimal	Over	Total
	Nudge	42	17	191	250
		16.8%	6.8%	76.4%	100.0%
Treatment	Price	66	26	108	200
		33.0%	13.0%	54.0%	100.0%
	Control	0	4	146	150
		0.0%	2.7%	97.3%	100.0%
	Total	108	47	445	600
		18.0%	7.8%	74.2%	100.0%

For the nudge and control groups, the optimal consumption level is 60. In the price treatment, it is 80.

D Individual type (under, optimal or over-consuming)

Table 15: Number of groups by consumption level (across all periods)

		Individual consumption			
		Under	Optimal	Over	Total
	Nudge	190	316	494	1,000
		19.0%	31.6%	49.4%	100.0%
Treatment	Price	234	295	271	800
		29.3%	36.9%	33.9%	100.0%
	Control	75	79	446	600
		12.5%	13.2%	74.3%	100.0%
	Total	499	690	1,211	2,400
		20.8%	28.7%	50.5%	100.0%

For the nudge and control groups, the optimal consumption level is 15. In the price treatment, it is 20.

E Distribution of messages received in nudge treatment

Table 16: Distribution of messages received in nudge treatment by period

	Period									
Message received (t-1)	2	3	4	5	6	7	8	9	10	Total
Under consumption :-) (t-1)	9	18	22	19	18	20	24	20	24	174
	5.2%	10.3%	12.6%	10.9%	10.3%	11.5%	13.8%	11.5%	13.8%	100.0%
Optimal :-) (t-1)	19	28	30	33	35	32	34	36	35	282
	6.7%	9.9%	10.6%	11.7%	12.4%	11.3%	12.1%	12.8%	12.4%	100.0%
Over consumption :-((t-1)	72	54	48	48	47	48	42	44	41	444
	16.2%	12.2%	10.8%	10.8%	10.6%	10.8%	9.5%	9.9%	9.2%	100.0%