EXAMINING AGGREGATED HOUSEHOLD BEHAVIOR OF AMBIENT TEMPERATURE CONTROL STRATEGY AND ENERGY EFFICIENT APPLIANCE OWNERSHIP: AN APPLICATION OF LATENT CLASS ANALYSIS

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Section 1: Overview

Energy efficient behavior of households is driven by both the use of effective temperature control strategy of heating and cooling equipment and the usage of energy efficient appliances that do not affect air temperature, such as washing machine, dryer, and refrigerator. Across several geographic regions, studies that use household surveys generally consider factors such as purchase of an energy efficient appliance as well as a variety of householder actions including temperature setting strategy to determine overall energy efficient behavior of a household, and statistically these can be considered as important explanatory variables for residential electricity consumption as well. Using nationally representative household survey data published by the U.S. Energy Information Administration, this paper attemtsp to classify households based on their aggregate behavior in terms of usage of appliances with explicit temperature control mechanism and ownership of energy efficient variants of other appliances using a nationally representative sample. While several studies have used housing and socioeconomic characteristics such as type of house, age, income etc. to explain energy consumption or purchase of energy efficient appliances (e.g. Yohanis. 2012), this paper uses these variablesto explain the odds that households follow certain types of behavioral classifications (e.g. high percentage of energy efficient appliance ownership and thermostat usage for temperature control) over others (e.g. moderate percentage of energy efficient appliance ownership and high percentage of manual operation for temperature control). It also investigates the effect of relevant utility incentives on behavioral class switching and any regional pattern in behavioral classifications.

Section 2: Data and Methods

This paper uses EIA's Residential Energy Consumption Survey (RECS) 2015 that tracks the temperature control strategy of heating and cooling equipment in households – manual operation, no change in temperature, use of thermostat, and no control; as well as the ownership of energy efficient variants of several appliances that do no affect the ambient temperature using separate survey questions; and a range of socioeconomic and housing variables for over 5,000 households. Older versions of RECS has been used in the literature (e.g. Tso and Guan. 2014) to study regional trends in energy consumption, structural model of energy usage, and prediction of consumption utilizing machine learning techniques. This paper uses Latent Class Analysis (LCA) for household behavior classification based on temperature control strategy and energy efficient appliances. LCA has been utilized in the literature to classify consumers on the basis of switching patterns between competitive electricity retailers and identify groups of consumers based on their willingness to adopt and pay for renewable energy (e.g. Ivanova. 2013). This paper uses the procedure to approximate the observed joint distribution of temperature control strategy and energy efficient appliance ownerships as the weighted sum of a finite number, which denotes the number of classes. Three and four-class models are generated and evaluated on the basis of a number of goodness of fit criterion such as chi-square goodness of fit, AIC, BIC, and entropy. The classes are then considered as dependent variables in a multinomial logistic setting and regressed on a set of socioeconomic and housing variables to determine whether certain factors increase the odds of membership to classes where households are more likely to exhibit energy efficient temperature control strategy and appliance ownership pattern. Finally, the exercise is repeated on region-restricted samples using RECS' division identifiers, and the results are compared against the national outcome. In all cases, appropriate publicly provided sample weights are utilized.

Section 3: Results

The analysis suggests that a four-class model is a better fit compared to a three or five-class solution based on lower AIC and BIC scores. The four classes are households that – a) prefer manual temperature control with 62% of the constituent households owning one or more energy efficient appliance, b) prefer the use of a programmable thermostat with 86% of the constituent households owning one or more energy efficient appliance, c) prefer keeping a single temperature with 60% of the constituent households owning one or more energy efficient appliance, and d) has no control over cooling temperature, is evenly split between manual control/single temperature for heating and 55% of of the constituent households owning no energy efficient appliances. Class 1 – (with households largely preferring manual temperature control) as the base class, we find that odds of a household belonging to Class 2 (thermostat preferring class) over Class 1 increases with residence in single family house, completion of an energy audit, utilization of one or more utility incentive related to energy efficient appliances, higher income, and college education. Odds decrease when the householders are renters. Odds of a household belonging to Class 3 (Single temperature preference) compared to Class 1 increase when the respondent is male and decreases when they are college educated or higher. Odds of a household belonging to Class 4 (Where majority does not own any energy efficient appliance) over Class 1 increase if the household is renting or has unknown energy status, and decreases with residence in a single family house, a relatively newer house, and college education or higher.

Section 4: Conclusions

Households in most regions own at least one energy efficient appliance but thermostat is not a major part of the strategy, which should be targeted, specifically in parts of the Central and Mountain regions. Surprisingly, Pacific is the region with the highest share of Class 4 households – and specific policy interventions can be used to improve energy efficient appliance ownership. Groups such as renters, low-income households, residents of older dwellings or apartments, and non-college educated households can be targeted for more energy efficient appliance adoption and better temperature control strategy.

References

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