Energy price sensitivity: installation vs. usage stage of heating appliances

○Jiaxing Wang* and Shigeru Matsumoto**
○王 佳星； 松本 茂

1. Introduction and Objectives

People first choose a product by comparing selling prices with expected operating costs, and then consume energy to use the chosen product. Household characteristics and energy prices can influence people's behavior in both product choice and use, which in turn should affect their final energy consumption. However, previous studies have not simultaneously assessed the effects of household characteristics and energy prices on product choice and use. This study focuses on heating energy, which accounts for a large share of household energy consumption and evaluates the impact of household characteristics and energy prices in both the product selection and use stages. Specifically, we compare the sensitivity of energy consumption to income and energy prices between central heating system (CHS) and non-central heating system (non-CHS) households.

2. Research method

Using data from Household CO_2 Survey by the Ministry of the Environment of Japan, this study examined how energy source choice, CHS adoption, and household winter energy consumption vary with household characteristics and energy prices. Hokkaido, Japan, where CHS is more prevalent than in other regions due to its cold winters, was selected as the target region. Unobserved household characteristics could affect not only final energy consumption but also the adoption of CHS. To avoid this sample selection problem, we conducted our analysis using the estimation model proposed by Bourguignon et al. (2007).

First, we conduct a multinominal logit model to estimate how energy price affect households' choice of CHS adoption. Based on whether or not a household uses CHS or not and their choice of primary source, we divide households into 4 groups: CHS households (kerosene), non-CHS households (kerosene), CHS households (electricity), and non-CHS households (electricity). The probability that household i chooses jth heating appliances is as follows:

$$P_{ij}(\epsilon_i < 0) = \frac{exp(\alpha + \beta_j W_i + \Gamma_j R_i + \theta_j I_i + \boldsymbol{\gamma}_j \boldsymbol{Z}_i)}{\sum_{j=1}^{J} exp(\alpha + \beta_j W_i + \Gamma_j R_i + \theta_j I_i + \boldsymbol{\gamma}_j \boldsymbol{Z}_i)}$$

* Faculty of Economics and Business Administration, Sapporo Gakuin University, E-mail: wangjx@sgu.ac.jp.
** College of Economics, Aoyama Gakuin University, E-mail: shmatsumoto@aoyamagakuin.jp

where W_i is winter temperature, R_i is relative energy price of electricity, I_i is household income, and $\boldsymbol{Z}_i$ is a vector of the socioeconomic characteristics of household i. The impact of these factors is examined by parameters $\beta_j, \Gamma_j, \theta_j$, and $\boldsymbol{\gamma}_j$, respectively.

The outcome equation of winter energy consumption conditional on choosing $j = k$ is

$$y_{ik} = \alpha + \beta_j W_i + \Gamma_j R_i + \theta_j I_i + \boldsymbol{\gamma}_j \boldsymbol{Z}_i + E(u_i|\epsilon_i < 0) + w_i$$

where w_i is a residual that is mean-independent of the regressors. $E(u_i|\epsilon_i < 0)$ is bias correction based on Dubin and McFadden (1984).

3. Main findings

Table 1 compares the factors affecting winter energy consumption between CHS and non-CHS households. For households that chose kerosene as their primary source, the results show that household income, age of household head, and household size affect winter energy consumption for non-CHS households but not for CHS households.

The results of sample selection model further confirms that energy prices were influential at the installation stage, but not at the use stage, except for non-CHS households that chose electricity as their primary source.

Table 1. Impact on energy consumption in winter (Y = winter energy consumption, MJ)

Variables	Kerosene				Electricity or Gas			
	CHS-using households		Non-CHS-using households		CHS-using households		Non-CHS-using households	
	Coefficients	Std. Err.	Coefficients	Std. Err.	Coefficients	Std. Err.	Coefficients	Std. Err.
Region (base = douou area)								
Dounan area	6796.5280 *	3925.0390	-1548.0890	2638.7570	-6348.6900	5066.5480	122.6367	3197.8180
Doutou area	1393.6950	4839.5080	-4476.0840 *	2645.4740	-5324.0650	5062.4540	-649.4639	4233.4610
Douhoku area	6134.7150	5393.5790	-8799.7240 ***	3096.4880	-3811.7890	6098.1450	4008.0960	6970.5400
Average winter temperature	-2241.8210 **	1074.8580	-799.7496	550.5411	-722.6689	2204.9310	-325.3551	1090.4390
Present relative price of electricity	104.8376	737.0606	-67.3254	461.2101	-737.6824	1268.9000	-1481.3420 **	689.4751
Household income (ln)	-4811.2580	5358.3360	6011.9560 **	2410.9100	866.4294	5133.4320	4647.8920	4624.9970
Age	-107.4333	188.4609	168.7596 *	102.0127	-91.0603	208.4764	-3.4460	137.1770
Household size	680.5756	1280.4660	2179.1720 **	865.9397	917.3172	2328.3930	122.4284	1399.6740
Age of house	843.7452	865.9976	-263.5953	297.6842	358.2861	940.0708	215.8026	967.0874
Floor area (m2)	64.0133 **	28.2835	24.8571	20.2355	90.1170 **	43.7844	38.9383	39.2326
Constant	56897.7800	35192.0000	-9279.3450	13638.9100	27244.2400	40538.0200	-4328.4200	23995.5100

4. Conclusion

Our results suggest that households are more sensitive to energy prices at the product installation stage than at the product use stage. It seems difficult to get people who have already established product use patterns to adopt energy saving behavior by increasing energy prices.