LOAD SHIFTING BEHAVIOR UNDER DYNAMIC ELECTRICITY PRICING AND THE ROLE OF INFORMATION FEEDBACK

Yeonseo Kim, KAIST College of Business, Republic of Korea, +82 10 7400 2126, dus1346@kaist.ac.kr
Soyoung Yoo, KAIST College of Business, Republic of Korea, +82 10 6620 9039, jessyoo@kaist.ac.kr
Jiyong Eom, KAIST College of Business, Republic of Korea, +82 10 8612 1606, eomjiyoung@kaist.ac.kr

Overview

Demand-side management (DSM) is becoming an important means of reducing peak electricity demand and thereby ensuring the stability of the power market. In this regard, the residential sector in particular has received much attention not only for its relatively independent and flexible nature of electricity use [1] but also for its energy consumption and load accounting for an increasingly large share of national energy systems [2]. Dynamic electricity pricing is considered as one of the most promising DSM measures for the residential sector, and a number of pricing pilots have so far been conducted. Under a dynamic pricing, price differential between peak and off-peak hours would induce electricity consumers to curtail activities in peak hours—*load foregoing*—or to shift them from peak to off-peak hours—*load shifting*. Between the two possible options, promoting and leveraging load shifting instead of load foregoing could provide less negative or even positive impact on consumer welfare, increasing not only the program's political acceptability but also its load reduction performance by encouraging the consumers to alter their energy consumption patterns in a more aggressive way.

Previous studies, however, point out that households indeed respond to dynamic pricing, but they mostly do so by cutting electricity usage in peak hours and often even in periods before and after [3-5]. As such, doubts remain about whether households are making an informed, efficient load-shifting decision. Although there can be many possible reasons and channels by which efficient load-shifting choices may not materialize, we approach from the perspective of salience bias [6, 7] and rational inattention [8]. The hypothesis is that providing information feedback on load-shifting alternatives and their payoffs, which collectively establish the basis for informed decision making, can help the consumers overcome the barriers and thus make individually efficient choices. In order to investigate how such information feedback might influence the nature and extent of demand response made by residential consumers, we have conducted a carefully designed field experiment for 320 Korean households during the winter of 2017.

Methods

Our experiment employs a panel of 320 households recruited to receive the installation of free electricity smart meters in return for participating "Smart Energy Campaign" from December 15th, 2017 to February 14th, 2018 (2 full metering months). The participants were recruited from a larger sample of 4,888 registered households residing in three adjacent apartment complexes located in Gyeonggi-do, Korea. Over the three months of recruitment period, 415 households applied to participate in our experiment, and a total of 320 households were selected using the sampling procedure. Specifically, we combined pre-monitoring information of electricity use and quick pre-surveys delivered at the time of meter installations to conduct a blocked random assignment. Eventually, the participants were randomly assigned to one of three experimental groups varying in the types of electricity prices and information feedback: Control (100 households), Treatment I (110 households, peak reminder only), Treatment II (110 households, peak reminder and load shifting information). Households in Treatment I and Treatment II groups are all subjected to a virtual dynamic pricing for peak hours (5-8 pm on weekdays) on top of the current increasing-block tariff (IBT). Treatment I households receive *peak reminder message* two hours before the start of peak hours every weekday and a *weekly report* about the individual households' average hourly usage during peak and off-peak hours and their balance of incentives every Sunday. Treatment II households receive the same information as Treatment I, except the former also receiving individualized information about *load-shifting alternatives and their payoffs* estimated based on their peak-hour usage in the previous weekdays. Households in Control group remain only under the current IBT and thus do not receive neither peak reminder messages nor load-shifting information.

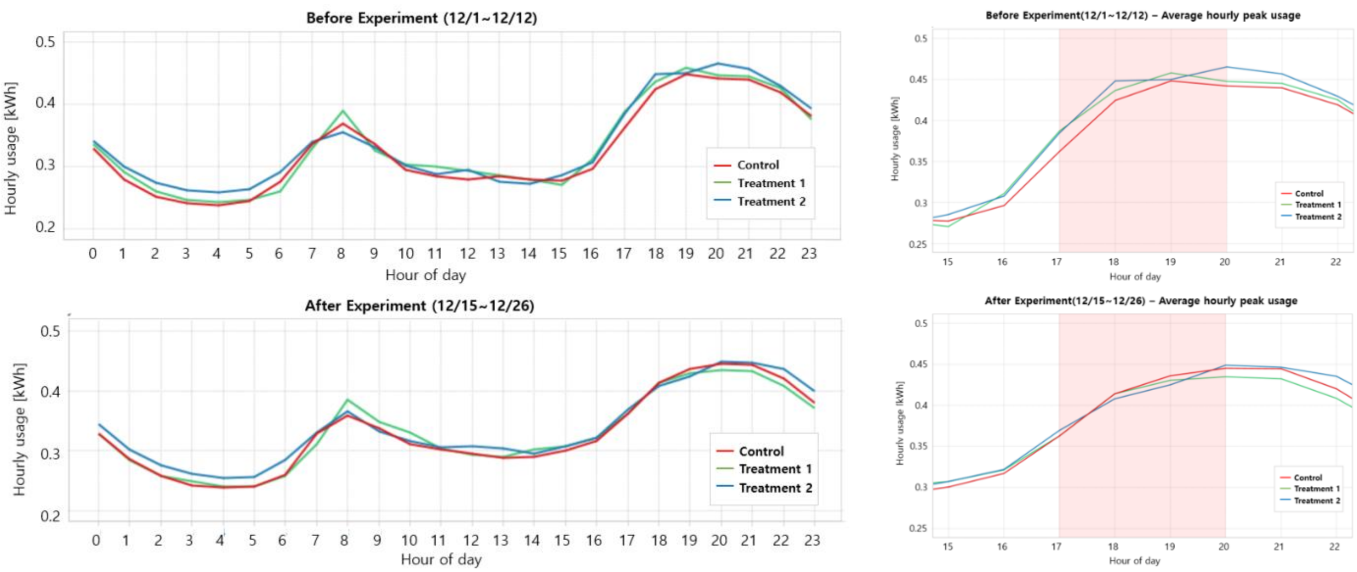
The virtual dynamic pricing administered to the treatment groups is implemented as follows: households in the treatment groups are given with the initial incentive balance of KRW50,000 with the start of the experiment; and the initial balance decreases at the rate of KRW700 per each kWh usage in peak hours until it reaches the minimum balance of KRW10,000 under which no deduction is made. Given that all of the 320 participants are already under the prevailing IBT (Tier1=KRW93.3, Tier2= KRW187.9, Tier3=KRW280.6), the imposition of the dynamic pricing effectively implies the peak-hour rates of KRW793.3 over Tier 1, KRW887.9 over Tier 2, and KRW980.6 over Tier 3 (of course with the initial incentive balance of KRW50,000). As a participation incentive, Households in Control group are guaranteed to receive the same participation incentive of KRW20,000 at the end of the experiment.

*Acknowledgement: This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIP) (No. 2017R1A2B4002170) and also by the Korean Ministry of Science, ICT, and Future Planning through the Graduate School of Green Growth at KAIST College of Business.

Results

Our experiment is still underway and the full-scale analysis has not been undertaken at the moment. The preliminary results, however, make us expect to find significant effects of load-shitfing information on demand response. The load pattern of 8 days (only weekdays) each before and after the experiment (Table 1) shows both Treatment I and II groups receiving daily peak reminder message in common are likely to respond to the dynamic pricing by reducing their peak hours usage compared to the control group. Further, Treatment II group who receive daily information about load-shifting alternatives and their payoffs in addition to the peak reminder message seems to show a larger peak load reduction than Treatment I. Interestingly, the load of Treatment II starts to increase after the end of peak hours, while Treatment I keeps reducing electricity usage even after the peak hours, which may imply the potential benefits of the load-shifting information feedback in increasing demand-side flexibility and welfare.

Table1. (a) Daily load pattern before/after the experiment (b) Average hourly usage in peak and near-peak before/after the experiment



(a) (b)

Conclusions

As the recent technological developments accelerate the diffusion of enabling technologies such as smart meters, the market transition in demand-side management along with the development of dynamic electricity pricing in residential sector is being facilitated. In the study, we examine the effects of information feeback about load shifting alternatives and their payoffs in inducing consumers' choice of load shifting behavior instead of a simple load foregoing. Further works include the basic analysis to test our hypotheses and additional analysis: (i) average treatment effects of the load-shifting information feedback, (ii) whether there exsists learning effects or the pattern of backsliding when no information feedback is given. Further, we plan to implement a structure-based econometric model of electricity demand under existing IBR and suggest more politically viable dynamic pricing based on our analysis.

References

1. Ironmonger, D.S., C.K. Aitken, and B. Erbas, *Economies of scale in energy use in adult-only households.* Energy Economics, 1995. **17**(4): p. 301-310.
2. Faruqui, A. and S. Sergici, *Household response to dynamic pricing of electricity: a survey of 15 experiments.* Journal of regulatory Economics, 2010. **38**(2): p. 193-225.
3. Allcott, H., *Real time pricing and electricity markets.* Harvard University, 2009. **7**.
4. Jessoe, K. and D. Rapson, *Knowledge is (less) power: Experimental evidence from residential energy use.* The American Economic Review, 2014. **104**(4): p. 1417-1438.
5. Faruqui, A., S. Sergici, and L. Akaba, *Dynamic pricing of electricity for residential customers: the evidence from Michigan.* Energy Efficiency, 2013. **6**(3): p. 571-584.
6. Tiefenbeck, V., et al., *Overcoming Salience Bias: How Real-Time Feedback Fosters Resource Conservation.* Management Science, 2016.
7. Allcott, H. and D. Taubinsky, *Evaluating behaviorally motivated policy: experimental evidence from the lightbulb market.* The American Economic Review, 2015. **105**(8): p. 2501-2538.
8. Sallee, J.M., *Rational inattention and energy efficiency.* The Journal of Law and Economics, 2014. **57**(3): p. 781-820.