Energy Policy 63 (2013) 809–813

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Energy-saving behavior and marginal abatement cost for household CO_2 emissions

Mitsutsugu Hamamoto *

Faculty of Economics, Dokkyo University, 1-1 Gakuen-cho, Soka-shi, Saitama 340-0042, Japan

HIGHLIGHTS

- Consumers' perceived net costs of energy-saving measures in using energy-consuming durables are measured.
- Using the estimated net costs, a marginal abatement cost (MAC) curve for the average household's CO_2 emissions is produced.
- A high carbon price is needed in order to provide households with an incentive to take actions for energy-savings.
- Households' attributes affecting their energy-saving behavior are revealed by a regression analysis.

ARTICLE INFO

Article history:
Received 4 December 2012
Accepted 23 August 2013
Available online 14 September 2013

Keywords:
Household
Energy-saving measures
Marginal abatement cost curve

ABSTRACT

This paper attempts to measure consumers' perceived net benefits (or net costs) of energy-saving measures in using energy-consuming durable goods. Using the estimated net costs and the volume of CO_2 reduced by the measures, a marginal abatement cost (MAC) curve for the average household's CO_2 emissions is produced. An analysis using the curve suggests that in order to provide households with an incentive to take actions that can lead to CO_2 emission reductions in using energy-consuming durables, a high level of carbon price is needed. In addition, a regression analysis reveals that the net benefits of the measures are larger for households that put a higher priority on energy saving, for those living in detached houses, for those with a smaller number of persons living together, and for those with less income. The result of the analysis using the MAC curve may suggest that promoting energy-saving behavior will require not only a policy to provide economic incentives but also interventions to influence psychological factors of household behavior.

1. Introduction

The enhancement of energy efficiency and conservation contributes not only to cutting energy-related expenditures but also to reductions in CO_2 emissions. Recently the need for reducing household energy use has been emphasized in the debate on climate change policy. As income rises, consumers' lifestyle changes and the use of appliances gets popularized. These factors cause increases in household energy consumption (Kadian et al., 2007; Feng et al., 2011). Improvements in the energy efficiency of appliances will contribute to decreasing energy consumption in the household sector, and there are significant potentials for such improvements in developing countries (Saidur et al., 2007). Changing consumer habits leading to consumption of carbon-intensive goods and services is one of the key challenges (Munksgaard et al., 2000).

Although reducing energy consumption brings benefits to both individual energy users and society as a whole, there are many barriers that dampen incentives to invest in energy efficiency. Typical barriers are externalities, information deficiencies (lack of information and asymmetric information), and limited availability of capital (Tietenberg, 2009). These barriers to energy efficiency investment can be seen as market failures and appropriate government intervention is needed in order to overcome them.

Closely related to the barriers to energy efficiency is the issue of implicit discount rates used by consumers and firms in evaluating energy-efficiency investment. A large number of empirical studies on the issue find that discount rates implied by consumers' choices are relatively high (Train, 1985). Ruderman et al. (1987) examine consumers' efficiency choices for eight residential appliances, finding that while the aggregate market discount rates of room and central air conditioners are about 20%, those of six appliances (refrigerators, freezers, gas and oil central space heaters, and electric and gas water heaters) have higher values, ranging from 39% to 825%. They offer several explanations for underinvestment in energy efficiency in the household sector, which include lack

* Tel./fax: +81 48 942 6465.
E-mail address: hmitutug@dokkyo.ac.jp

0301-4215/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.enpol.2013.08.082

of information and limited availability of capital for purchasers, suggesting that high implicit discount rates are attributable not only to individual time preferences but also to the market failures. Consumers' high implicit discount rates may constitute a serious obstacle to the diffusion of energy-efficient durables.

While purchasing energy-efficient durables might be perceived as unprofitable by consumers because of high implicit discount rates, households can reduce their energy consumption even without investments in energy efficiency: if they take care not to waste energy when using energy-consuming durables, their energy-related expenditures can be cut. Such energy-saving behavior is encouraged by the Japanese government. The Energy Conservation Center, Japan (ECCJ), a general incorporated foundation whose aim is to promote energy efficiency in Japan, provides households with information about reductions in energy consumption and CO_2 emissions that are achieved by energy-saving behavior in using energy-consuming durables [1].

There are debates about policy intervention to induce households to take actions that have the potential to achieve large reductions in CO_2 emissions. Vandenbergh and Steinemann (2007) and Vandenbergh et al. (2008) claim that there are low-hanging fruit measures: by carrying them out, households can reduce energy consumption without effort or sacrifice. Vandenbergh et al. (2010) discuss the design principles for energy efficiency programs to encourage households to implement such measures. The low-hanging fruit actions include both the adoption of more efficient equipment (i.e., investment in energy efficiency) and the curtailment of existing equipment use (i.e., energy-saving behavior in using energy-consuming durables). As discussed above, however, the former is faced with the barriers that dampen incentives to invest in energy efficiency. With regard to the latter, it is inevitable to bear costs associated with energy-saving behavior in using energy-consuming durables: for instance, if consumers raise their air conditioners' temperature settings in order to save electricity during the summer season, they may have to take the heat to some extent. In addition, it might be troublesome to turn lights or TVs off when not in use so that electricity may not be wasted. Rational consumers compare disutility associated with measures to save energy in using energy-consuming durables with gains from energy savings achieved by the measures in order to decide whether to carry out the measures or not.

Disutility associated with energy-saving behavior in using energy-consuming durables can be measured by estimating consumers' perceived costs of specific energy-saving measures. Measuring the disutility is an important task because the reason why there are households that do not carry out measures to save energy in using energy-consuming durables in spite of reductions in their energy-related expenditures can be explained. In addition, using the cost estimates, to what extent a carbon-pricing policy may promote energy-saving behavior in using energy-consuming durables can be examined.

The aim of this paper is to estimate the disutility of energy-saving behavior in using energy-consuming durables. In order to obtain information necessary for the estimation, a survey of consumers' energy-saving behavior was carried out. The questionnaire of the survey includes questions to elicit information on the costs of specific measures to save energy in using energy-consuming durables. Using the cost estimates and the volume of CO_2 emissions reduced by the measures, a marginal abatement cost (MAC) curve for household CO_2 emissions associated with the use of energy-consuming durables can be obtained. In addition, the effects of households' attributes on the net benefits of the energy-saving measures are examined.

[1] See the website of the ECCJ (http://www.eccj.or.jp/dict/index.html [accessed May 18, 2010]).

The remainder of the paper is organized as follows. Section 2 describes the methodology of the analysis and explains the survey carried out to collect data used in the analysis. The results are presented in Section 3. Section 4 examines the effects of households' attributes on the net benefits of energy-saving measures. Section 5 concludes the paper.

2. Methodology

The costs of the following fourteen energy-saving measures encouraged by the ECCJ are estimated:

(A) Set your room air conditioner's temperature to 28 °C during the summer.
(B) Set your room air conditioner's temperature to 20 °C during the winter.
(C) Turn your room air conditioner off if you do not need to use it.
(D) Clean filters in your room air conditioner once or twice a month.
(E) Set your room gas or oil heater's temperature to 20 °C during the winter.
(F) Turn your room gas or oil heater off if you do not need to use it.
(G) Adjust the temperature setting of your electric heating carpet frequently to maintain the desired temperature.
(H) Turn your TV off when not in use.
(I) Adjust the temperature setting of your refrigerator seasonally and do not put too much food in the refrigerator.
(J) Keep proper space between your refrigerator and the wall.
(K) Unplug your electric hot water pot when it is not used for an extended period of time.
(L) Reduce your water heater's temperature as far as possible when washing dishes.
(M) Everyone in your family takes a bath while water in the bathtub is hot in order not to heat the bath several times.
(N) Do not leave the shower running.

These are not all of the energy-saving measures encouraged by the ECCJ. The reason why the fourteen measures were selected is that they are representative and can bring about relatively large reductions in household CO_2 emissions. The questionnaire includes several questions to elicit information necessary for estimating the cost for each of the energy-saving measures. For example, questions to elicit the disutility of measure (A) are as follows. First, the respondents were asked the following question: "(a) How much per one room air conditioner do you think you could save annually on your electricity bills by carrying out measure (A)?" Next, they were asked to what extent they carried out the measure. The respondents who answered that they always carried out the measure (hereinafter called type I respondents) were asked the following question: "(b) What is the maximum amount of annual electricity bill savings for each room air conditioner that makes you quit carrying out the measure?" The respondents who answered that they did not carried out the measure very much or that they did not at all (hereinafter called type II respondents) were asked the following question: "(c) What is the minimum amount of annual electricity bill savings for each room air conditioner that makes you always carry out the measure?" In order to avoid the effects of the respondents' willingness to pay for environmental protection on their answers to questions (b) and (c), the descriptions of these questions include the sentence as follows: "Suppose that the use of energy does not lead to environmental problems."

The amounts of money that respondent i provided as the answers to questions (a) and (b) (or (c)) are denoted by ESP_i and ESQ_i (or ESR_i), respectively. ESQ_i and ESR_i are the money amounts