AN EMPIRICAL ANALYSIS ON IMPACT OF TIME-OF-USE RATE ON HOUSEHOLD ELECTRICITY SAVING BEHAVIOUR UNDER POWER SHORTAGE AND DIFFUSION POTENTIAL OF TIME-OF-USE RATE

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Overview

Japan experienced power shortage after the Great East Earthquake and Fukushima Nuclear Power Plant accident on March 11th in 2011. All of electricity customers including industrial, commercial and residential customers were required to reduce their electricity consumption during summer and winter season, when electricity demand were high. An unexpected blackout was avoided by the customers' effort to reduce electricity consumption. Japanese government and electric power companies make a electricity saving campaign and provide various information regarding to demand and supply situation in each hour and know-how in electricity saving to encourage customers to reduce their consumption. However, demand response using time-of-use (TOU) rate could not be applied to most of residential customers except for customers choosing TOU rates because most of residential customers did not have smart meters with hourly metering function. The government started to discuss on demand response using TOU rate and smart metering considering the experience.

Demonstration experiments were conducted to analyze effects of demand response of residential customers in Japan as same as the US and European countries (Faruqui and Palmer, 2012; Renner et al., 2011). However, whether effects could be realized under actual power shortage have not been verified. This study analyzes effect of TOU rate on demand reduction of residential customers under actual power shortage during summer in 2011 in Japan.

A demand reduction effect is expected to become large when a large number of customers choose TOU rates. However, there could be self-selection problem as Ericson(2011) studied. There is a possibility that only customers who could reduce electricity cost without changing their consumption patterns would like to choose TOU rates. Under that situation, there could not be social benefit of peak demand reduction. In this study, diffusioin pontential of TOU rate and self-selection problem are also analyzed.

Methods

This study analyzed effect of TOU rate and the other factors on electricity saving behaviours based on binomial logil model as discrete choice model by using data collected through residential customers' questionnarire survey conducted in August and September 2011. Electricity saving behaviours were categorized into three kinds of behaviours, (1) peak demand reduction (such as saving electricity of air-conditioning for cooling in peak time), (2) peak demand shifting (such as clothing washing in off-peak time), and (3) saving base load (such as standby power reduction). Binary data whether customers took on these electricity saving behaviours or not were dependent variables. It is assumed that residential customers choosing TOU rates would be more likely to take behaviour of (1) peak demand reduction and (2) peak demand shifting than customers choosing standard flat rates. On the other hand, there would not be difference in implementation probabilities of base load reduction between TOU rates and standard flat rates. In addition to TOU rates, customers' information search behaviours, attitudes towards electricity saving, and customers' attributes such as family size were also considered as explanatory variables, because various information provided by various media and electric power companies could affect customers' attitudes and electricity saving behaviours under the actual power shortage.

Self selection problem and diffusion potential of TOU rate are investigated through analysis of customers' preferences for TOU rates based on binomial logit model as discrete choice model by using data collected through questionnaire survey conducted in October and November 2011. Binary data whether customers would like to

choose TOU rate or not within one year from survey resonses date was dependent variable. Consumption patterns and customers' attitudes towards electricity saving were assumed as explanatory variables. Variables such as family size and two-income household were used as variables representing aspects of consumption patterns.

Results

As expected, it was confirmed that customers choosing TOU rates were more likely to wash their clothing in off-peak time as peak demand shifting than customers choosing standard flat rates. Customers who would like to avoid unexpected blackout were more likely to do so. It was found that implementation probabilities of standby power reduction were not significantly different between customers choosing TOU rates and standard flat rates. Contrary to the theoretical expectation, it could not be confirmed that customers choosing TOU rates were more likety to save electricity of air-conditioning for cooling as peak demand reduction than standard flat rates. On the other hand, customers, who searched information regarding electricity saving on the internet and who felt that their friends and collegues were willing to save electricity, were more likely to save electricity of air-conditioning. These factors did not affect implementation of washing in off peak time.

As the result of analysis on preference of TOU rate, preferences of customers who were households of two members and not two-income were lower than the other customers. However, there was not significant difference in preferences between single households and two-income households without kids, whose consumption rate in off-peak time could be high, and households with three or more members, who could consume more electricity in peak time. Thus, not only customers who could reduce electricity cost without changing their consumption patterns but also customer who could need to change their consumption patterns to reduce electricity cost could choose TOU rates. In addition, preferences of customers who were more willing to save electricity continuously could be higher. However, a percentage of customers who chose standard flat rates at the suvey response date and answered that they would like to consider choosing TOU rates within one year was about 40 percents, which included preferences when improved TOU rates would be provided in addition to current TOU rates.

Conclusions

This study confirmed that TOU rates could be effective to shift electricity demand from peak time to off peak time under the actual power shortage in summer. However, it could not be confirmed that TOU rates could encourage customers to save electricity of air-conditioning. It could be because current TOU rates, where rates in peak time were about 3 - 4 times higher than off peak time, and were about 1.2 - 1.6 times higher than standard flat rates, could not provide enough economic incentive to customers. If customers would be asked to reduce electricity consumption, and would be provided with know-how for electricity saving under power shortage, higher electricity rate could not stimulate customers to reduce peak demand while those information could encourage customers to reduce peak demand. This study could suggest that it could be important to consider combination of demand response by electricity pricing and the other measures such as information provision. This study also found that self-selection problem could be not significant. However, diffusion potential of TOU rates under an opt-in system was not so high. To develop a diffusion strategy would be important.

References

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