[*WHEN DOES FEEDBACK WORK? THE EFFECT OF SMART METER MOBILE APP IN RELATION TO ELECTRICITY CONSUMPTION BEHAVIOR*]

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Overview

With evolving artificial intelligence (AI) and internet of things (IoT), smart meter technology is receiving growing attention as a part of smart energy infrastructure. A smart meter digitally sends the meter readings to users in real-time helping them to actively engage in the energy use behavior. Multiple research results have revealed the effectiveness of smart meters with emphasis on the information feedback in relation to energy saving[1]. This study contributes to the literature by further investigating the behavior change with feedback from the mobile app, which is different from in-home displays (IHD).

A smart meter with a mobile application (app) allows individuals to monitor and receive personalized services with high accessibility. While IHD involves assumptions of participants' monitoring activity, individuals' mobile app data for provides their actual behavior. This paper answers the question of when does increased knowledge lead to behavioral change in the context of reducing electricity consumption. We propose billing date and progressive levels, exogenous conditions that will lead to saving behaviour. It will be answered with the evidence from a unique panel data of daily household-level electricity use, smart meter mobile app data and survey data. With the help of the largest smart metering service provider in Korea, Encored, over two hundred household data was collected for analysis. EnerTalk is the name of their mobile app, allowing panels to check their hourly, daily and weekly usages as well as the prediction of the month's bill amount.

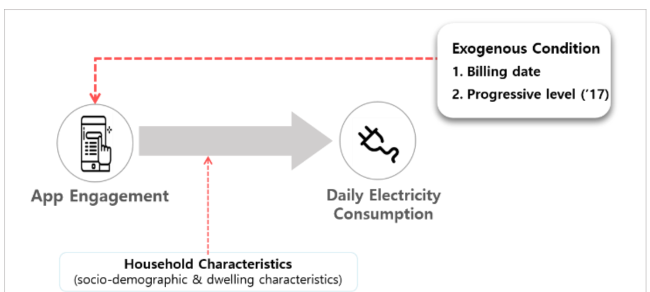

Fig. 1. Research Design

South Korea has adopted a progressive electricity tariff system since 1974. The electricity rates for all stages are applied according to a month's cumulated consumption volume of households. Every stage has different base kWh rates and the tariff structure for residential use is as follows: indispensable interval of 0 ~ 200 kWh (first stage), average usage interval of 201 ~ 400 kWh (second stage), and high consuming of over 401 kWh (third stage). The applied rates for each stage are different. For example, the second-stage rate is twice as high as the first-stage and the third-stage rate is three times as high as the first-stage [2].

Methods

H1. People monitor the smart meter app when their electricity consumption has been increased
H2. Electricity consumption decreases when people monitor the smart meter app in any time of the month
H3. Electricity consumption decreases when people monitor the smart meter app before and after entering the next progressive tariff stage

The above hypotheses will be tested with the EnerTalk panels whom already installed and used the smart meter service. The data was collected from October to November 2017. The electricity consumption was organized based on individuals' billing cycle, meaning October analysis would include November dates but counted as October billing dates. Daily electricity consumption amount in kWh allowed us to calculate individuals' total monthly consumption.

Mobile app data was analyzed in a binary format thus, data only revealed whether a panel had opened the EnerTalk app or not on the day. The survey asked basic demographic questions as well as their attitude towards environment, self-efficacy, and energy saving behavior.

$$Y_{it} = \begin{pmatrix} appopen_{it} \\ usage_{it} \end{pmatrix} = \sum_{s=1}^{P} \Phi_s \begin{pmatrix} appopen_{it-s} \\ usage_{it-s} \end{pmatrix} + \begin{pmatrix} \delta_{1t} \\ \delta_{2t} \end{pmatrix} + \begin{pmatrix} f_{1i} \\ f_{2i} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1it} \\ \varepsilon_{2it} \end{pmatrix} \tag{1}$$

$$\ln(E_{it}) = \alpha_i + \beta * Progressive2_t + (\gamma * AppCheckatT_i) * (Progressive2_t) + d_t + \varepsilon_{it} \tag{2}$$

Applying the panel vector autoregression (PVAR) methodology, Eq.1 identifies the impact on the daily consumption after checking the mobile app which answers H1 and H2. Eq.2 explores the effect of progressive levels; exogenous conditions that apply to everyone. The dynamic panel structure of the data allows to control for unobserved individual heterogeneity. Household characteristics, energy usage behavior and house electronic appliances from the survey were controlled in the individual fixed effect and dates were used for time fixed effect. All models were estimated with time and individual fixed effects in order to reduce bias. In addition, difference-in-differences estimation was applied for discovering the effect of progressive levels

Results

Interestingly, people did not check the app the day after their consumption has increased. In addition, electricity consumption did not decrease after panels received information from the app. PVAR results were statistically insignificant and it revealed the role of the smart meter when the novelty effect has been diminished. These results support the argument that the panels as not seeking for information provision for conversation purposes but to check the current status.

Among the 284 panels, 192 entered 2nd or 3rd stage in October and the app indeed had an impact on their consumption. The subgroups that were divided according to the demographics revealed statistically significant and insignificant results. The panels with housing area under $99m^2$ consumed 6.8% less electricity after entering the second stage than those who did not check the app before or after entering the second stage from the same group. The group with a smaller family (less than four) used 4.4% less compared to those from the same subgroup who did not check the app. On the contrary, the consumption of large families (more than three members) was statistically insignificant meaning their usage is not influenced by the app. Interestingly, the panels without a child reduced the most among all the groups; they reduced about 8.4% in the second stage when they monitor the app. Though the income amounts were divided based on the national average neither of the groups was statistically significant. This supports the argument that Korean retail electricity consumer price is lower than other developed countries. The result gives a significant implication for policy makers as the electricity price is expected to rise in the near future.

Conclusions

Gaining the consumer smart meter mobile app usage and electricity usage behavior insights provides both theoretical and empirical contributions. Our result suggests that indeed smart meters are still effective even after novelty wears off to the consumers. Though the Korean electricity price is too low to provide conservation incentives on itself, policy makers and smart meter companies can yield maximum result when the feedback is designed with the electricity tariff system. In the context of Korea's progressive tariff system, message frame with loss aversion will be effective as Korean citizens are well aware of different stages. People are more likely to behave when they realize the loss in this context, higher kWh electricity price after entering the next progressive tariff stage. Consequently, this would also increase app engagement and retention rates as more users would use the app.

References

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