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The influences of financial and non-financial factors on energy-saving behaviour: A field experiment in Japan

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HIGHLIGHTS

- We studied the effects of (non-)financial factors on household electricity use.
- Financial factors had a significant effect; non-financial ones were inconclusive.
- Externalities had a positive effect across time and households on saving energy.
- There is a heterogeneous treatment effect in financial-reward intervention.
- Before the experiment, participants underestimated the marginal costs of saving electricity.

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ABSTRACT

This study examines the influences of financial and non-financial factors on electricity-conservation behaviour. A random sample of 236 Japanese households participated in the field experiment and the participants were offered two interventions, such as monetary rewards, depending on their reduction in electricity consumption and comparative feedback. The average saving rates of the (i) reward-intervention group (5.9%) and the (ii) reward with comparative feedback group (8.2%) are statistically larger than those of the (iii) control group (1.7%). Our study demonstrates the following. First, our econometric analysis confirmed a significant response by households to financial incentives but a more inconclusive response to the treatment that provided non-financial, additional information. Second, we found a positive influence of treatment externalities across time and households on energy saving. Third, there is a heterogeneous treatment effect in the reward-intervention group, with the households having a high New Ecological Paradigm (NEP) score being more likely to respond to the reward programme and save electricity than those that do not. Finally, and most interestingly, differences in responses to the questionnaire before and after the experiment suggest that the participants had underestimated the marginal costs of saving electricity before they actually started to do so.

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1. Introduction

The 'Great East Japan Earthquake' of March 2011 and subsequent radiation leak from the Fukushima nuclear plant have triggered widespread concerns about the safety of nuclear plants. Since then, most of the nuclear power reactors in Japan have been shut down.¹ However, replacing nuclear power with an alternative source of electricity in the short term presents great difficulty. Thus, massive attempts have already been implemented to cut the peak demand for electricity. The household sector will need to

play a key role in these attempts, but significant energy saving has been less than successful in this sector.²

Many studies have examined effective intervention for encouraging household energy-saving behaviour, such as information provision, public campaigns, goal setting, feedback, comparative feedback and reward (Winett et al., 1978; Becker, 1978; McClelland and Cook, 1980; Midden et al., 1983; Brandon and Lewis, 1999; Abrahamse et al., 2005; Darby, 2006; Abrahamse et al., 2007; Petersen et al., 2007; Ehrhardt et al., 2010; Allcott, 2011b). Abrahamse et al. (2005) reviewed 38 field studies in social and environmental psychology and evaluated the effectiveness of

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E-mail addresses: kmizobuc@cc.matsuyama-u.ac.jp (K. Mizobuchi), takeuchi@econ.kobe-u.ac.jp (K. Takeuchi).¹ In the interests of safety, as of July 2013, 52 out of Japan's 54 nuclear power reactors had been shut down.² In 2011, the electricity-saving rates of large and small customers of the industrial sector were 29% and 19% higher than the rates of the previous year, respectively. However, the rate of electricity saving among households was only 6% (Tokyo Electric Power Company, 2011).

the above-mentioned interventions. However, it is not clear from these studies which form of intervention is most effective or which has the most enduring effect. One of the main reasons for this fact is that each study focussed on only a few factors. In order to learn about policies that can effectively and efficiently reduce energy consumption, various data and insights need to be integrated. In particular, one needs to understand, first, the motivations of consumers in implementing certain types of energy-saving behaviour. Second, a careful analysis is required of the various factors that influence household behaviour; excluding crucial factors will lead to biases in the assessment of a particular factor's contribution to household behaviour (Van den Bergh, 2008). Therefore, an extension to the broadest possible range of policy instruments would require considering a great many factors, such as financial, non-financial and demographic.

Traditionally, financial and non-financial approaches differ; hence, research efforts tend to be confined only to each academic area. Economists tend to examine the influence of external conditions – such as price, income and other socioeconomic characteristics – upon pro-environmental behaviour.³ Thus, econometric studies of pro-environmental household behaviour that include non-financial variables relating to attitudes, knowledge, perceptions and values are rare. However, studies by psychologists that include these variables exclude economic variables. Recently, several studies have considered both financial and non-financial factors in analysing households' pro-environmental behaviour (Clark et al., 2003; Kotchen and Moore, 2007).

Within traditional economic theory, individuals maximise their own utility, subject to budget constraints, and they have little incentive to strive towards a public good, that is, pro-environmental behaviour; hence, they will choose a 'free ride' instead. However, this theoretical prediction is rarely shown empirically. Thus, economists have started to consider the role of non-financial factors, such as warm-glow altruism (Andreoni, 1990) and paternalistic altruism (McConnell, 1997), in motivating individuals to contribute to public goods. In the discipline of psychology, Fransson and Garling (1999) have reviewed many studies examining the relationship between non-financial variables and pro-environmental behaviour. The influence of some non-financial factors, such as attitudes, knowledge, perceptions and values, has been demonstrated in terms of pro-environmental behaviour. By means of a natural experiment, Guagnano et al. (1995) proved the hypothesis that attitudinal factors and external conditions act in combination to influence pro-environmental behaviour.⁴

As a result, recent developments in economics (psychology) emphasise the need to consider internal (external) influences. However, as we mentioned above, what is lacking is a systematic integrated analysis of interventions or instruments: non-financial (internal) factors, such as attitude, knowledge, motivation and perception, and financial (external) factors, such as prices (a subsidy or tax) and incomes.

This study aims to evaluate the influences of both financial and non-financial factors on encouraging electricity-conservation behaviour. We conducted a field experiment based on an intervention study from October to November 2011 in randomly

selected Japanese households. We attempted to separate the treatment effects and other externalities that influence electricity saving across time and households. We also examined the tests for heterogeneous treatment effects. Moreover, we examined the size and changes of the marginal costs of electricity saving from the pre- and post-questionnaire surveys.

This article is organised as follows: Section 2 discusses previous studies on household energy-saving behaviour. In Section 3, the field experiment, in which we used subsidies as an economic incentive for electricity-conservation behaviour within households, is described and Section 4 discusses the empirical analysis. Section 5 analyses the marginal costs of electricity-conservation behaviour and discusses some limitations of our study, and section 6 concludes the discussion.

2. Factors of influence on household energy-saving behaviour

Over the past several decades, many scholars have emphasised the importance of financial or non-financial factors in encouraging household energy-conservation behaviour (Stern, 1992; Dwyer et al., 1993; Abrahamse et al., 2005; Darby, 2006; Allcott et al., 2007; Van den Bergh, 2008; Ehrhardt et al., 2010). This section gives a brief overview of relevant studies that have used financial or non-financial factors – such as rewards, comparative feedback, social norms, environmental concerns, goal setting and some socioeconomic variables – with a specific focus on these factors' influence on households' energy-saving behaviour.

To evaluate the effects of taxes and subsidies for household energy usage, many previous studies have focussed on the behavioural impacts of energy prices by a degree of price elasticity with time-series, cross-section and panel data (Silk and Joutz, 1997; Vaage, 2000; Halvorsen and Larsen, 2001). Most of these studies showed statistically significant price elasticities. However, the degree of elasticity fluctuates, depending on the data and the estimation method (Espey and Espey, 2004). In addition, some field studies are based on an intervention through economic rewards (e.g., money or prizes) to examine household energy-saving behaviour (Winett et al., 1978; Midden et al., 1983; McClelland and Cook, 1980; Petersen et al., 2007). These studies indicate that financial rewards have been successful in reducing household energy consumption.⁵ However, two problems remain in these previous studies. One is low statistical reliability because of the small number of households involved in the experimental groups (fewer than 20). Another is an identification problem, that is, the treatment effects of rewards could not be isolated because a combination of other interventions, such as information and individual and comparative feedback, was used in the study.

Feedback is widely used to encourage energy conservation (Matsukawa, 2004; Darby, 2006; Ehrhardt-Martinez et al., 2010; Gleerup et al., 2010; Jessoe and Rapson, 2012). Fischer (2008) reviews a considerable number of feedback studies. In general, feedback is given in terms of a household's own energy savings, in order to confirm the effectiveness of its efforts to save energy; feedback becomes more effective, in particular, if its frequency is increased. Another type of feedback – wherein participants are provided with information on the energy savings of other study

³ Traditional econometric studies that analyse residential energy conservation behaviour tend to focus on the behavioural impacts of energy prices by a degree of price elasticity. Dubin and McFadden (1984) were among the first to investigate household electricity demand with econometric approaches, using micro-level data. They investigated the influences of price, income, electrical appliances and other socioeconomic variables on household electricity demand. Espey and Espey (2004) provide an overview of econometric analyses of residential electricity demand.

⁴ They also showed, specifically, that external conditions affect the strength of attitude-behaviour relationships. Thus, strong positive external conditions increase the likelihood of attitudes that give rise to pro-environmental behaviours.

⁵ Winett et al. (1978) studied the effect of certain energy-saving interventions, including a financial incentive (i.e., a reward for reducing electricity consumption), involving 107 single-family households in Texas. The electricity conservation by the group with a financial incentive was significantly higher than that by other intervention groups and the control group. Moreover, if households were in competition with each other, the influence of the rewards was more effective (McClelland and Cook, 1980; Petersen et al., 2007).

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