UNDERSTANDING TRENDS IN EFFICIENT LIGHTING ADOPTION ACROSS THE U.S.

Jihoon Min, Carnegie Mellon University, 646-957-4993, minjihoon@cmu.edu
Inês L. Azevedo, Carnegie Mellon University, 412-268-3754, iazevedo@cmu.edu
Jeremy Michalek, Carnegie Mellon University, 412-268-3765, jmichalek@cmu.edu

Overview

We characterize the light bulb market and highlight key regional trends from 2004 to 2012. This period witnessed two important events for energy-efficient lighting. First, the Energy Independence and Security Act (EISA) was enacted in 2007 setting standards on luminous efficacy of light bulbs. The EISA of 2007 defines that general service lamps have medium screw bases and light outputs between 310 and 2600 lumens. These general service light bulbs are the focus of our analysis. Second, also in 2007, a key retailer chain ran a nationwide campaign of selling 100 million compact fluorescent lamps (CFL) by the end of 2007. It announced the plan at the end of November 2006 and achieved the goal three months early at the end of September 2007. Within that year, the chain sold 162 million CFLs.

In this work, we assess the trends in lighting sales for different lighting technologies across the country and by store type based on an extensive consumer panel dataset spanning from 2004 to 2012. Then, building on these observations, we attempt to investigate consumer preferences by estimating choice models, from which we assess which factors or events influences adoption of an efficient lighting technology. We also estimate willingness-to-pay (WTP) for light bulb attributes. After that, we estimate the implicit discount rates (IDR) that consumers use when making lighting choices. Finally, we compare the WTP and IDR estimates from using this real sales data (i.e., revealed WTP and IDRs) with the ones computed based on the experimental study in Min *et al.* (2014).

Methods

We use a unique dataset acquired from a marketing firm, A.C. Nielsen, via the James M. Kilts Center for Marketing, at the University of Chicago Booth School of Business. The dataset contains six years of purchase data of household products with Universal Product Codes (UPC) from a nationally and regionally representative panel dataset that includes about 100,000 households, which have scanned their purchases from 2004 to 2012. We use the weighting factors provided in the dataset to estimate light bulb sales at the country or region level. We selected purchases corresponding to general service light bulbs. With these selected data, we model choices with a random utility model. The utility U_{ij} that consumer *i* draws from product alternative *j* is modeled as:

$$U_{ij} = V_{ij} + \epsilon_{ij} = \sum_{k=1}^{K} (\beta_k \cdot x_{ijk}) + \epsilon_{ij}, \quad (1)$$

where β_k is the preference coefficient for attribute *k*, x_{ijk} is the *k*-th attribute of alternative *j* subject *i*'s choice task, *K* is the number of observed attributes of alternatives, and ϵ_{ij} is the random error term, taken as an i.i.d. standard Gumbel distribution.

In Min *et al.* (2014), we conducted a choice-based conjoint experiment for incandescent and compact fluorescent bulb choices to quantify the influence of factors that drive consumer choices based on the stated preference. We showed that providing operating cost information at the time of choice reduces consumers' implicit discount rate significantly, which will increase the adoption of energy efficient products. Here, we compare the previous findings from Min *et al.* (2014) with those from the consumer panel data. We mainly compare willingness-to-pay (WTP) for light bulb attributes (watt and type) and implicit discount rates (IDR) consumers adopt for their purchases.

Results

The total light bulb sales generally decrease over time with a bounceback in 2011 (Figure 1a). Potential reasons for the CFL peak in 2007 can be either the enactment of the Energy Independence and Security Act (EISA) or the nationwide CFL campaign by a key retailer in 2007 as explained above. The CFL sales decrease can be due to the longer lifetime and turnover rate of CFLs or the economic plunge starting from 2008. A small peak of incandescent bulb sales in 2011 can potentially be due to the fact that the EISA is becoming effective in 2012 for the first group of inefficient bulbs, so that consumers try to stock up incandescent bulbs before they disappear from the market.

Figure 1b shows that a majority of bulb sales from warehouse stores are CFLs, while in dollar stores, the ratio is as low as 20% in 2008 or 2009 at its highest. The ratio generally increases until 2008 but shows a slow downward trend between 2008 and 2011. Then in 2012, almost consistent directional changes are observed in all channels except

hardware stores. The slope of the curves was the steepest between 2006 and 2007, which corresponds with the CFL sales trend shown in Figure 1a.
The top 50 retailers shown in Figure 1c sold 88% of all general service light bulbs. The top five retailers account for 43% of sales. The top selling retailer chain is a discount store[1] and records more than twice the sales of the second retailer, which is a hardware store.

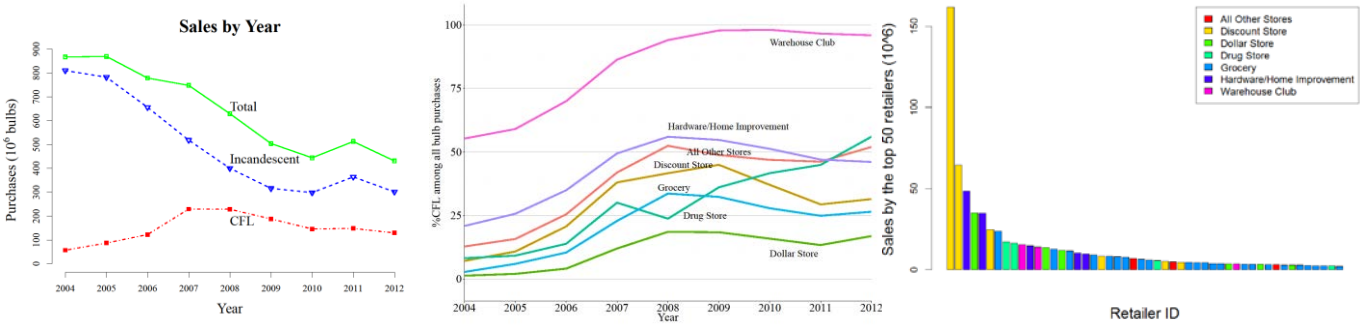

Figure 1(a) Quantity of incandescent lamps and CFLs sold each year, scaled by weighting factors to provide a nationally representative sample; (b) Trends of percentage of CFLs among all general service bulb purchases from each store type ; (c) Histogram of light bulb sales by for the 50 retailer chains with the largest number of sales from 2004 to 2012, by retailer type.

Our estimated model shows that CFL type is preferred in the base case when all other attributes are kept constant. This can be partly because the type variable in the data is confounded with unobserved life and color attributes. Also, even though the coefficient for CFL type is positive, CFLs are not always preferred mainly because of higher price. According to the model, overall preference for CFLs over incandescent type gradually increased from 2005, peaked in 2007, and significantly dropped afterwards. Preference toward CFLs from the key retailer increased very steeply in 2006 and 2007 and appears to stay near the peak level during the later years. This suggests that the promotion of efficient bulbs by Wal-Mart in 2007 may be significantly related to the spike in CFL adoption in 2007 in addition to an increase in general awareness of CFLs and also that the effect is sustained even after the promotion ends. Several issues may be playing a role in decreasing CFL sales observed: since CFLs last longer, fewer purchases are needed over time to maintain the same lighting service. Or CFLs may already have filled a large part of the sockets that consumers intended to use CFLs in. Also, the EISA 2007 or other events around 2007 raised interests in CFLs, but over time consumers may have lost the interest in CFLs and looked for inefficient bulbs again.
We observed implicit discount rates from Pennsylvania , Ohio, California, and Texas. The result shows that the range of discount rate values from this panel dataset is in a comparable range estimated from our stated preference study (Min *et al.*, 2014), suggesting the results are robust.

Conclusions

Light bulb sales are heavily concentrated to several key retailers, which can imply that efforts taken by these retailers can influence nationwide adoption of efficient lighting. Our model shows that the peak in CFL adoption in 2007 was indeed significantly related to the increase of CFL sales by a large retailer chain, which in turn could potentially be linked to its nationwide promotion campaign for CFL the same year. From the findings, we can argue that the well-directed efforts through major retailers might have a significant effect on higher adoption of energy efficient lighting.
We found that consumers prefer lower price in general, but preference for wattage depends on bulb types (CFL or incandescent). At an identical price level, consumers prefer CFLs to incandescent bulbs, but the large price difference keep CFLs from being purchased.
The implicit discount rates estimated in four representative states were in a range from two to four hundred percent similar to the values from our previous conjoint experiment. The large size of discount rates indicates that barriers to energy efficient lighting carry on during the period we observed.

Reference

Min, Jihoon, Inês L. Azevedo, Jeremy Michalek and Wändi Bruine de Bruin (2014). "Labeling energy cost on light bulbs lowers implicit discount rates." Ecological Economics **97**(0): 42-50.

[1] Examples of discount stores are Wal-Mart, Target, and Kmart.