DISCUSSION PAPER SERIES

2014-02

Do households misperceive the benefits of energy-saving actions?

Evidence from a Japanese household survey

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April 30, 2014

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Abstract

Using a household survey conducted in a suburb of Tokyo, we examine whether individuals properly perceive the benefits of energy-saving actions. A bivariate regression shows that on average, individuals overestimate the benefits. The tendency for overestimation is robust to controlling for individual characteristics as well as home characteristics. Our results are the opposite to those of Attari et al. (2011), in which individuals in the U.S. were found to underestimate the benefits. This suggests that the provision of information about the benefits of energy saving may be an effective policy against global warming issues in one country but not necessarily in all countries.

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1. Introduction

To mitigate global warming and climate change problems, a number of governments have introduced various policies such as subsidies for low-carbon products, carbon taxes and emission trading systems. These policies are expected to help reduce greenhouse gas (GHG) emissions from the most important target, namely, the industrial sector. However, households are also an important target, as they are responsible for 15-20% of the total energy requirements in OECD countries (OECD, 2001).

A sizable contribution to GHG emissions may be achieved by energy-saving actions among households without significant economic sacrifices or losing a sense of well-being. Studies in the United States estimated that energy consumption could be reduced 20-30 percent by changing the selection and use of household and motor vehicle technologies (Dietz et al., 2009; Gardner and Stern, 2008). Although this magnitude may not directly apply to households in other developed countries, it is reasonable to expect that the amount of reduction may be non-negligible, as lifestyles in other countries are more or less similar to those of households in the U.S.

The fact that the potential for reduction remains unfilled has motivated researchers to examine the determinants of energy-saving actions and investments. Among recent studies, Urban and Scasny (2012) found that individuals with higher environmental concerns are more likely to perform energy-saving curtailments and investments. Truelove and Parks (2012) and Sutterlin et al. (2011) argued that personal factors such as knowledge, adherence to animism and beliefs about global warming issues play an important role in shaping individuals' energy-saving behaviors.

Another important determinant may be knowledge about the monetary benefits of energy-saving actions and investments. Put differently, individuals may not opt for energy-saving actions and investments because they are unaware of how much these actions and investments can save. In this regard, Attari et al. (2011) used data from an online survey in the United States and found that individuals underestimate energy use and savings on average. Yohanis (2012) provided evidence that 84 percent of the households surveyed in Northern Ireland have no idea about the energy performance of their household appliances. Using survey data in the U.S., Allcott (2011) also revealed that 89 percent of the households calculated fuel costs less carefully than usual when they purchased vehicles.

This study aims to provide additional evidence on whether individuals properly perceive the monetary benefits of energy-saving actions. Using data from a survey conducted in Soka city, a suburb of Tokyo, we examine simple energy-saving actions recommended by the Energy Conservation Center Japan (2010), such as "setting air conditioner temperatures to 28 degrees Celsius in summer," "setting air conditioner (gas/oil heater) temperatures to 20 degrees Celsius in winter," and "turning off a gas/oil heater when unnecessary."

A bivariate regression shows that on average, individuals overestimate the benefits of energy-saving actions. The tendency for overestimation is robust to controlling for individual characteristics as well as home characteristics, and it is more pronounced when the potential nonlinearity between actual and perceived benefits is accounted for. These results are in sharp contrast to those of Attari et al. (2011), suggesting the existence of country heterogeneity in how individuals misperceive the monetary benefits of energy-saving actions.

2. Data

2.1 Survey Description

To examine the relationship between the actual and perceived benefits of energy-saving actions, we conducted a household survey in Soka City, a suburb of Tokyo (25 kilometers away from Tokyo). The population of the city is approximately 240 thousand, with a population density of 8.9 thousand persons per square kilometer. Although the population is not large, the density is relatively high in comparison to the average in Japan, which is approximately 0.3 thousand persons per square kilometer.

The survey was implemented in the following procedure. From all households in Soka City, 1,200 households were randomly selected. Data collectors visited the households from January 7 to February 7, 2011 and provided a questionnaire to a member of each household with an explanation that they would receive a coupon book worth 500 yen (about 5 US dollar) for participating in the survey. At a later date, the data collectors revisited the households to collect the questionnaires. Most likely because we used a door-to-door survey method, the response rate is high (59.5 percent), corresponding to replies from 714 households. Because 464 of the respondents did not answer all of the questions required for analysis, they were discarded from the sample. As a result, our analysis is based on 250 respondents.

For this paper, we consider the 18 energy-saving actions presented in Table 1. These actions are recommended by the Energy Conservation Center of Japan (2010) as "simple actions for energy savings." The Center also provides information on actual annual savings from each action, which we hereafter refer to as "actual benefit." In the survey, the respondents are asked for each action how much energy (s)he thinks the action saves per year. The answer will be hereafter referred to as his/her "perceived benefit."

2.2 Perceived and Actual Benefits

For respondent i and energy-saving action j, we have a pair of actual and perceived benefits (ab_j, pb_{ij}), where ab_j is the actual benefit from action j and pb_{ij} is the benefit respondent i perceives for action j.[2] It should be mentioned that we did not ask the respondent to report pb for action j if it is irrelevant to him/her. For example, if the respondent does not have a plasma TV, (s)he was not asked to answer pb for "turning it off when unnecessary." As a result, the number of observations analyzed is 2,496, representing approximately 10 actions per respondent.

To examine how the actual and perceived benefits are related, we plot (ab_j, pb_{ij}), i = 1,…,250 and j = 1,…,18, in Figure 1, where the horizontal and vertical axes represent actual and perceived benefits (measured in yen), respectively. In the figure, we also present the fitted linear regression line, $pb = 4473.3 + 0.437ab$, obtained by regressing pb_{ij} on ab_j. The 45-degree dashed line is also added to the figure. If respondent i correctly recognizes the monetary benefits of action j (i.e., $pb_{ij} = ab_j$), then the point will be exactly on the line.

As is evident from the figure, the respondents overestimate the monetary benefits of the energy-saving actions, on average. The intercept greater than zero (i.e., 4,473.7) and the slope greater than zero and smaller than 1 (i.e., 0.437) imply that the extent of overestimation is more pronounced when the amount of actual savings is smaller for an action. In addition, the regression line intersects with the 45-degree line at approximately 8,500 yen per year. This indicates that respondents underestimate actions that result in a large benefit, but no energy-saving action is listed in the Table 1.

3. Factors accounting for perceived benefits

3.1 Variable description

[2] It is expected that actual benefits from energy-saving actions depend on households' characteristics such as performance of a home electrical appliance and structure of a house. However, only one estimated actual benefit as benchmark is reported in the Energy Conservation Center of Japan (2010). Therefore, in this paper, one actual benefit is regarded to be irrelevant to households' characteristics.

As illustrated in Figure 1, there is much variability around the regression line. To examine what factors account for the variability of the perceived benefits among the respondents, we extend the bivariate regression model by including individual as well as home characteristics.

As individual characteristics, we consider age, gender (= 1 if the respondent is male), education (= 1 if the respondent has a bachelor's or higher degree), marital status (= 1 if the respondent is married), the number of family members in a household, as well as comfortable temperatures measured in degrees Celsius in summer and winter. Income is also considered as a potential factor, for which we construct a scale variable; it takes a value of 1 if the income is under 2 million yen, 2 if it is between 2 and 3 million yen, 3 if between 3 and 4 million yen, 4 if between 4 and 5 million yen, 5 if between 5 and 7 million yen, if between 7 and 10 million yen, 7 if between 10 and 15 million yen, and 8 if more than 15 million yen.

To examine whether environmental concerns are associated with perceived benefits, we construct a dummy variable that takes a value of 1 if a respondent answers "very high" to the question, "to what extent are you concerned with global warming issues? (1: very high, 2: high, 3: low, 4: very low)."

We also construct a variable that captures how the respondent thinks of energy expenses in relation to other expenses. The respondents were asked: "Suppose you want to save money and cut your expenses from the following expense categories: energy, food, water, transportation and communication, housing, health care, entertainment, cultural-amusement and education. Please rank energy expenses as follows: 1 if you would cut them first among other expenses, 2 if they are your number two priority, 3 if your number three priority, and the like."

As for home characteristics, we include home age and size, as well as a dummy variable that takes a value of 1 if the respondent owns his/her home. We also include a dummy variable that takes a value of 1 if the respondent's household uses an electric water heating system. Similarly, we include a dummy variable for the use of a gas water heating system. We further include how many pieces of electrical equipment are present in the respondent's household.

3.2 Estimation results

Column (1) in Table 3 presents the results obtained by ordinary least squares. The coefficient on actual benefits is found to be positive and significant at the 1% level. The size of the coefficient is 0.52, similar to that in the bivariate regression. We test the null hypothesis that the coefficient is equal to 1. This hypothesis is rejected at the 1% level, suggesting that on average, the respondents misperceive the monetary benefits of energy-saving actions.

Attari et al. (2011) argued that the relationship between actual and perceived benefits may be non-linear rather than linear. To account for potential non-linearity, we extend the model by including a quadratic term of actual benefits (i.e., ab^2). The results are presented in Column (2). The coefficients on actual benefits and the square of actual benefits are both found to be significant at the 1% level. In terms of sign, the former is negative and the latter positive, implying that the relationship between actual and perceived benefits is U-shaped.

Figure 2 illustrates how the actual and perceived benefits are related across the models. The 45-degree dashed line represents no gap between actual and perceived benefits. "Simple OLS" is the fitted line obtained by regressing the actual perceived benefits on actual benefits only. "Model 1" and "Model 2" correspond to the fitted lines for the models in Columns (1) and (2) of Table 3, respectively. These lines are drawn by setting the variables (except actual benefits) to their sample means.

"Model 1" is very close to "simple OLS," suggesting that the results presented in the previous section are robust to controlling for individual as well as home characteristics. “Model 2” is always located above the 45-degree line. That is, when we account for potential nonlinearity between the actual and perceived benefits, the tendency for overestimation becomes even more pronounced. Overall, these results suggest that individuals, on average, overestimate the benefits of energy-saving actions.

With regard to the other variables, we found that age, gender, marital status, number of family members in the household, comfortable temperature for summer, home ownership, and the relative importance of energy expenses when required to save money explain the variability of the respondents’ perceived benefits. In particular, the results indicate that the extent of overestimation will be the largest for single young males, whereas the benefits perceived by married older females are the smallest.

4. Concluding remarks

Based on a survey conducted in a suburb of Tokyo, this study examined whether individuals properly perceive the monetary benefits of energy-saving actions. Our results suggest a particular pattern with regard to individuals’ perceptions about the benefits. That is, their estimates tend to be larger than the actual benefits, which is the opposite of the pattern found by Attari et al. (2011) for individuals in the United States. We also found that individual and home characteristics explain the perceived benefits to some extent.

Our results have several policy implications. First, the provision of information about the benefits of energy-saving actions may be an effective policy in one country but not necessarily in another country. This is because individuals in one country may underestimate the benefits of energy-saving actions, while those in another country may not, as suggested by the contrast found between our results and those of Attari et al. (2011). Second, the provision of information may be effective even in a country such as Japan where individuals overestimate the benefits on average. Our results showed that the respondents who are married and older females tend to underestimate the benefits the most. Therefore, informing this group of the actual benefits of energy-saving actions may help reduce their energy consumption.

Acknowledgements

This study was supported by the Japan Foundation Center for Global Partnership, the Japanese Ministry of the Environment and the Japan Society for the Promotion of Science (Grant-in-Aid for Scientific Research (C: 24530267)).

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Tables and Figures

Table 1. Energy-saving actions

	Equipment	Energy-saving action
1	Air conditioner	Set to 28 degrees in summer
2	Air conditioner	Set to 20 degrees in winter
3	Air conditioner	Turn off when unnecessary
4	Air conditioner	Clean filters
5	Gas heater	Set to 20 degrees in winter
6	Oil heater	Set to 20 degrees in winter
7	Gas heater	Turn off when unnecessary
8	Oil heater	Turn off when unnecessary
9	Electric carpet	Frequent temperature control
10	CRT TV	Turn off when unnecessary
11	Plasma TV	Turn off when unnecessary
12	Liquid crystal TV	Turn off when unnecessary
13	Refrigerator	Temperature control
14	Refrigerator	Fixed away from wall
15	Electric pot	Unplug when unnecessary
16	Water heater	Set water temperature low
17	Water heater	Refrain from reheating water
18	Water heater	Turn shower off when unnecessary

Table 2. Descriptive statistics

Variables	Mean	S.D.	Min	Max
Perceived benefits (yen)	5,339.80	7,678.40	0	72,000
Actual benefits (yen)	1,829.60	1,498.30	330	5,920
Income (scale variable)	4.58	1.82	1	8
Age	53.56	13.64	22	84
Male	0.3	0.46	0	1
Education (Bachelor’s degree or higher)	0.25	0.43	0	1
Environmental concerns	0.27	0.44	0	1
Importance of energy expenses when saving	2.77	1.67	1	9
Married	0.92	0.27	0	1
Number of family members	3.48	1.3	1	7
Own house	0.85	0.36	0	1
House size	5.08	1.43	1	10
House age	17.83	11.02	1	50
Number of electrical equipment	1.72	1.12	0	9
Comfortable temperature in summer	25.71	2.01	18	30
Comfortable temperature in winter	23.49	2.5	15	30
Electric water heating	0.16	0.37	0	1
Oil water heating	0.04	0.2	0	1

Table 3: Estimation results

	(1)			(2)		
Variables	Coefficient.			Coefficient.		
Actual benefits	0.52	(0.12)	***	-1.13	(0.43)	***
Square of actual benefits				0.0003	(0.00007)	***
Income	-9.7	(94.7)		3.3	(94.6)	
Age	-54.9	(15.7)	***	-52.6	(15.6)	***
Male	1324.8	(408.3)	***	1324.3	(406.9)	***
Education	325.0	(407.5)		336.9	(405.6)	
Environmental concerns	82.2	(369.4)		111.3	(367.4)	
Importance of energy expenses when saving	259.1	(115.8)	**	264.6	(115.4)	**
Married	-1639.5	(811.4)	**	-1641.6	(808.8)	**
Number of family members	-477.1	(132.7)	***	-463.4	(132.4)	***
Own house	1239.8	(486.5)	**	1234.9	(486.1)	**
House size	-106.5	(148.6)		-79.8	(148.3)	
House age	4.6	(17.1)		2.6	(17.0)	
Number of electrical equipment	227.3	(167.6)		58.1	(174.6)	
Comfortable temperature in summer	-184.5	(74.3)	**	-180.6	(74.3)	**
Comfortable temperature in winter	58.3	(59.2)		63.0	(59.1)	
Electric water heating	50.6	(473.0)		38.7	(472.2)	
Gas water heating	-115.4	(783.6)		-122.6	(778.0)	
Constant	11737.7	(2813.2)	***	13031.3	(2826.7)	***
Adjusted R-squared	0.03			0.04		
F value (P value)	4.91***			4.97***		

Note: The number of observations is 2,496. ***, ** and * denote significance at the 1 percent, 5 percent and 10 percent levels, respectively. Robust standard errors are in parentheses. Though included in both models (i.e., Column (1) and Column (2)), the interaction term of "Comfortable temperature in summer (winter)" and a dummy variable for the action regarding air conditioners is found to be insignificant and hence not reported here.

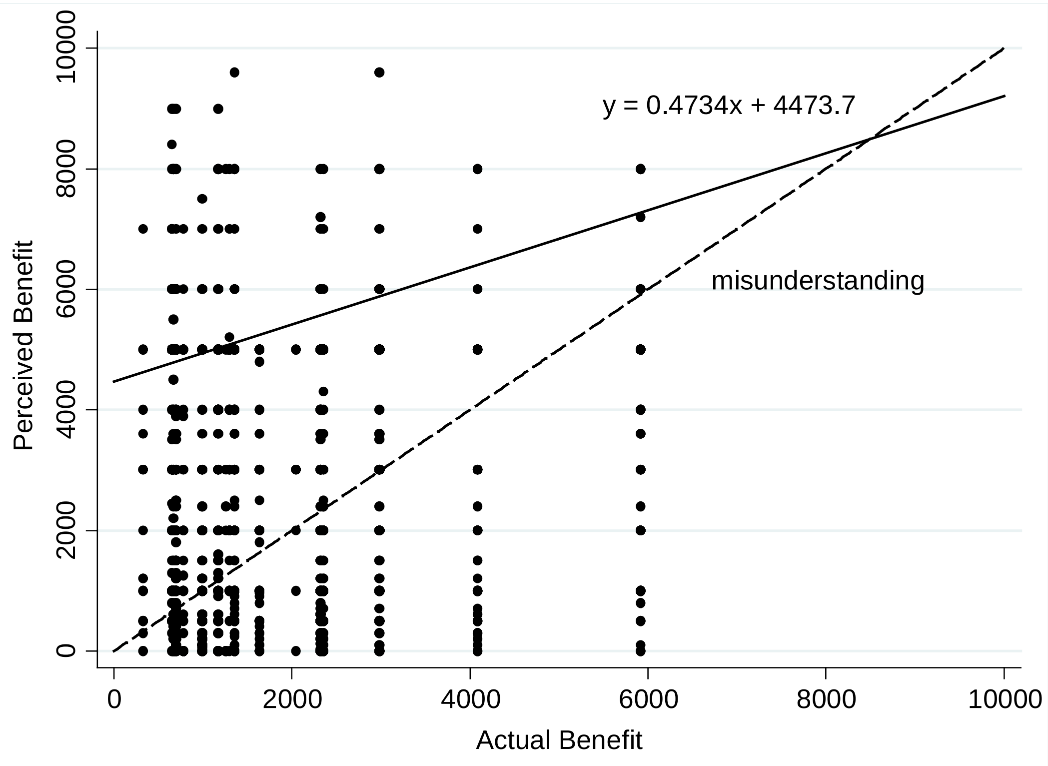

Figure 1. Actual (X-axis) and perceived (Y-axis) benefits

Note: the observations which values are more than 10,000 are omitted in the figure in order to easily view the relationship.

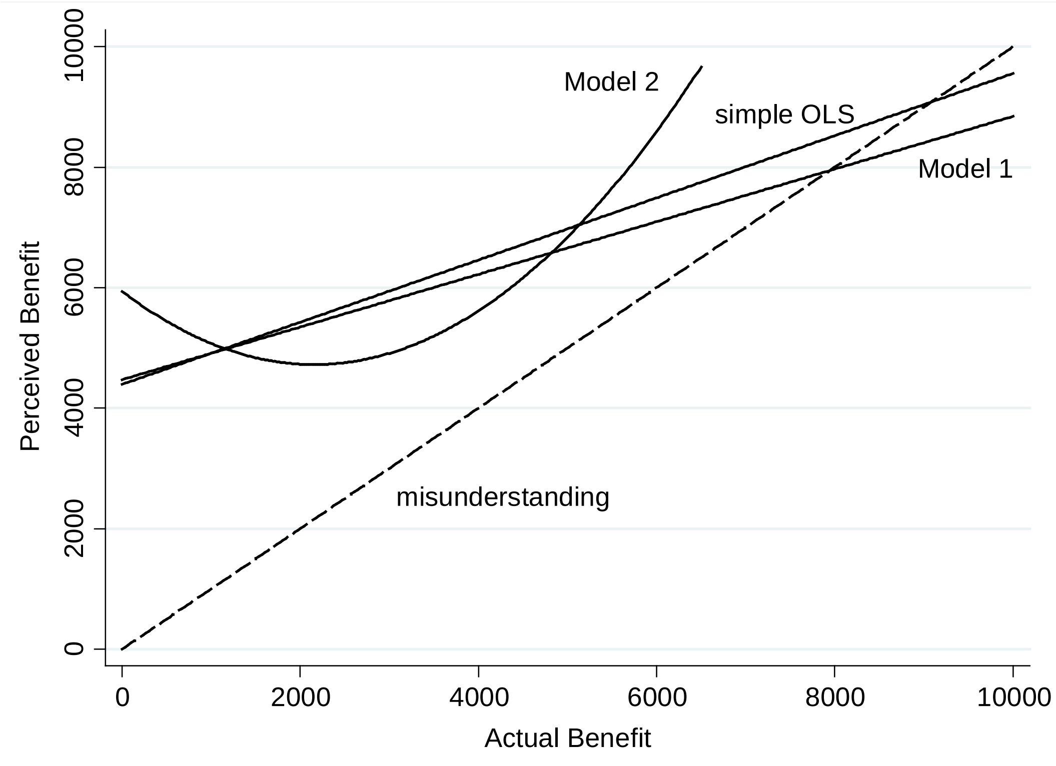

Figure 2. Relationship between the actual and perceived benefits across models

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