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Appliance labeling and consumer heterogeneity: A discrete choice experiment in India

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HIGHLIGHTS

- Differentiated response to the categories of efficiency on appliance labels is estimated.
- Consumers differentiate between categories in air conditioners but not in refrigerators.
- Sources of consumer heterogeneity are different in the two appliances.
- Prior knowledge of labels increases consumer willingness to pay for higher efficiency in both appliances.

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ABSTRACT

Appliance labels are a widely used policy instrument to increase the adoption of energy-efficient technologies. Most countries use categorical labels to facilitate comparison of appliances based on energy consumption. Studies have found that consumers respond positively to the labels, but the differentiated response to the categories on labels is not well understood in the literature. This study presents the results of a discrete choice experiment corroborated by an analysis of secondary market data to demonstrate that consumers differentiate between label categories; with a greater value being placed on appliances with higher levels of energy efficiency performance. We examine two appliances - air conditioners and refrigerators and observe that there are some differences in consumer response - likely due to the different usage patterns of the two appliances. Consumer responses were observed in hypothetical choice situations constructed ensuring statistical and design efficiency. In a mixed logit model specification with correlated random parameters, the magnitude and the distribution of consumer preference for the highest category of energy efficiency are estimated. The results are validated by estimating the incremental price of higher category of energy efficiency using market data for comparison. The sources of consumer heterogeneity for the highest category of energy efficiency are identified after controlling for other consumer variables. The findings presented in this paper are useful for improving the effectiveness of existing energy efficiency programs and designing new programs to accelerate adoption of energy efficient technologies.

1. Introduction

The development and deployment of low-carbon technologies are crucial to achieving international climate mitigation goals [1]. Renewable energy and energy-efficient technologies are also critical in addressing several energy-related challenges, particularly in emerging economies. Carbon pricing policies, such as a carbon tax and cap and trade regulation are important in increasing the diffusion of these technologies in the long term. In the short and medium term, technology policies will be essential in energy and climate-related policy portfolios [2]. After the oil crisis in the 1970s, developed economies responded by implementing several policies to promote energy-efficient technologies [3]. Appliance standards and labeling (S&L) was introduced to promote energy-efficient technology in appliances. The minimum energy performance standards (MEPS) prohibits manufacturers from selling products with efficiency below a specified level and appliance labels inform consumers about the energy consumption or energy efficiency of appliances [4].

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The labels used by different countries are endorsement labels and comparative labels. The endorsement labels are certificates of lower energy consumption and comparative labels facilitate the comparison of products based on electricity consumption. Endorsement labels, such as ENERGY STAR, are more commonly used in electronic appliances and are also used to complement the comparative labels for large appliances. In comparative labels, countries have primarily used two types of formats - linear and categorical labels. Harrington and Damnics [5] discussed the label design in 45 countries, of which 41 countries have implemented categorical labels. In categorical labels, the categories are presented in different formats, like bars or stars [6]. The labels on which the categories are displayed using bars, such as the European Union label, are the most common style of labels followed by labels using stars in a linear or dial arrangement. The categories are referred to by using different terms, for instance, classes in Europe, ranks or tiers in China, grades in Korea and star ratings in Australia and India.

Several studies have reported that the S&L program is an effective policy intervention and has contributed to energy and emission reduction [7–9]. Direct elicitation of consumer willingness to pay (WTP) for labeled appliances and energy-efficient appliances using questionnaire-based surveys indicate positive responses, but produce a large range of estimates [10–12]. Studies using econometric and statistical models on market data give robust results but have large data requirements and are likely to suffer from unobserved factors in consumer choices [13,14]. Discrete choice experiments have been used in several studies to elicit consumer preference from the stated preference data [15–18]. The household choices are observed in hypothetical choice situations. The differential response to categories of energy efficiency on labels studied so far is likely to be biased due to inter-attribute correlation in the experiment design [15,17].

The difference in consumer response to labels on air conditioners and refrigerators has been reported by Shen and Saijo [16]. However, the differential response to categories is not revealed, since the categories are assumed to be a continuous variable. Consumer heterogeneity has been identified as one of the factors that explain the lower penetration of efficient technology in households [19]. However, the attempts to identify the sources of heterogeneity in consumer preference for labels are limited [16,20]. Studies using discrete choice models on stated preference data identify the sources of heterogeneity by allowing the model parameters to vary in the sample, assuming a distribution, such as normal or uniform. Allowing the parameters to correlate freely is likely to improve the model fit, but has not been used by any of the studies estimating the consumer response to labels. The discrete choice experiments allow the identification of sources of heterogeneity, isolating the effect of unobserved factors. However, the hypothetical bias and generalisability of results is a common concern.

This study aims to expand the limited knowledge about consumer response to categorical appliance labels. A discrete choice experiment is designed, ensuring non-collinearity in the choice of attributes and design of alternatives. The hypothetical choice situations are constructed using sound statistical and design principles to maximise the information collected from the relatively small sample. The data is collected from the households in personal interviews on weekends and holidays to capture household decisions. The sources of heterogeneity in preference for a higher category of energy efficiency are estimated after controlling for other attributes. The incremental price for a higher energy efficiency category in the market is estimated using multivariate regression analysis. The estimates from market data are compared with the results from survey data to validate the results. The consumer sensitivity to categories in labels and heterogeneity in their preferences for energy-efficient technologies is studied for the categorical star labels on air conditioners and refrigerators adopted in India.

The S&L program in India was launched in May 2006. It is implemented by the Bureau of Energy Efficiency (BEE) under the provisions of the Energy Conservation Act 2001 [21]. Under this program, a comparative five star-labeling system has been established where 1-star is the least efficient and 5-star is the most efficient. The program was voluntary for all appliances and was made mandatory for air conditioners and frost-free refrigerators in 2010. The star rating on air conditioners is given based on a range of energy efficiency ratio (EER) calculated using cooling output (W) and power input (W). The lowest level of allowed EER corresponds to the lower value of the range of a 1-star rating. The star rating on refrigerators is given based on a range of electricity consumption calculated using total adjusted volume, constant multiplier (kWh/litre/year) and constant fixed allowance (kWh/year). The maximum allowed electricity consumption corresponds to the lower value of the range of a 1-star rating. The minimum allowed EER for room air conditioners has been increased three times in 2012, 2014 and 2018, and the maximum allowed electricity consumption of frost-free refrigerators has been decreased three times in 2012, 2014 and 2016 (Table 1).

Table 1
Periodic strengthening of MEPS on air conditioners and refrigerators in India.

	Range of EER (W/W)[a]							
	2010–11		2012–13		2014–17		2018-	
	Min	Max	Min	Max	Min	Max	Min	Max
1 star	2.30	2.49	2.50	2.69	2.70	2.89	3.10	3.29
2 star	2.50	2.69	2.70	2.89	2.90	3.09	3.30	3.49
3 star	2.70	2.89	2.90	3.09	3.10	3.29	3.50	3.69
4 star	2.90	3.09	3.10	3.29	3.30	3.49	4.00	4.49
5 star	3.10		3.30		3.50		4.50	

	Range of electricity consumption (kWh/y)[b]							
	2010–11		2012–13		2014–15		2016-	
	Max	Min	Max	Min	Max	Min	Max	Min
1 star	1015	812	812	650	520	416	416	333
2 star	812	650	650	520	416	333	333	266
3 star	650	520	520	416	333	266	266	213
4 star	520	416	416	333	266	213	213	170
5 star	416		333		213		170	

[a] Split air conditioners.
[b] Frost free refrigerator of storage volume of 250 litre.

The market share of appliances based on their star rating in total sales has changed over the years due to strengthening of the standards and consumers preference for energy-efficient technologies. The market share of air conditioners and refrigerators based on star rating in total sales is shown in Figs. 1 and 2. In both the appliances, two or three of the five categories have historically dominated the total annual sales. In terms of air conditioner sales, the share of 3-star and 5-star has increased steadily, despite an increase in efficiency standards in 2012 and 2014. For refrigerator sales, after an increase of standards in 2014, the market has been dominated by 2-star and 3-star refrigerators. This

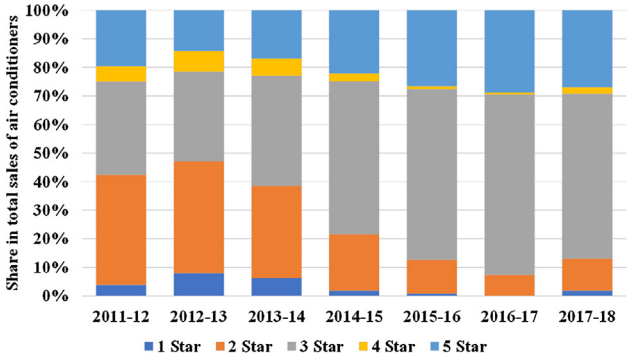

Fig. 1. Share of star rating in air conditioner sales in India [22].