The Heterogenous Impact of Energy Price Changes on Household Expenditure from the Aspect of Different Types of Households in Japan

Hoshino, Yuko, ENEOS Corporation, +81 3 6551 9772, hoshino.yuko@eneos.com
Ogawa, Junko, The Institute of Energy Economics Japan, +81 3 5547 0222, junko@tky.ieej.or.jp

Overview

Price elasticity of energy demand is the key value when we evaluate the impacts of carbon prices on energy conservation and the household expenditure. Some previous papers (Frondel et.al (2019), Chindarkar et.al (2019)) suggest that it is important to consider the differences of price elasticities caused by the household heterogeneity. We focus on income and city size difference as the household heterogeneities. We find that the lower the household income or the larger the city size, the smaller the value of estimated price elasticity of demand. Our results show that energy pricing policy should be carefully designed considering the heterogenous response of different types of households.

Methods

According to Kuroda(1989), the indirect utility function of representing household consumers takes the form:
$V = (p, Y)$ and we get the following trans-log form:

$$lnV = \alpha_0 + \sum_i \alpha_i \ln(p_i/Y) + (1/2)\sum_i\sum_j \beta_{ij} \ln(p_i/Y)\ln(p_j/Y), \quad Y = \sum_i p_i x_i \tag{1}$$

Where p_i, p_j are the i, j^{th} prices, Y is total consumption value, x_i is the i^{th} consumption volume.
$i, j =$ electricity, LPG, city gas, kerosene, gas oil, transporatation service, other consumption

The i^{th} value share w_i can be written as : $w_i = (\alpha_i + \sum_j \beta_{ij} lnq_j)/(\sum_i \alpha_i + \sum_j\sum_k \beta_{kj} lnq_j)$ (2)

Own-Price Elasticity and Cross-Price Elasticity are calculated as follows, respectively

$$\eta_{pii} = -1 + \left(\beta_{ii}/w_i - \sum_j \beta_{ij}\right)/\left(\sum_j \alpha_j + \sum_j\sum_k \beta_{jk} ln(p_k/Y)\right) \tag{3}$$

$$\eta_{pij} = (\beta_{ij}/w_i - \sum_j \beta_{ij})/(\sum_k \alpha_k + \sum_k\sum_l \beta_{kl} ln(p_l/Y)) \quad , (i \neq j) \tag{4}$$

Where $\sum_i w_i = 1,\ \ \sum_i \alpha_i = -1 , \sum_j \beta_{ij} = 0,\ \ \beta_{ij} = \beta_{ji}$

Base on the above model, we estimate the price elasticity of energy demand using the aggregated data of “Annual Report on the Family Income and Expenditure Survey” from the year 2001 to 2017. We model households’ whole consumption including non-energy expenditure.

Results

We estimate the model shown in the equation (2) for different types of households of five income classes, and four city sizes. Table.1 shows the own-price elasticity and cross-price elasticity which are calculated by using the estimated model parameters. In this table, bold numbers show the own-price elasticities which are derived from the equation (3), and the non-bold numbers show cross-price elasticities derived from the equation (4). Most own price elasticities are negative which is theoretically expected, except for the elasticity of transport expenditure in the low-income households.

As for the income class effects on the price elasticities, we find that the own price elasticities are larger in the high-income households than in the low-income households. And for the influence of city size differences on the price elasticities, the own price elasticities of small cities are larger than those of large cities.

Conclusions

We find the price elasticities vary according to the household income and the size of the cities where households live. The higher own-price elasticities in the high-income households means that energy conservation is easier in high-income households because they can afford to invest in energy efficient appliances. On the other hand, lower own-price elasticities in the low-income households means that the rise of energy prices increases household energy expenditure burdens more severely.

The price elasticities of households in a small city are bigger than those of households in a large city. This result is consistent with the study for India presented by Chindarkar(2019). In the case of developed countries, Bernstein and Griffin(2006) also found that the regional price elasticities of residential energy demand are diverse in the US.

In a small city, average house size is larger and transportation tends to depend more on automobiles. This implies that the households in a small city have more energy appliances and automobiles. Therefore, they have more chance to buy new appliances and cars ,which are usually energy efficient.

The results suggest that energy pricing policy should be carefully designed considering the heterogenous response of different types of households.

Table 1. The Price Elasticities of Energy Demand in the Different Types of the Household

Low Income									
	Electricity	LPG	City Gas	Kerosene		Gas Oil	Trans port		Other
Electricity	**-0.32**	0.32	-0.09	0.04	Gas Oil	**-0.54**	-0.24	Other	**-0.92**
LPG	1.31	**-2.32**	0.46	-0.09	Trans port	-0.40	**0.89**		
City Gas	-0.29	0.36	**-0.05**	-0.06					
Kerosene	0.23	-0.12	-0.10	**-0.50**					

High Income									
	electricity	LPG	City Gas	kerosene		Gas Oil	Trans port		Other
electricity	**-0.62**	-0.01	0.23	0.15	Gas Oil	**-0.90**	0.32	Other	**-0.94**
LPG	-0.05	**-2.39**	0.75	-0.20	Trans port	0.32	**-0.51**		
City Gas	0.68	0.33	**-0.43**	-0.33					
kerosene	1.44	-0.28	-1.05	**-1.37**					

Large City									
	electricity	LPG	City Gas	kerosene		Gas Oil	Trans port		Other
Electricity	**-0.31**	0.01	0.05	0.16	Gas Oil	**-0.46**	2.62	Other	**-0.96**
LPG	0.11	**-0.30**	1.48	-0.48	Trans port	1.72	**-5.23**		
City Gas	0.09	0.23	**-0.15**	-0.22					
kerosene	1.89	-0.48	-1.44	**-0.16**					

Small City									
	electricity	LPG	City Gas	kerosene		Gas Oil	Trans port		Other
Electricity	**-0.44**	-0.07	0.25	0.16	Gas Oil	**-1.01**	0.65	Other	**-0.92**
LPG	-0.22	**-0.75**	0.15	-0.15	Trans port	1.82	**-4.35**		
City Gas	3.51	0.68	**-1.45**	-0.49					
kerosene	0.66	-0.19	-0.15	**-1.13**					

References

Kuroda, Masahiro, General Equibilium Analysis , Modern Economics series 19, Iwanami-syoten, in Japanese, 1989

Frondel, Manuel, Gerhard Kussel, Stephan Sommer, Hetrogeneity in the price response of residential electricity demand: A dynamic approach for Germany, Resource and Energy Economics, Vol.57, pp119-134, 2019

Chindarkar, Namratam, Nihit Goyal, One price doesn’t fit all: An examination of heterogeneity price elasticity of residential electricity in India, *Energy Economics*, Vol.81. pp765-778, 2019

Bernstein, M.A, J.Griffin, Regional Differences in the Price-Elasticity of Demand for Energy, National Renewable Energy Laboratory, SR-620-39512, 2006