NO SUBSIDY LIKE INFORMATION:
THE EFFECT OF ENERGY INFORMATION ON ENERGY EFFICIENCY BEHAVIOR

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Overview

The concept of 'rational inattention' that one could be rationally inattentive when the benefit of additional information gained from paying extra attention does not exceed the associated costs [1] has provided alternative explanation to the existence of the energy efficiency gap [2, 3]. Previous literature has suggested that such rational inattention behavior should be properly taken into account in our pursuit of energy efficiency, providing a justification for various information- or technology-based instruments, such as energy efficiency certification program, minimum efficiency standard, and technology mandates [1, 4]. In addition, the idea that the attention involves real costs lends itself to the opportunity to improve economic efficiency through the public provision of low cost energy information. Put differently, with the help of an appropriate system decreasing information processing requirements, residential households might be made more rationally attentive.

Our research highlights the value of providing more personalized, service-level energy performance and use information for households. In principle, the choice of an appliance may involve the uncertainty about potential benefits at three levels. First, the total expected savings of operating costs from replacing one appliance with another are uncertain as information of standard energy efficiency performance, in combination with the forecast of energy price, needs to be translated in monetary terms. Second, the individual households' demand for energy service that the appliance is supposed to fulfill is also highly uncertain, which exacerbates the estimation of potential individual-specific cost savings. Third, on top of these uncertainties, the heterogeneity in energy use behavior among the households [5] is another consideration to give. Yet, previous literature has mainly focused on the effect of standard energy efficiency labels, leaving the rest part of the uncertainty nearly untouched.

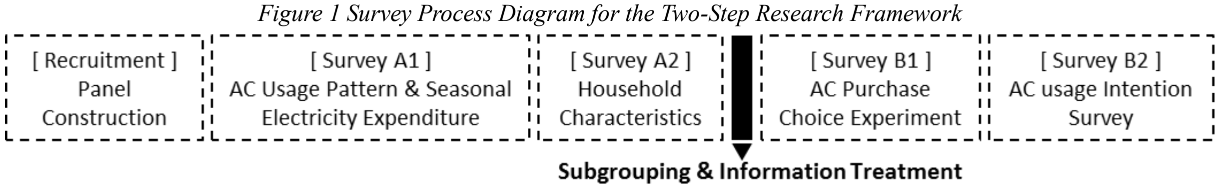
It is argued that, with more personalized energy efficiency and use information, rational attention is more likely to be paid as the households can take less effort to assess the full benefit of improving energy efficiency. Personalized energy use information may also promote energy efficiency behavior well beyond the choice of energy efficient appliances. For example, the consumers may set a 1ºC higher temperature for the air conditioner (AC) if these consumers learn they face a higher marginal price of electricity. We chose an AC and its usage as our subject of analysis because a suite of products with different characteristics and energy efficiency performance are available in the market and the utilization rate of AC varies widely among electricity customers over time.

Our study addresses the following research questions: (i) How would different levels of information about energy efficiency and energy use influence household energy efficiency behavior? (ii) To what extent can the purchase choice of an AC or its daily usage be made inefficient due to the undersupply of energy information? (iii) How would information-based interventions compare with conventional economic incentives? To answer these important questions, a set of surveys and choice experiments have been conducted for the 1,440 mobile survey respondents. This abstract presents the preliminary results, and more comprehensive analysis and model estimation are underway.

Methods

Our analysis employs the combined results of the mobile survey and the stated choice experiment, all administered to the same panel of Korean households. 1,440 respondents between 30s and 50s who pay their own electricity bills were recruited to reflect a range of energy consumption behavior.

Figure 1 Survey Process Diagram for the Two-Step Research Framework



The first, pre-survey part is to characterize the households' basic socioeconomic status and the seasonal pattern of AC usage and thus to evaluate the degree of uncertainty about lifetime AC operation costs (Survey A in Figure 1). This step establishes a statistical benchmark for the individual households' electricity costs associated with air conditioning, which is later used to provide personalized, service-level information for the survey panel. Second, assuming the existence of the sizeable costs of paying full attention to energy efficiency in the decisions of AC purchase and use, the samples were divided into three subgroups according to the standard propensity score matching procedure, in order to expose them to different levels of treatment of personalized information, $\mathrm{d} = [\mathrm{Ivd}, \mathrm{Ave}, \mathrm{Agr}]$. A carefully designed stated choice experiment and an AC usage intention survey were followed right after the information treatment (Survey B in Figure 1).

To capture the combined effect of energy information on the purchase of an AC and its daily use, we construct a random utility model for household i choosing air conditioner j. The utility U_{ij} consists of the AC purchase related part, $ProdU_{ij}$, and the usage related part, $UseU_{ij}$ [Eq.1], the former of which is a function of product attributes [Eq.2] and the latter concerns the AC's present discounted cost of operation over its lifetime ($OppCost_j$). $OppCost_j$ is a function of the household's demand for air conditioning service, $Consump_i$, which in turn is determined by the household's deliberate sequence of optimal choices of cooling temperature, $t \in T$, which provides temperature-related utility component, $TempU_{ijt}$ [Eq.3].

$$U_{ij} = ProdU_{ij} + UseU_{ij} + \epsilon^*_{ij}, \qquad ProdU_{ij} = \alpha_{ij} - \eta_i P_j + \boldsymbol{\beta_i X_j} \qquad \textit{Eq.1 Eq.2}$$

$$UseU_{ij} = \theta OppCost_j[Consump_i\{TempU_{it}\}], \quad \theta = \eta \frac{1-\rho^L}{1-\rho}, \quad \rho = \frac{1}{1+r} \qquad \textit{Eq.3 Eq.4 Eq.5}$$

The temperature-related utility component consists of two parts [6], which are the thermal discomfort, $Discom_t$, and the expected cooling cost, $TempCost_{ijt}$, given the information at hand ($InfoL_i$) [Eq.6]. It can be expected that if the household is given with personalized energy use information (high $\boldsymbol{d_i}$), the attention cost $\boldsymbol{K_i^e}$ for energy efficient behavior diminishes [Eq.9], resulting in an increase in the net value of applying private discernment, V_i^e, to energy efficiency information. It improves the probability of the consumer pursuing improved energy efficiency information H_i^e [4], which in turn influences the expected cost of the cooling choice [Eq.7] [Eq.8].

$$TempU_{ijt} = \alpha_t^t + \beta_i^{t,c} E[TempCost_{ijt}|I(InfoL_i(d_i))] + \beta_i^{t,d} Discom_t + \epsilon_{it}^t \qquad \textit{Eq.6}$$

$$E\left[TempCost_{ijt}\middle|I(InfoL_i(d))\right] = \sum_{e=\{CE,EG,NA\}} H_i^e\left(InfoL(d_i)\right) E[TempCost_{ij}^e(t)] \qquad \textit{Eq.7}$$

$$H_i^e(d) = \frac{exp\left(V_i^e(d_i)\right)}{\sum_{d=\{Ivd,Ave,Agr\}} exp\left(V_i^e(d_i)\right)} \qquad \textit{Eq.8}$$

$$V_i^e(d_i) = -\boldsymbol{K_i^e}(\boldsymbol{d_i}) + \lambda^{e,m} Mean\left(E\left[TempCost_{ij}^e(t)\right]\right) + \lambda^{e,v} Var(E\left[TempCost_{ij}^e(t)\right] \qquad \textit{Eq.9}$$

Results

To establish a statistical benchmark for residential cooling expenditures, which are unknown, we have processed the stated responses of the households' AC usage patterns and their house-structural and socio-demographic characteristics obtained from Survey A. Regarding the AC usage patterns, the respondents were asked their AC utilization rate (%) and associated temperature setting (°C) over the five time periods of the day in August: morning, afternoon, evening, night, and deep night. The household level information is then combined with the local weather data to construct what we call the AC use index, which is used to predict the individual respondents' electricity expenditures for AC operation. The preliminary analysis indicates considerable heterogeneity among the respondents in their pattern of AC use and associated expenditures for AC operation (Table 1), which to some extent suggests sizeable opportunities of promoting energy efficiency via various information-based behavioral interventions.

Table 1 Basic Statistics of Expenditures for AC Operation and AC Use Index

Variables	Mean	Std.Dev.	Variables	Mean	Std.Dev
Aug. Electricity Expenditure	8.218	5.615	Expenditure Difference	3.963	4.297
Oct. Electricity Expenditure	4.255	3.092	AC Use Index	19.563	8.993

As an initial step of econometric analysis, we estimated the individual households' importance weights on discomfort and cooling cost under the counterfactual scenario where the rational inattention does not take effect, i.e., the decision makers are all rationally attentive [Eq.6], following the procedure suggested by JinaKim and Eom [6]. If the households were rationally attentive to the cooling cost and discomfort, their coefficients would be estimated to be negative for all households. The results, however, indicate that while the discomfort coefficient β_i^d remains negative and statistically significant, the cooling cost coefficient β_i^c does not, which alludes the respondents' inattention on cooling costs [Table 2].

Table 2 Coefficient Estimates of MNL Models for AC Temperature Setting Choices

$\boldsymbol{\beta_i^d}$	$\boldsymbol{\beta_i^c}$	$\boldsymbol{\alpha_1}$	$\boldsymbol{\alpha_2}$	$\boldsymbol{\alpha_3}$	$\boldsymbol{\alpha_4}$	$\boldsymbol{\alpha_5}$	$\boldsymbol{\alpha_6}$	$\boldsymbol{\alpha_7}$	$\boldsymbol{\alpha_8}$
-0.407*	0.337	-11.998***	-8.518***	-5.682***	-3.542***	-2.195***	-2.120***	-3.452***	-3.197***
-0.596*	-	-9.839***	-6.696***	-4.172***	-2.348***	-1.302***	-1.519***	-2.990***	-3.142***

† P<0.10, * P<0.05, ** P<0.01, *** P<0.001

Summary

Our survey and choice experiment results clearly indicate wide-ranging differences in household energy behavior regarding air conditioning, even after controlling for many house-structural and socio-demographic factors. Based on the system of structural equations suggested above, behavioral parameters related to the household's purchase of AC and its daily use will be estimated against the counterfactual case of individual rationality, and the identified model will be used to evaluate the effectiveness of providing more personalized, service-level information. More comprehensive econometric analysis is underway to provide concrete policy implications.

References

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