Factors Influencing Willingness-to-Pay for the Energy Star Label

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Abstract

In the United States, nearly 17 percent of greenhouse gas emissions come from residential energy use. Increases in energy efficiency for the residential sector can generate significant energy savings and emissions reductions. Consumer labels, such as USEPA's Energy Star, promote conservation by providing consumers with information on energy usage for household appliances. This study examines how the Energy Star label affects consumer preferences for refrigerators. An online survey of a national sample of adults suggest that consumers are, on average, willing to pay an extra \$249.82 to \$349.30 for a refrigerator that has been awarded the Energy Star label. Furthermore, the results provide evidence that willingness to pay was motivated by both private (energy cost savings) and public (environmental) benefits.

Keywords: Energy Star, willingness-to-pay, eco-label

Introduction

Household energy conservation has been a topic of interest among researchers in various disciplines within the fields of psychology and economics since the 1970's. In simplified terms, household energy conservation can be defined as any action taken by a household member to reduce the energy consumption of his or her household. This can include anything from adjusting thermostat levels to installing more efficient windows, lighting, insulation or appliances. The latter examples can be considered actions to increase energy efficiency, the process of doing more for less energy. In just the past few years, growing concern for the environment coupled with rising energy costs[1] has focused an increasing amount of attention on energy efficiency.

Beginning with the oil shocks of the 1970s, it became widely accepted that our nation's energy supply arrangements were not as reliable as once thought (Harper, 2001). By the time the oil shocks were over, significant changes had occurred in the availability of energy, the technical means of converting it into usable forms, and the way consumers viewed energy consumption habits (Harper, 2001). In general, the 1970s energy crisis resulted in consumer and producer efforts to become more energy efficient. The modern drive for efficiency, however, has been primarily ignited by the threat of externalities associated with energy use such as global climate change and biodiversity loss (Kempton *et al*., 1992; Gardner and Stern, 2002).

In the United States, nearly 17 percent of greenhouse gas (GHG) emissions, which are thought by many to be the leading cause of global climate change, come from residential energy use (USEPA, 2003, 2007). In addition, from 1990 to 2005, emissions related to electricity use have risen by 2.4 percent annually (Abrahamse *et al*., 2005). While residential energy use is not

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[1] From 1975 to 2008, price per kWh of electricity rose by 25% in real dollars (http://www.eia.doe.gov/emeu/mer/pdf/pages/sec9_14.pdf).

the largest source of GHG emissions[2], studies have shown that, compared to current consumption, increasing energy efficiency in the residential sector offers potential energy reductions of 25 to 30 percent (USEPA, 2003).

While there may be significant opportunities for consumers to reduce energy consumption in their homes, it would be useful to know more about what factors influence consumers' to partake in these measures. Thus, the primary objective of this study is to estimate consumer willingness to pay (WTP) for energy saving measures in the home. More specifically, we will be looking at WTP for major appliances with the Energy Star label. In the process, the effects demographics, electricity costs, and stated environmental concern have on WTP will also be investigated.

Previous Studies

There has been widespread research in the areas of energy efficiency and environmental concern. Of particular interest to this study, are the efforts to evaluate consumer reaction to environmental labels (or "eco-labels") on products: more specifically, consumer willingness to pay (WTP) for that particular label (e.g. Aguilar and Vlosky, 2007; Bjørner *et al*., 2004; Blend and van Ravensway, 1999; Loureiro *et al*., 2002; Srinivasan and Blomquist, 2009). These studies have included both stated preference and revealed preference approaches. Revealed preference studies on eco-labels examine consumers' actions in actual marketplace settings (e.g. Anderson and Hansen, 2004; Bjørner *et al*., 2004). These studies are, however, rare compared to the stated preference variety because they tend to be more difficult and costly to perform. Stated preference research is a popular method in evaluating WTP for eco-labels because it allows the researcher to place consumers in an easily-controlled hypothetical marketplace and give them a choice

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[2] Industrial energy accounts for 22% and the transportation sector accounts for 25% of all US GHG emissions (USEPA, 2003).

amongst several alternatives (e.g. Bartels *et al*., 2004; Revelt and Train, 1998; Srinivasan and Bloomquist, 2009). Some studies have even evaluated the same product in both scenarios to test the credibility of stated preference experiments (e.g. Adamowicz *et al*., 1994; Arnot *et al*., 2006). In general, these studies show a positive WTP for environmental labels regardless of the methodologies.

Environmental Concern

The 'green' or environmental movement has spread from politics to consumerism and from consumerism to marketing and manufacturing (Zimmer *et al*., 1994). In many cases, environmental concern has been found to be positively related to respondents' stated or actual WTP for a product with positive environmental externalities (Krarup and Russell, 2005). This phenomenon has been found for both renewable energy (Farhar and Houston, 1996; Roe *et al*., 2001; Zarniaku, 2003) and environmentally sound food products (Moon and Balasubramanian, 2001; Wandel and Bugge, 1996).

Data on the effect of environmental concern on consumers' purchases of energy-using appliances is scarce. However, environmental concern has been used as an explanatory variable for determining WTP for items such as water quality (Cooper *et al*., 2004), protecting the rain forest (Kramar and Mercer, 1997), and aiding endangered species (Kotchen and Reiling, 2000; Ojea and Loureiro, 2007). In Cooper *et al.*, (2004) a contingent valuation survey was administered to determine the relation between stated environmental concern and WTP for water quality improvements to a lake within the grounds of the University of East Anglia. A payment vehicle was developed to assess WTP and environmental concern was measured by each individual's responses to a series of questions known as the New Ecological Paradigm (Dunlap

et al., 2000). The results were consistent with previous research in suggesting that concerns about the environment and altruism are relevant to WTP.

Energy Savings

Energy labeling is becoming more common in marketplaces around the world (Weil and McMahon, 2003). Two main types of energy labels are currently seen in the market: "seal-of-approval" and "report card" (Banerjee and Solomon, 2003). The "seal-of-approval" labels, like the Energy Star label, are usually seen as evidence that the product has met one or more well defined tests and promise better environmental performance than the standard products in that category. In most cases, these labels are administered by a third party. "Report card" labels, on the other hand, like the EnergyGuide label, provide comparative test data for that specific product and compare it to products of a similar nature.

Previous work on the effect energy labels have on WTP is limited. Banerjee and Solomon (2003) conducted a meta-evaluation of five energy labels in the US; two of which are government sponsored (EnergyGuide and Energy Star) and three privately sponsored (Green Seal, Scientific Certification System, and Green-e). The criteria used to evaluate these labels were consumer response, measured by awareness, understanding and behavior, and manufacturer/marketer response. The analysis revealed that the government-sponsored programs, especially the Energy Star program, were much more successful in these terms than the private labeling programs. The Energy Star program in particular has achieved market penetration rates of 5%-100% in 31 different product categories. Furthermore, 54% of the people surveyed who were aware of the Energy Star label and had purchased appliances within the previous 12 months said the label was somewhat or very influential in their purchase decision.

Research has shown that consumers value energy saving measures (Banfi *et al.*, 2008); however, in many instances the amount consumers are willing to pay for the energy efficient products is not as high as economic theory might predict (Howarth and Anderson, 1993). This difference has come to be known as the 'efficiency gap' (Howarth and Anderson, 1993). Potential explanations for the gap include imperfect information, liquidity constraints, and uncertainty about future energy savings. The evidence for an efficiency gap is unexpectedly high implied discount rates on energy-consuming equipment (Howarth and Sanstad, 1995). For example, Revelt and Train (1998) examined this gap in their stated preference study on refrigerators with a rebate, loan, or no incentive on the high-efficiency units. They found that consumers are willing to pay between $2.12 and $2.46 up front per $1 of annual energy savings on energy efficient refrigerators. These WTP figures imply discount rates between 46% and 39% assuming a 10 year lifespan.

One study of particular interest was conducted by Shen and Saijo (2009) on the effect of the China Energy Efficiency labeling program on Shanghai consumers. While the actual purpose of Shen and Saijo's study was to determine the effectiveness of China's energy labeling programs, similar methodologies to those used in the study reported here were used. A hypothetical choice experiment was employed to analyze consumers' WTP for a one level upgrade in energy efficiency rank on the China Energy Efficiency Label via a web-based survey and face-to-face interviews. The products evaluated were refrigerators and air conditioner units. For refrigerators, the attributes included in the choice experiment were price, energy efficiency rank, label indicating electrical bill savings, daily electricity consumption, capacity, and noise reduction. The first three attributes were the same for air conditioners along with hourly electricity consumption, cooling space, and whether there was an air purification function. The

alternatives were fixed in terms of condition (used or new) and brand origin (foreign or domestic). Their results revealed a WTP for a one step upgrade in energy efficiency of $76-$89 in refrigerators and $35-$54 in air conditioners. Furthermore, their findings showed slightly larger WTP values in face-to-face interviews compared to the web-based survey for both refrigerators and air conditioner units. Similarly, Sammer and Wüstenhagen (2006) performed a discrete choice analysis as a survey instrument to determine the importance of the European Energy Label in consumers' purchasing decisions. They found that consumers in Switzerland placed a 30% premium on washing machines with an A versus a C rating on the European Energy Label[3].

Survey Methods and Data

The data for the analysis reported here were obtained through an online survey conducted in March and April of 2009. The survey sample and online hosting services were provided by Knowledge Networks® (KN). The sample was drawn from an online research panel maintained by KN that is designed to be representative of the U.S. population. Members were recruited to the panel by either random digital dialing or address-based sampling methods. If those recruited to the panel did not have internet access, they were provided with free internet access and a means of connecting to it in exchange for agreeing to complete surveys. A profile with demographic information is maintained for each panel member. The responses to the survey questions used in the analysis presented here were supplemented with the demographic information from the panel member profile. More information on the online research panel and the recruitment methodologies can be found in Knowledge Networks (2010).

A survey weight designed to compensate for non-response to the survey was calculated by comparing respondent demographics with benchmark demographics from the Current

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[3] The EU Energy Label grades the efficiency of appliances on an A-G scale, with A being the most efficient.

Population Survey (i.e., gender, age, race/ethnicity, education, Census Region, metropolitan area, and internet access). The weight was calculated with an iterative proportional fitting procedure. The distribution of the calculated weights was examined to identify and, if needed, trim outliers at the extreme upper and lower tails of the weight distribution. The post-stratified and trimmed weights were then scaled to the sum of the total sample size. All results presented in this paper reflect the resulting weights.

A conjoint analysis choice experiment was employed in the survey to gather data on consumer WTP for an Energy Star label on a refrigerator. Conjoint analysis, as a generic name, actually encompasses a number of specific "stated choice" methodologies (Freeman, 2003). These are differentiated on the basis of the choice task posed to the respondent. The contingent choice methodology was used for this survey because it most closely replicates the purchase decision faced by actual consumers and, thus, permits the construction of an instrument that has the look and feel of a product design task rather than an environmental-information-gathering exercise. The choice of a refrigerator as the energy-using product was based on a number of factors, including its high energy consumption, its pervasiveness, and the apparently high relevance of the Energy Star label to buyers for this appliance. It is estimated that refrigerators are responsible for nearly 14 percent of the electricity consumed in US households (EIA, 2008a) and that nearly 99 percent of households contain at least one refrigerator (Barkenbus, 2006). Furthermore, consumers strongly associate the Energy Star label with refrigerators, as prior research indicates that among those who recognized the Energy Star label, 74 percent of households had seen the label on refrigerators (USEPA, 2007).

The survey began with general background questions on the respondents' home and refrigerator ownership. Following these, a series of information screens were provided to give

basic information about the refrigerator attributes in the choice experiment. The first screen explained and graphically presented the two different styles of refrigerators being used (i.e. French door and side-by-side). The next screen discussed external ice and water dispensers and displayed graphics illustrating the positioning of these dispensers on each style of refrigerator. The third screen, seen in Figure 1 in the Appendix, provided general information about the Energy Star program and its goal of reducing GHG emissions by promoting energy efficiency. Furthermore, it informed the respondents that an Energy Star refrigerator would save them $14 per year in annual electricity costs compared to a refrigerator that only met the basic federal energy use standard. The choice of $14 as the annual electricity cost savings associated with an Energy Star refrigerator was based on Energy Star materials estimating electricity cost savings ranging from $12 to $15 depending upon volume and other refrigerator attributes. Lastly, a screen provided information about internal capacity for refrigerators. Each of the information screens consisted of a 3-4 sentence explanation of the feature and gave an option to continue with the survey or get more information about the feature.

The information screens were followed by the choice experiment, which consisted of 14 contingent choice questions in which respondents were asked to choose the one refrigerator they would most likely purchase out of three refrigerator options and a "none" option. Participants were asked to assume that all of the choices fit in the space they had for a refrigerator, were available in the color or finish of their choice, and had both automatic defrost and a built-in icemaker. If at any point during the choice task a respondent chose the "none" option, a follow up question was asked at the end of the choice experiment asking why the 'none' option was chosen.

The refrigerator attributes included in the choice experiment were price, internal capacity, whether it had an external ice and water dispenser, whether or not it had been awarded the Energy Star, brand, and configuration. The price options were $879, $929, $979, and $1,029. The prices were chosen based on current market prices of refrigerators that were similar to those described in the choice experiment. The internal capacity options were 23.78, 24.52, 25.34, and 25.83 cubic feet and the brand options were LG, GE, Whirpool, and Kenmore.[4] Based on focus group trials, the two configuration options most desired were side-by-side and French door. The possible options for external ice and water dispensers were none, ice only, water only, or both ice and water. Whether the refrigerator was Energy Star qualified was represented as a simple "Yes" or "No" identification. An example of one of the choice tasks is provided in Figure 2.

The survey was fielded to 2,195 panel members and a total of 1,395 responses were received before the survey was closed to further responses. The survey consisted of four different versions. Out of the 1,395 respondents, a total of 355 completed the version used for the analysis in this paper. Each of those 355 respondents was asked to complete 14 choice tasks yielding a possible 4,965 individual choice tasks of which 4,960 were obtained. Given that each choice task included 3 alternatives and a "none" option, there were a possible 19,880 individual observations (19,860 were obtained).

Economic Model

Choice-based modeling is based on the theory of utility maximization. It can be assumed that all consumers, when presented with a choice of alternatives, will choose the alternative that possesses the combination of attributes that gives them the highest level of utility. It can also be assumed that the utility received from a particular alternative is related to a set of observable

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[4] The internal capacity options and brand options were chosen based on market popularity.

attributes associated with the choice. Thus, the utility individual *n* receives from alternative *j* can be expressed as:

(1) $U_{nj} = \boldsymbol{\beta}'\boldsymbol{X_{nj}} + \varepsilon_{nj}$

where X_{nj} is a vector of observed attributes of alternative *j* for individual *n*, β is a vector of coefficients to be estimated, and ε_{nj} is an extreme value error term. If Equation 1 is estimated with a conditional logit (McFadden, 1972), the probability individual *n* chooses alternative *j* can be expressed as

(2) $\prod_{nj} = \dfrac{\exp(\beta' X_{nj})}{\sum_{j=1}^{J_n} \exp(\beta' X_{nj})}.$

WTP for a particular attribute, *k*, is then calculated as:

(3) $WTP_k = -\dfrac{\beta_k}{\beta_P}$

where *P* is price and *k* is a non-price attribute.

However, the conditional logit is limited due to its assumptions of homogeneity of individuals. As pointed out by Steckel *et al.* (1988), the conditional logit assumes that the elements of the β vector are constant across all individuals and the ε_{nj}'s are independently and identically distributed (iid) across all individuals and alternatives. The model can be modified to incorporate heterogeneity of preferences across individuals by using random coefficient models such as the mixed logit (Train, 2003). The utility function for the random coefficient model can be expressed as

(4) $U_{nj} = \overline{\boldsymbol{\beta}}'\boldsymbol{X_{nj}} + \boldsymbol{\sigma}'\boldsymbol{X_{nj}} + \varepsilon_{nj}$

where the random coefficients (β) have been broken down into their means ($\bar{\beta}$) and standard deviations (σ). An estimate of WTP for attribute k can be obtained from (Revelt and Train, 1998):

(5) $WTP_k = -\dfrac{\bar{\beta}_k}{\bar{\beta}_P}.$

Another way of incorporating heterogeneity is by explicitly relating the deterministic component of the utility function to attitudinal and/or demographic variables (Steckel *et al.*, 1988). With this approach, the utility function for the fixed parameters model becomes:

(6) $U_{nj} = \boldsymbol{\gamma'Y_nX_{nj}} + \boldsymbol{\varphi'Z_nX_{nj}} + \boldsymbol{\beta'X_{nj}} + \varepsilon_{nj}$.

The demographic and attitudinal variables, Y_n , and individual's opinions about the attributes of the refrigerators (taste indicators), Z_n ,are introduced as interaction terms with X_{nj} and γ and φ are their associated parameters. If these demographic and attitudinal variables are interacted with a non-price variable, k, then WTP for attribute k, when calculated at the sample mean, becomes:

(7) $WTP_k = -\dfrac{\beta_k + \gamma_k\bar{Y}_n + \varphi_k\bar{Z}_n}{\beta_P}.$

This same procedure can also be used in the random parameters model (Lavin and Hanemann, 2008). The utility function for the random parameters model with demographic and attitudinal variables can be written as:

(8) $U_{nj} = \boldsymbol{\gamma'Y_nX_{nj}} + \boldsymbol{\varphi'Z_nX_{nj}} + \boldsymbol{\bar{\beta}'X_{nj}} + \boldsymbol{\sigma'X_{nj}} + \varepsilon_{nj}$

where, as in equation (5), Y_n are demographic characteristics and attitudinal variables and Z_n are taste indicators and γ and φ are their associated parameters. As in equation (3), the random coefficients (β) have been broken down into their means ($\bar{\beta}$) and standard deviations (σ). The

model then becomes the random parameters logit with demographic and attitudinal interactions with the product attributes. When calculated at the sampled means of the random parameters, demographics, and attitudinal variables, WTP becomes (Hensher and Greene, 2002):

(9) $WTP_k = -\dfrac{\bar{\beta}_k + \gamma_k \bar{Y} + \varphi_k \bar{Z}}{\bar{\beta}_P}.$

Four models are used in the analysis - two fixed parameters models and two random parameters models. The fixed parameters conditional logits consist of one with product attributes only and one with product attributes and interactions between the Energy Star label and demographic and attitudinal variables. Similarly, one random parameters logit is estimated on product attributes only and one on product attributes and interactions of demographic and attitudinal variables with the Energy Star label. Both random parameters logits are estimated with simulated maximum likelihood using Halton draws with 1,000 repetitions and are assumed to have normally distributed parameters. Also, in both cases, the refrigerator attributes, with the exception of price, are randomized (Train, 1999).

The product attributes, demographic characteristics, and attitudinal variable definitions, along with hypothesized signs and sample means for each, are presented in Table 1 in the Appendix. The refrigerator attributes are *Price*, *Capacity*, brand (*LG*, *GE*, and *Kenmore*, with Whirlpool as the base case), configuration (*Frenchdr* with Side-by-Side as the base case), external dispenser type (*Ice* only, *Water* only, and ice and water (*IandW*), with no dispenser as the base case), and whether the refrigerator has been awarded the Energy Star (*Label*). In order to include the "none" responses in the analysis, an alternative-specific constant (*ASC*) was created. *ASC* takes a value of 1 if the "none" option is chosen and 0 if one of the three alternatives is chosen (Vermeulen *et al.*, 2008). The demographic characteristics included in the analysis are

gender (*Male*), household income (*Income*), respondent's age (*Age*), and whether the respondent possessed a Bachelor's degree or higher (*College*).

Two economic variables are also included in the analysis - average electricity rate per kilowatt-hour (*kWh*) by county and the fraction of household income spent on electricity annually (*Inc_elec*). Data for 2008 electricity rates by utility provider were obtained from the Energy Information Administration (EIA, 2008b). A bridge model was obtained from David Carrier, Senior Economist for the Appalachian Regional Commission which provided a basis for converting average rate by utility provider into average rate by county. If a rate was missing for a county with multiple utility providers, the missing value was replaced with the average rate of the provider(s) in the county. Similarly, if there was a missing value for a county that had only one utility provider, missing values were replaced with an average of the surrounding counties. Average monthly household electricity costs are calculated based on respondents' answers to their estimated highest and lowest electric bill. The average of the two was multiplied by 12 and then divided by household income to get the fraction of income spent on electricity annually.

Lastly, environmental concern was analyzed based on respondents' answers to twelve environmental questions. The questions were based on the New Ecological Paradigm (Dunlop *et al*., 2000) and other similar scales and measured perceived consumer effectiveness, views on global climate change, and faith in others. A list of these questions can be seen in Table 2. Since the exact combination of questions were not derived from previous research, there were no clear hypotheses that could be used to structure one or more explanatory variables. The approach taken here is to conduct an initial factor analysis on the responses to the group of questions. A varimax rotation of that analysis revealed two usable factors defined by eight of the twelve items. This reduced set was then factored again and the results are presented in Table 3. This analysis

produced weights on the eight responses defining three variables: perception of consumer effectiveness in affecting product design and manufacturing and the ambient environment (*PCE*), views towards non-personal means of combating climate change (*ALT*), and the need for action concerning environmental issues (*ACT*). A Chronbach's alpha test[5], which tests the reliability and acceptability of indexed variables, for each of the three factors was also conducted and is presented in Table 3 along with their loadings.

Based on prior research on energy efficiency labels, WTP is expected to be positive for the Energy Star label (Revelt and Train, 1998; Shen and Saijo, 2009). Following findings on other eco-labeled products by Aguilar and Vlosky (2007), Bjørner, *et al.* (2004), and Jensen *et al.* (2004), females, individuals with higher disposable incomes, and those with higher levels of education are expected to have a greater WTP for the Energy Star label. The coefficient for *Age* is expected to have a negative sign and both *kWh* and *Inc_elec* are hypothesized to have positive effects on WTP for the label[6]. The other attributes associated with refrigerators and their hypothesized signs are listed in Table 1.

While the relationship between environmental concern and WTP for household appliances has not been investigated, a number of other studies have analyzed the relationship between environmental concern and WTP for other public and private goods (Cooper *et al*., 2004; Farhar and Houston, 1996; Kotchen and Reiling, 2000; Moon *et al*., 2002; Roe *et al*., 2001; Zarniaku, 2003). In general, the results of these studies have shown a positive relationship between environmental concern and WTP for products with positive environmental externalities. Thus, positive relationships between WTP and those with a higher degree of perceived consumer effectiveness (*PCE*) and those who assert a need for action concerning environmental issues

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[5] More information on Chronbach's Alpha can be found in Cortina (1993) and Nunnally (1967).
[6] Results of a multicollinearity test for kWhrate and Inc_elec revealed no significant collinearity.

(*ACT*) are expected. Furthermore, a negative relationship between WTP for the Energy Star label and those who exhibit strong views toward non-personal means of combating climate change (*ALT*) is hypothesized.

Results

Respondents' ages ranged from 19 to 88 with an average of 46. Approximately 45 percent of respondents were male and just under 30 percent possessed a Bachelor's degree or higher. The average household income, based on midpoints of categorical ranges, was $63,000. The 2008 national average price per kWh to residential consumers was 11.3 cents[7]. In the study sample, average prices per kWh of electricity by county ranged from a low of 6.1 cents to a high of 24.2 cents with a mean of 11.68 cents. For the percentage of income spent on electricity annually, our sample mean was approximately 4.5 percent, which is greater than the 2.7 percent obtained by the Bureau of Labor Statistics in a 2008 consumer expenditures survey[8]. This difference may be attributed to the fact that, in this study, the average bill was calculated using only the highest and lowest bills and the distribution of monthly bills (or respondent's recollection of monthly bills) may be somewhat skewed.

In order to determine the most probable outcome, a log-likelihood ratio test was used to compare the four different models. These tests, seen in Table 4, indicate that the random parameters models are preferred to the fixed parameters models for both the attribute only models and those including demographic and attitudinal information. In addition, comparison of the log-likelihood functions for the models that include demographic and attitudinal information to those including attributes only indicated that the inclusion of demographic and attitudinal

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[7] Obtained from http://www.eia.doe.gov/cneaf/electricity/epm/epm_sum.html.
[8] Data used can be obtained from http://www.bls.gov/cex.

information was significant for both the fixed parameters (LLR=2500.36, 10 df) and the random parameters logits (LLR=1904.24, 10df).

Table 5 lists the estimated coefficients and significance levels for all variables across the four models. Based on the log-likelihood functions, the random parameters model including demographic and attitudinal information (Model 4) is the most preferred outcome. Thus, the following discussion focuses on the results for this model. As expected, the coefficient for *Price* was negative and highly significant in Model 4, suggesting respondents were sensitive to price changes. The coefficient for *Label* was positive and significant, suggesting that respondents were more likely to choose a refrigerator that had been awarded the Energy Star. Other positive and significant variables included *Capacity*, *Ice*, and *IandW*, showing that respondents preferred larger refrigerators and those equipped with external ice or ice and water dispensers. All three brand names were significant and negative, indicating consumers preferred the base case, *Whirlpool*, to the other brands. *Water* and *Frenchdr* were the only two insignificant product attributes.

The signs of the coefficients of the interaction terms for *Age* and *Income* conform to hypotheses; however, only the coefficient for *Age* is significant. The coefficient for *College*Label* is negative and significant at the 85% confidence level, which is contrary to hypotheses, suggesting that individuals with less than a Bachelor's degree have a great likelihood of choosing an Energy Star labeled refrigerator. The coefficient of the interaction term for *Male* is significant and positive, which is contrary to expectations. While the sign of *Male*Label* is contrary to our hypothesis, it is important to note that the hypothesis was based on previous literature on the effect gender has on WTP for eco-labeled products. It could be argued that the Energy Star differs from the labels considered in other studies because of the private benefit it

offers in addition to its public benefit. Thus, an individual could be motivated to purchase an energy star appliance for the private benefit, the public benefit, or a combination of both. So in order to test the effect Energy Star's private benefit has on females, a triple interaction term (*Male*kWh*Label*) was created to control for those males motivated to choose an Energy Star refrigerator for its private benefit and included in a random parameters logit regression. The results from that regression (which are not presented) were similar to those in Model 4, except that none of the three relevant interaction terms (*Male*Label, kWh*Label, and Male*kWh*Label*) were significant.

For environmental concern, the signs of the estimated coefficients conform to expectations. The coefficient for *PCE*Label* is positive and significant suggesting that individuals with positive attitudes toward the effect of consumer behavior on product design and the ambient environment have a greater likelihood of choosing an Energy Star labeled refrigerator. The estimated coefficient for *ALT*Label* did have the negative sign as hypothesized; however, it was not significant in Model 4. Lastly, the coefficient for *ACT*Label* was positive and significant as expected, suggesting a positive relationship between consumers exhibiting the need for action concerning environmental issues and likelihood of choosing an Energy Star labeled refrigerator. These results are consistent with previous studies on the effect environmental concern and perceived consumer effectiveness[9] have on individuals' WTP for environmentally friendly products.

The coefficient for *kWh*Label* was positive and significant, suggesting that individuals paying higher electricity rates have a greater likelihood of choosing an Energy Star refrigerator. The fraction of income spent on electricity annually (*Inc_Elec*) was negative and significant.

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[9] More information on perceived consumer effectiveness can be found in Berger & Corbin, 1992; Ellen *et al*., 1991; Scholder *et al*., 1991.

While this is contrary to our a priori hypotheses, one possible explanation for this could be the wealth effect. Since only 15 percent of respondents disagreed with the statement "when I buy a product with the ENERGY STAR label, I can always be sure it's high quality," it can be concluded that the Energy Star is perceived to be a quality or luxury attribute and as household income decreases and the percentage of income spent on electricity increases there is less disposable income to be spent on luxury items. Also, as total energy bill increases, maybe the $14 in annual energy savings provided by an Energy Star refrigerator seems less important. A third possible explanation is that those who were motivated to buy an Energy Star labeled refrigerator are also those people who are already taking steps to conserve energy and, thus, spend less of their income on electricity.

Table 6 provides estimates of WTP for the Energy Star label across the four models. All of the WTP estimates are positive and significantly different from zero. For Model 1, mean WTP was calculated by using equation (3) while equation (5) was used to calculate WTP for Model 2. Similarly, equation (7) was used to calculate mean WTP for Model 3 while equation (9) was used to calculate mean WTP for Model 4. Willingness-to-pay estimates for the random parameters models are calculated at the sample means and at the estimated mean parameters. Standard errors for the willingness-to-pay estimates are calculated using the Krinsky-Robb method for parametric bootstrapping with 15,000 draws (Krinsky and Robb, 1991).[10] The mean WTP for the fixed parameters and random parameters logits with attributes only (Models 1 and 2) are $258.71 and $249.82 respectively, while the mean WTP for the fixed parameters and random parameters logits with attributes, demographics, environmental, and economic interactions (Models 3 and 4) are $275.45 and $349.30 respectively.

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[10] The Krinsky-Robb procedure uses random draws from the estimated asymptotic normal distribution of parameter estimates to calculate confidence intervals around WTP estimates.

In the survey, respondents were informed that the Energy Star label would save them $14 per year in electricity costs. Average ownership expectancy, based on respondents' answers, was approximately 11 years. So, assuming an 11 year ownership with a constant $14 per year return on investment, respondents were expecting on average $154 in energy savings for purchasing a refrigerator with the Energy Star label. Even without being discounted, this stream of savings is significantly less than our mean WTP estimates. Possible explanations for the large difference in WTP and energy cost savings include expectations of increased future energy prices[11], or a willingness to pay for the public benefits associated with the label. A slightly different approach would be to look at the discount rates associated with our WTP estimates and the stream of cost savings over an 11 year period. Using the lowest WTP estimate of $249.82 and the highest WTP estimate of $349.30 the results imply discount rates ranging from -7.31% to -11.65%. These negative discount rates suggest that consumers are not only willing to pay for the private benefit associated with the Energy Star label, but also the public benefit associated with the Energy Star label.

Summary & Conclusions

The results from this study indicate that consumers have a positive and significant WTP for household energy efficiency through the purchase of Energy Star qualified appliances. The results suggest that an individual, when faced with a choice between two refrigerators, identical except that one has an Energy Star and one does not, would be willing to pay a premium in the range of $249.82 to $349.30 for the Energy Star qualified refrigerator. If consumers expect no real growth in future energy prices, these WTP values imply discount rates ranging from -7.31% to -11.65%. These negative discount rates provide evidence that WTP was motivated by both private (energy cost savings) and public (reduction in energy generation) benefits. To

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[11] However, only 20% of survey respondents expected energy prices to rise faster than inflation rate.

manufacturers and government regulators, these results suggest that the Energy Star label can play a significant role in a consumer's decision making process when selecting a new appliance. However, these results are solely based on refrigerators and may or may not extend to other major home appliances. Further research into the effect Energy Star labels have on other appliances is warranted.

The results from this study also indicate that consumer demographics and attitudes influence WTP. In particular, the rate consumers pay for electricity (*kWh*) was positive and significant, indicating that as consumers pay more per kWh of electricity they are willing to pay more for an Energy Star refrigerator. *PCE*Label* and *ACT*Label* were positive and significant, suggesting a positive relationship between individuals with positive attitudes toward both the effect of individual consumer behavior on the ambient environment and individuals expressing the need for action concerning environmental issues, and WTP for Energy Star labeled appliances. These results suggest that not only do consumers factor in electricity cost savings, but also the potential environmental benefits of the Energy Star. *Age* and education (*College*) were found to be statistically significant factors in determining an individual's likelihood of choosing an Energy Star refrigerator as expected; however, income was not. On the other hand, the fraction of income spent on electricity annually (*Inc_Elec*) was significant and negative, suggesting that those who spend a smaller fraction of annual income on electricity costs have a greater WTP for Energy Star refrigerators. While this is contrary to the hypothesis, there are several explanations for the negative sign, including the possibility that those who were motivated to buy an Energy Star labeled refrigerator are also those people who are already taking steps to conserve energy and, thus, spend less of their income on electricity.

The coefficient for *Male* was significant but had a positive sign, which was contrary to the hypothesis. It was determined that one possible explanation for this discrepancy could be that males were motivated to choose and Energy Star refrigerator based on the private benefit while females were motivated by the public benefit. So in order to test the effect Energy Star's private benefit has on females, a triple interaction term (*Male*kWh*Label*) was created to control for those males motivated to choose an Energy Star refrigerator for its private benefit and introduced into the random parameters logit regression. Results from that regression hinted that females were motivated to choose an Energy Star refrigerator by the public benefit and males were motivated by the private benefit; however, the results were not significant. Thus, a closer look into how gender and other economic factors influence consumer purchasing decisions of energy using durables might be an area for further research.

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Appendix
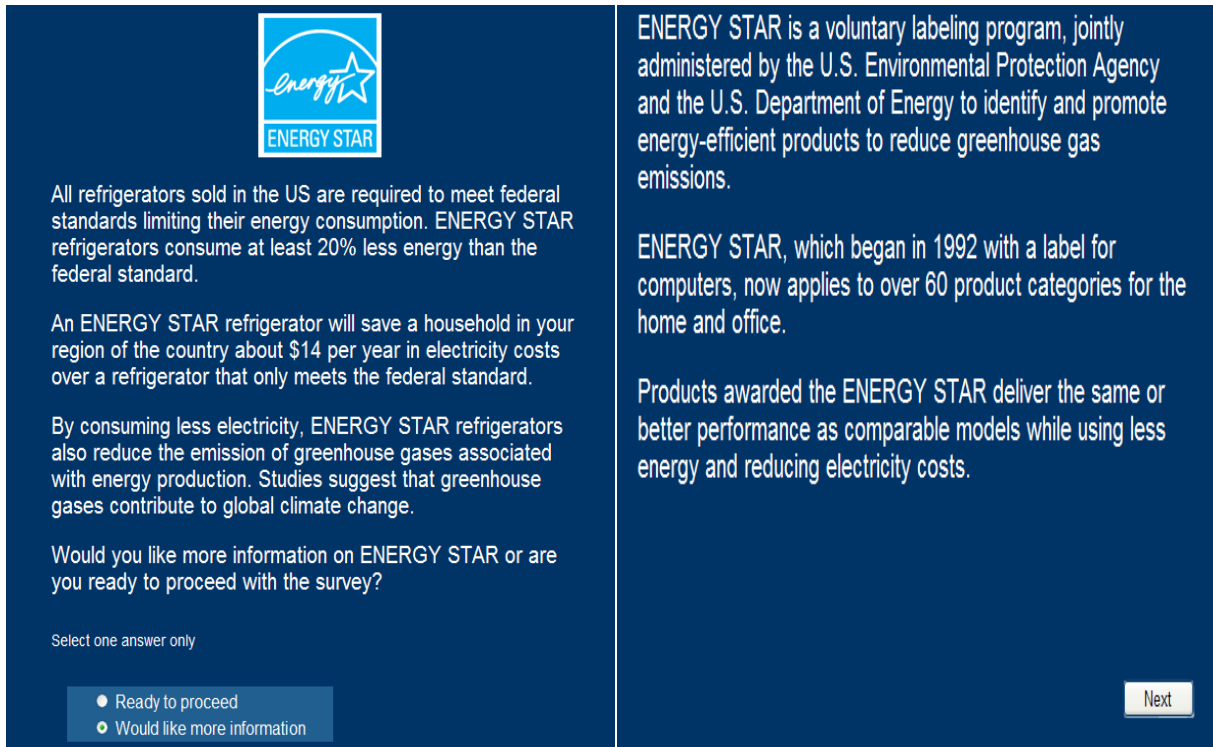
Figure 1: Energy Star Information Screen and "More Information" Screen

If you needed to buy a refrigerator and <u>these were your only options</u>, which would you choose?

You may assume that all of these choices fit in the space that you have for a refrigerator, are available in the color or finish that you want, and have both automatic defrost and a built-in icemaker.

Please select a refrigerator by clicking one of the buttons below:

	Alternative 1	Alternative 2	Alternative 3	
Price	$929	$1,029	$929	
Brand	General Electric	Kenmore	LG	
Configuration	Side-by-side	French door	Side-by-side	NONE: I wouldn't choose any of these ○
Capacity (cu. ft.)	23.78	25.34	24.52	
Through-the-Door Dispenser	Water	Ice	Ice & Water	
Energy Star	No	Yes	Yes	
Your choice	○	○	○	

Next

Figure 2. Sample Choice Experiment Task

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Table 1. Variable Names, Definitions, Hypothesized Signs, and Sample Means

Variable Name	Definition	Hypothesized Sign	Sample Means
Dependent Variable			
Chosen	1 if the alternative is chosen, 0 otherwise	NA	0.2500
Explanatory Product Attribute Variables			
Price	$879, $929, $979, or $1,029	+	715.8902
Label	1 if Energy Star qualified, 0 if not	+	0.3846
Capacity	23.78, 24.52, 25.34, 25.83 cubic feet	+	18.6312
Frenchdr	1 if French door style, 0 if side-by-side	+	0.3845
Brand Choices (Whirlpool as base case)			
LG	1 if LG brand, 0 otherwise	NA	0.1991
GE	1 if GE brand, 0 otherwise	NA	0.1847
Kenmore	1 if Kenmore brand, 0 otherwise	NA	0.1833
External Dispenser Type (No ice or water as base case)			
Ice	1 if equipped with external ice dispenser only, 0 otherwise	+	0.2012
Water	1 if equipped with external water dispenser only, 0 otherwise	+	0.1838
IandW	1 if equipped with external ice & water dispenser, 0 otherwise	+	0.1811
ASC	1 if "None" option, 0 otherwise	NA	0.2500
Demographic, Economic, and Attitudinal Explanatory Variables			
Age	Age of respondent in years	-	46.4937
Male	1 if male, 0 otherwise	-	0.4510
College	1 if Bachelor's degree or higher, 0 otherwise	+	0.2985
Income	Annual household income (categorical midpoints)	+	63069.67
kWhrate	Average price of electricity by county of residence (cents per kWh)	+	11.6778
Inc_Elec	Average annual electricity costs as a percentage of annual household income	+	0.0448
ALT	Factor analysis score for alternative means of combating global climate change	-	0.0172
ACT	Factor analysis score for desire of action to address climate issues	+	0.0225
PCE	Factor analysis score for perceived consumer effectiveness	+	0.0488

Table 2. Environmental Concern Questions [b]

1	I will try to conserve energy only when it helps to lower my utility bills
2	When I buy products, I consider how my use of them will affect the environment
3	By choosing environmentally friendly products, I signal to manufacturers the types of products they should be producing.
4	I don't have enough knowledge to make well-informed decisions on environmental issues
5	The conservation efforts of one person are useless as long as other people refuse to conserve
6	Global climate change will have a noticeably negative impact on the environment in which my family and I live
7	There is no urgent need to take measures to prevent global climate change today.
8	The production of electricity from renewable sources such as solar, wind and biomass is an effective way to combat global climate change.
9	The most effective way to combat global climate change is to reduce energy consumption
10	Science and technology will come up with effective ways to combat global climate change
11	Most people are not willing to make sacrifices to protect the environment.
12	We need more government regulations to force people to protect the environment.

[b] Response options were 1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, and 5=Strongly Agree

Table 3. Rotated Factor Loadings with Reliability Score

	Factor Weights
Perceived Consumer Effectiveness (PCE)	
Chronbach's α=0.79	
When I buy products, I consider how my use of them will affect the environment	0.7210
By choosing environmentally friendly products, I signal to manufacturers the types of products they should be producing.	0.7029
Alternative Measures (ALT)	
Chronbach's α=0.72	
The production of electricity from renewable sources such as solar, wind and biomass is an effective way to combat global climate change.	0.4436
The most effective way to combat global climate change is to reduce energy consumption	0.5597
Science and technology will come up with effective ways to combat global climate change	0.5160
Need for Action (ACT)	
Chronbach's α=0.68	
We need more government regulations to force people to protect the environment.	0.4606
There is no urgent need to take measures to prevent global climate change today.	-0.4175
Global climate change will have a noticeably negative impact on the environment in which my family and I live	0.5228

Table 4. Log-Likelihood Ratios Comparing Fixed and Random Parameters Logits

Model	Description	Log-likelihood	LLR Statistics Comparing Fixed and Random[f]	df
1	Fixed Coefficients-Product Attributes Only	-5453.37	2921.78 ***	10
2	Random Parameters-Product Attributes Only	-3992.48		
3	Fixed Coefficients-Product Attributes,	-4203.19	2325.66 ***	10
4	Random Parameters- Product Attributes, Demographic Characteristics, and Environmental Concern Variable	-3040.36		

[f]The log likelihood ratio test (LLR) is calculated as -2(log likelihood restricted-log likelihood unrestricted).

Table 5. Estimated Models of WTP for Energy Star Labeled Refrigerators

	Conditional Fixed Parameters Logits				Random Parameters Logits			
	Model 1		Model 2		Model 3		Model 4	
			Mean of Est.				Mean of Est.	
Variable	Est. Coeff.	Z	Coeff.	Z	Est. Coeff.	Z	Coeff.	Z
Price	-0.0042	-8.99***	-0.0049	-9.47***	-0.0078	-6.45***	-0.0088	-5.89***
Label	1.0759	20.02***	1.2267	4.97***	2.1455	11.52***	3.4527	3.75***
Capacity	0.1071	3.31***	0.1259	3.45***	0.1413	2.58***	0.1466	2.3***
Frenchdr	-0.0250	-0.5	0.1210	2.14***	-0.1190	-0.72	0.3490	1.15
LG	-0.2405	-3.3***	-0.2535	-3.2***	-0.4044	-3.8***	-0.4278	-3.49***
GE	-0.1082	-1.52*	-0.1471	-1.86**	-0.2116	-2.07***	-0.2301	-1.91**
Kenmore	-0.1792	-2.51***	-0.2070	-2.65***	-0.2400	-2.12***	-0.2949	-2.23***
Ice	0.2734	3.67***	0.3288	3.97***	0.4300	2.96***	0.5381	3.13***
Water	0.2467	3.17***	0.1780	2.04***	0.3565	2.62***	0.1955	1.31
IandW	1.0008	13.72***	0.9626	11.69***	1.7803	7.85***	1.6110	5.78***
ASC			-0.3034	-0.3			-3.3657	-1.55*
Age*Label			-0.0157	-5.51***			-0.0392	-3.64***
Income*Label			-1.75E-07	-0.18			1.51E-06	0.74
Male*Label			0.0476	0.54			0.9998	2.27***
College*Label			-0.0378	-0.37			-0.6506	-1.52*
PCE*Label			0.1231	2.04***			0.4656	1.86**
ACT*Label			0.2218	2.75***			0.9563	3.11***
ALT*Label			-0.1084	-1.4			-0.2270	-0.87
kWh*Label			0.0646	4.5***			0.0675	1.48*
Inc_Elec* Label			-1.2247	-2.1***			-8.7594	-2.87***
Standard Deviations								
Label					1.9651	9.32***	1.9053	7.82***
Capacity					0.1908	6.13***	0.1737	11.48***
Frenchdr					2.7226	10.45***	2.7495	8.57***
LG					0.3673	2.12***	0.4700	1.36
GE					-0.5740	-3.45***	-0.4616	-2.13***
Kenmore					0.8064	4.89***	0.6477	2.83***
Ice					1.2141	7.35***	1.3366	6.39***
Water					0.7812	3.53***	-0.3127	-0.79
IandW					2.0229	10.92***	2.3573	9.56***
ASC					2.4366	2.91***	1.4210	6.57***
Log likelihood	-5453.37		-4203.19		-3992.48		-3040.36	

***, **, * denotes significance 95%, 90%, and 85% confidence levels, respectively.

Table 6. Estimates of WTP for Energy Star Labeled Refrigerators

| | Conditional Fixed Parameters Logits | | | | Random Parameters Logits | | | |
| | Model 1: Attributes | | Model 2:Attributes, Demographics, Attitudes | | Model 3: Attributes | | Model 4: Attributes, Demographics, Attitudes | |
Variable	Mean.	Std. Error	Mean.	Std. Error	Mean.	Std. Error	Mean.	Std. Error
Label	258.71	61.13 ***	249.82	83.22 ***	275.45	100.74 ***	349.30	155.07 ***

*** denotes significance at the 95% confidence level.