

To the Graduate Council:

I am submitting herewith a thesis written by David Oakley Ward entitled “Consumers’ Willingness to Pay for Energy Labels on Household Appliances.” I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural Economics

Christopher D. Clark, Major Professor

We have read this thesis
and recommend its acceptance:

Kimberly L. Jensen

Steven T. Yen

Accepted for the Council:

Carolyn R. Hodges
Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

CONSUMERS' WILLINGNESS TO PAY FOR ENERGY LABELS ON HOUSEHOLD
APPLIANCES

A Thesis
Presented for the
Master of Science Degree
The University of Tennessee, Knoxville

David Oakley Ward
May 2010

Abstract

Voluntary environmental labeling or certification programs provide information about the environmental characteristics of one or more aspects of a product's life cycle to consumers. The U.S. Environmental Protection Agency and Department of Energy were among the first governmental agencies in the world to adopt environmental information programs. This study examines two U.S. programs – Energy Star, an energy efficiency labeling program, and Green Power Partnership (GPP), a green energy purchasing program, and estimates how much consumers are willing to pay for refrigerators that have been awarded these labels and what factors motivate that willingness to pay. The data were obtained from a survey conducted in March and April of 2009 via an online research panel, which was constructed to be representative of the U.S. population. Analysis of the data was conducted using conditional logit regression models with fixed parameters and mixed logit regression models with random parameters. Results revealed that consumers, on average, have a willingness to pay ranging from \$237.81 to \$350.54 for the Energy Star label and a willingness to pay ranging from \$48.52 to \$70.95 for the GPP label. The results also indicate that consumer demographics and attitudes influence WTP. In particular, individuals with greater levels of stated concern for the environment or individuals exhibiting strong perceptions on the effectiveness of consumers to affect product design and the ambient environment had a greater likelihood of choosing a labeled alternative, and thus, a greater WTP for both the Energy Star and GPP label. To manufacturers and government regulators, these results suggest that energy labels can play a significant role in a consumer's decision making process when selecting a new appliance.

TABLE OF CONTENTS

Part 1: Introduction

Introduction.....	1
References.....	6

Part 2: Willingness to Pay for Energy Star Refrigerators

Abstract.....	9
Introduction.....	10
Previous Studies.....	11
Methods.....	15
Results.....	25
Summary and Conclusion.....	31
References.....	34
Appendix.....	38

Part 3: Willingness to Pay for Refrigerators Produced With Green Power

Abstract.....	51
Introduction.....	52
Previous Studies.....	54
Methods and Procedures.....	57
Results.....	66
Summary and Conclusion.....	70
References.....	72
Appendix.....	75

Part 4: Summary and Conclusions

Summary.....	87
Vita.....	90

LIST OF TABLES

TABLE		PAGE
Part 1: Introduction		
1	Purchase Requirements for EPA’s Green Power Partner Program.....	3
Part 2: Willingness to Pay for Energy Star Refrigerators		
2	Variable Names, Definitions, Hypothesized Signs, and Sample Means.....	42
3	Environmental Concern Questions.....	43
4	Rotated Factor Loadings with Reliability Score.....	44
5	Attribute Only Model Estimates of WTP for Energy Star Labeled Refrigerators.....	45
6	Log-Likelihood Ratios Comparing Fixed and Random Parameters Logits.....	46
7	Attribute, Demographic, and Attitudinal Model Estimates of WTP for Energy Star Labeled Refrigerators.....	47
8	Male/Female Split Model Estimates of WTP for Energy Star Labeled Refrigerators.....	48
9	Estimates of WTP for Energy Star Labeled Refrigerators.....	49
Part 3: Willingness to Pay for Refrigerators Produced With Green Power		
10	Variable Names, Definitions, Hypothesized Signs, and Sample Means.....	78
11	Environmental Concern Questions.....	80
12	Rotated Factor Loadings with Reliability Score.....	81
13	Log-Likelihood Ratios Comparing Fixed and Random Parameters Logits.....	82
14	Estimated Models of WTP for GPP Labeled Refrigerators.....	83
15	Estimates of WTP for GPP Labeled Refrigerators.....	84
16	Estimated Cost to Produce One Refrigerator With Green Power.....	85

LIST OF FIGURES

FIGURE		PAGE
	Part 2: Willingness to Pay for Energy Star Refrigerators	
1	Energy Star Information Screen and “More Information” Screen.....	39
2	Sample Choice Experiment Task.....	40
3	Male Responsiveness to Energy Star Label Relative to Female Responsiveness Over the Range of County-Level Average Electricity Rates.....	41
	Part 3: Willingness to Pay for Refrigerators Produced With Green Power	
4	Information Screen for Green Power Partners.....	76
5	Sample Choice Experiment.....	77

Part 1: Introduction

The provision of information has, in the last few decades, become an important complement to, and even a means of, environmental regulation. A variety of information provision programs disseminate different types of information to different audiences. Voluntary environmental labeling or certification programs that provide information about the environmental characteristics of one or more aspects of a product's life cycle to consumers are among the most popular of these programs, having been widely adopted around the world in one form or another (USEPA 1993, 1994, and 1998).

The U.S. Environmental Protection Agency (USEPA) and the U.S. Department of Energy (USDOE) were among the first governmental agencies in the world to adopt environmental information programs.¹ While the number of environmental information programs instituted by USEPA and USDOE has continued to grow, they have, for the most part, been limited to providing information on attributes that include not only a "public" benefit for the ambient environment but also a "private" benefit for the individual consumer. This paper seeks to estimate how much individual consumers are willing to pay for these labels on household appliances. In particular, we will be looking at the USEPA's ENERGY STAR[®] label and Green Power Partnership program.

The Energy Star program, established in 1992, is jointly administered by the USEPA and the USDOE. One of the program's activities is to certify those appliances that meet specified energy saving criteria more stringent than the minimum federal requirements. For example, refrigerators became eligible for the Energy Star label in 1996, with Energy Star qualified refrigerator models using at least 20 percent less energy than required by federal standards (USEPA 2009). Since its introduction, the Energy Star logo has spread to more than 60 product

¹ Legislation authorizing Energy Guide, pesticide labeling, and the Fuel Economy Information Program were enacted in 1975, while authority for toxic substances labeling was passed in 1976 (Russell, 2001).

categories and has public awareness now exceeding 75 percent (USEPA 2008). Further, the program would appear to be having an influence on consumers as survey results indicate that about 73 percent of the households who had knowingly purchased an Energy Star product in the last six months pointed to the Energy Star certification as an influence in their purchase decision (USEPA 2008). Along the same lines, Banerjee and Solomon (2003) found that, among five popular U.S. eco-labeling programs (Energy Star, Energy Guide, Green-e, Green Seal and Scientific Certification Systems), Energy Star had the highest degree of market influence.

The Energy Star label is limited to the effect of the use of the labeled products on energy consumption and the program does not make any claims about the effects of labeled products on energy consumption or the natural environment associated with the manufacturing of the products. A USEPA program established in 2001, the Green Power Partnership, does not consider the amount of energy used in manufacturing a product, but it does consider the share of that energy derived from renewable sources (“green power”). To qualify as either a Green Power Partner or a Green Power Leader, a certain percentage of the energy consumed by the firm must come from renewable sources, with the percentage being based on the firm’s baseload, as shown in Table 1 below.

Table 1. Purchase Requirements for EPA’s Green Power Partner Program

Baseload or annual electricity use in kilowatt-hours	Percentage of baseload that must come from renewable sources to qualify as a:	
	Green Power Partner	Green Power Leader
≥ 100,000,001 kWh	2%	20%
10,000,001 – 100,000,000 kWh	3%	30%
1,000,001 – 10,000,000 kWh	6%	60%
≤ 1,000,000 kWh	10%	Not applicable

Source: USEPA (2007).

Partners may buy any eligible green power, such as solar, wind, geothermal, biomass, biogas or low-impact hydro resources. Partnership status enables the firm to use a logo in their marketing and promotion materials that identifies it as a Green Power Partner and makes explicit the program's affiliation with USEPA (USEPA 2007). The program now boasts more than 1,200 partners that are collectively buying more than 18 billion kilowatt-hours of renewable energy per year (USEPA 2010).

The Energy Star and Green Power Partnership programs are similar in that they both are related to reductions in GHG emissions, albeit in different ways, with Energy Star promoting reductions from reduced energy consumption, while, the Green Power Partnership promotes the consumption of energy from renewable resources. There are also some important differences in the programs as well. While the Energy Star program is concerned with specific products or even particular models of products, the Green Power Partnership is concerned with the environmental characteristics of a particular firm or other organization. An implication of this distinction is that the target audience of the Energy Star program is relatively clear – consumers of the products included in the program. On the other hand, the target audience for the Green Power Partnership program is less clear, although it would certainly seem to include consumers. For the purpose of this study, the Green Power Partnership program is presented in the form of a consumer label, similar to the Energy Star label, on household appliances.

The remainder of this report is organized as follows. The next section provides more information on energy and environmental labeling schemes and presents results from previous studies pertaining to some of these labels. The analysis and results pertaining to consumers' willingness to pay for Energy Star labeled appliances are also presented and discussed in this section. The third section provides more detailed information relating to green energy and green

pricing programs, as well as an analysis of consumers' willingness to pay for appliances produced by Green Power Partners. Lastly, the fourth section provides a brief summary and offers some thoughts on the relevance of this research for environmental policy.

References

- Banerjee, A., and B.D. Solomon. 2003. "Eco-labeling for Energy Efficiency and Sustainability: a Meta-Evaluation of US Programs." *Energy Policy* 31:109-123.
- Russell, Clifford S. 2001. Applying Economics to the Environment. New York: Oxford University Press.
- USEPA. 2010. Green Power Usage Edged Higher in 2009 among EPA Partners. Available at: <http://yosemite.epa.gov/opa/admpress.nsf/d0cf6618525a9efb85257359003fb69d/f74df277c3c6c40f852576b60064db10!OpenDocument>
- _____. 2009. ENERGY STAR® and Other Climate Protection Partnerships 2008 Annual Report. Office of Air and Radiation; United States Environmental Protection Agency. Washington D.C. (December)
- _____. 2008. *National Awareness of ENERGY STAR® for 2007: Analysis of 2007 CEE Household Survey*. Office of Air and Radiation, Climate Protection Partnerships Division. Washington DC.
- _____. 2007. Green Power Partnership. Available at <http://www.epa.gov/grnpower/>
- _____. 1998. Environmental Labeling Issues, Policies, and Practices Worldwide. EPA742-R-98-009. Office of Prevention, Pesticides and Toxic Substances; United States Environmental Protection Agency; Washington, D.C. (December).
- _____. 1994. Determinants of Effectiveness for Environmental Certification and Labeling Programs. EPA 742-R-94-001. Washington, D.C.; United States Environmental Protection Agency, Office of Pollution Prevention and Toxics (April).
- _____. 1993. Status Report on the Use of Environmental Labels Worldwide. EPA 742-R-93-001. Washington, DC; United States Environmental Protection Agency, Office of Pollution Prevention and Toxics (September).

Part 2: Willingness to Pay for Energy Star Appliances

Abstract

In 1992, the U.S. Environmental Protection Agency developed an environmental certification program, called Energy Star, to promote energy efficient products and practices. 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 the United States, nearly 17 percent of greenhouse gas emissions, which are thought by many to be the leading cause of global climate change, come from residential energy use. There are a number of ways a consumer can reduce household energy consumption including: adjusting the thermostat, installing insulation or better windows, or purchasing appliances with the Energy Star label. The objective of this study is to examine the Energy Star label on refrigerators and estimate how much extra consumers are willing to pay for refrigerators that have been awarded the label as well as the effects demographics, electricity costs, and stated environmental concern have on that willingness to pay. The data were obtained from a survey conducted in March and April of 2009 via an online research panel, which was constructed to be representative of the U.S. population. Analysis of the data was conducted using conditional logit regression models with fixed parameters and mixed logit regression models with random parameters. Results revealed that consumers, on average, have a willingness to pay ranging from \$237.81 to \$350.54 for the Energy Star label. Furthermore, the results provide evidence that willingness to pay was motivated by both private (energy cost savings) and public (environmental friendliness) benefits.

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 costs² 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, Darley, and Stern 1992; Gardner & Stern 2002).

In the United States, nearly 17 percent of greenhouse gas emissions (GHG), 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 rose by 2.4 percent annually (Abrahamse et. al 2005). While residential energy use is not the

² 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.

largest source of GHG³, studies have shown that, compared to current consumption, increasing energy efficiency in the residential sector offers potential reductions in energy consumption 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 undertake 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. Blend and van Ravensway 1999; Loureiro, McCluskey, and Mittlehammer 2002; Bjørner, Hansen, and Russell 2004; Aguilar and Vlosky 2007; 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, Hansen, and Russell 2004). These studies are, however, rare compared to the stated WTP 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-

³ Industrial energy accounts for 22% and the transportation sector accounts for 25% of all US GHG emissions (USEPA 2003).

controlled hypothetical marketplace and give them a choice amongst several alternatives (e.g. Revelt and Train 1998; Bartels, Fiebig, McCabe 2004; 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, Louviere, and Williams 1994; Arnot, Boxall, and Cash 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, Stafford, and Stafford 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 (Wandel and Bugge 1996; Moon and Balasubramanian 2001).

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, Poe, and Bateman 2004), protecting the rain forest (Kramar and Mercer 1997), and aiding endangered species (Kotchen and Reiling 2000; Ojea and Loureiro 2007). In Cooper, Poe, and Bateman’s (2004) study on water quality, 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 Label⁴.

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 essential demographic information is maintained for each panel member. The responses to the survey questions used in the analysis presented here were supplemented with that demographic information from the panel member profile. More information on the online research panel and the recruitment methodologies can be found in Dennis (2007).

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

⁴ The EU Energy Label grades the efficiency of appliances on an A-G scale, with A being the most efficient.

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).

A survey weight designed to compensate for non-response to the survey was calculated by comparing respondent demographics with benchmark demographics from the Current 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 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 2008) 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.

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 label, 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, Whirlpool, and Kenmore⁵. 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 below. 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.

Each of the 355 respondents who completed the survey 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). Responses to the survey questions were supplemented with demographic information from the panel member profile maintained by KN.

⁵ The internal capacity options and brand options were chosen based on market popularity.

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

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

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 1973), the probability individual n chooses alternative j can be expressed as

$$(2) \quad \Pi_{nj} = \frac{\exp(\beta' X_{nj})}{\sum_{j=1}^J \exp(\beta' X_{nj})}.$$

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

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

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, Wilfried, and Vanhonacker (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

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

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):

$$(5) \quad WTP_k = -\frac{\bar{\beta}_k}{\bar{\beta}_p}.$$

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

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

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 as 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:

$$(7) \quad WTP_k = -\frac{\beta_k + \gamma_k \bar{Y}_n + \varphi_k \bar{Z}_n}{\beta_p}.$$

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:

$$(8) \quad U_{nj} = \gamma' Y_n X_{nj} + \varphi' Z_n X_{nj} + \bar{\beta}' X_{nj} + \sigma' X_{nj} + \varepsilon_{nj}$$

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):

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

Four models are used in our 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 variable. 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. In the random parameters logits, only non-price attributes have random coefficients.

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 of French door (*Frenchdr*) with Side-by-Side (*sbs*) as the base case, external dispenser type (*Ice* only, *Water* only, and ice and water (*IandW*), with no

dispenser (*No_IW*) as the base case), and whether the refrigerator has been awarded the Energy Star (*Label*). In the random parameters models, the price coefficient is specified to be fixed so that estimates of WTP for non-price attributes are normally distributed (Train 1999). The demographic characteristics included in the analysis are gender (*Male*), whether household income was greater than \$100,000 (*Inc100*) or between \$50,000 and \$100,000 (*Inc50*), respondent 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) (*kWhrate*) 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 Energy Information Administration (EIA). 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 average 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 combinations 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 test⁶, 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, Hansen, and Russell (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 *kWhrate* and *Inc_elec* are hypothesized to have positive effects on label⁷. 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

⁶ More information on Chronbach's Alpha can be found in Cortina (1993) and Nunnally (1967).

⁷ Results of a multicollinearity test for *kWhrate* and *Inc_elec* revealed no significant collinearity.

between environmental concern and WTP for other public and private goods (Farhar and Houston 1996; Kotchen and Reiling 2000; Roe et al. 2001; Moon et al. 2002; Zarniaku 2003; Cooper, Poe, and Bateman 2004). 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 (*ACT*) are expected. Furthermore, a negative relationship between WTP for Energy Star appliances and those who exhibit strong views toward non-personal means of combating climate change (*ALT*) is hypothesized.

Respondents' ages ranged from 18 to 94 with an average of 47. Approximately 48 percent of respondents were male and just over 28 percent possessed a Bachelor's degree or higher. Thirty-three percent had incomes between \$50,000 and \$100,000 while just over 14 percent had incomes greater than \$100,000. The 2008 national average price per kWh to residential consumers was 11.3 cents⁸. In the study sample, average prices per kWh of electricity by county ranged from a low of 3.11 cents to a high of 40.88 cents with a mean of 11.58 cents. For the percentage of income spent on electricity annually, the sample mean was approximately 4.7 percent, which is greater than the 2.7 percent obtained by the Bureau of Labor Statistics in a 2008 consumer expenditures survey⁹. 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.

⁸ Obtained from http://www.eia.doe.gov/cneaf/electricity/epm/epm_sum.html

⁹ Data used can be obtained from <http://www.bls.gov/cex>

Results

Table 4 presents the results of the first two models, a fixed parameters and a random parameters logit, which analyzed product attributes only. All of the variables are significant and have the same signs in both models, with the exceptions of the configuration (*Frenchdr*), which is insignificant in both models. The results of a log likelihood ratio test, shown in Table 5, revealed that the random parameters logit (Model 2) is preferred to the fixed parameters logit (Model 1). As expected, the coefficient for *Price* was negative and highly significant, suggesting respondents were sensitive to price changes. Also as expected, the coefficient for *Label* was positive and highly significant, suggesting that the Energy Star label played an important role in determining refrigerator choice. Other positive and significant variables included *Capacity*, *Ice*, *Water* and *IandW*, showing that respondents preferred larger refrigerators and those equipped with external dispensers. Each of the three brand choices included in the analysis – *LG*, *GE*, and *Kenmore*, had negative coefficients suggesting that the base case brand, *Whirlpool*, was preferred over the other options.

Estimates for the fixed and random parameters models, which included demographic, economic, and attitudinal variables, can be seen in Table 6. The coefficients for price and label still conform to expectations in both the fixed parameters (Model 3) and the random parameters (Model 4) models. Similarly, the coefficients, signs, and significance levels for the other product attributes in these models are comparable to the results of Models 1 and 2, with the exception of the French door configuration and the water-only through-the-door dispenser. The coefficient for *Age*Label* was negative and significant suggesting that younger respondents had a greater likelihood of choosing an Energy Star labeled refrigerator than older respondents. Both *Inc50*Label* and *Inc100*Label* were not significant in either model while *Male*Label* and

*College*Label* were both significant in Model 3 but not significant in Model 4. The sign of the coefficient for *Male*Label* was positive suggesting males had a greater likelihood of choosing a labeled refrigerator than females and the sign of the coefficient for *College*Label* was negative suggesting that individuals with a college degree were less likely to choose a labeled refrigerator, both of which are contrary to our hypotheses.

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 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 refrigerators. These results are consistent with previous studies on the effect environmental concern and perceived consumer effectiveness¹⁰ have on individuals' WTP for environmentally friendly products.

The coefficient for *kWh*Label* was positive and significant in Model 3 as we had hypothesized; however, it was not significant in Model 4. The fraction of income spent on electricity annually (*Inc_Elec*) was negative and significant. While this is contrary to our hypothesis, 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

¹⁰ More information on perceived consumer effectiveness can be found in Scholder, Weiner, and Cobb-Walgreen 1991; Ellen et al. 1991; Berger & Corbin 1992.

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.

A log-likelihood ratio test, seen in Table 5, revealed that Model 4 is preferred to Model 3; however, as seen in Table 6, a number of variables, which are highly significant in Model 3, are insignificant in Model 4. Furthermore, three of the variables – *Male*Label*, *Inc_Elec*Label*, and *College*Label* had opposite signs from what were hypothesized. One possible explanation for the inconsistencies and nonconformities to expectations could be due to a gender effect. Up to this point, the Energy Star has been treated as an eco-label. However, it could be argued that the Energy Star functions as more than an eco-label, because it promises both public and private benefits to the consumer. Thus a person could be motivated to buy an Energy Star appliance solely for the private benefit of saving money or solely for the public benefit of reducing the need for energy generation or a combination of both. For example, a recent Gallup poll surveyed just over 1,000 Americans and found that 71 percent took steps to improve the energy efficiency of their homes mostly to save money, while only 26 percent did it mostly to protect the environment (Jones 2009). It has already been established by previous research that females, in general, have a greater WTP for “eco-labels” than males. So, one hypothesis could be that the public benefits associated with the label are likely to have a greater effect on females than males, while the opposite is true for the private benefits associated with the label.

In order to test this hypothesis, a three-way interaction term for *Male*kWh*Label* was created and added to the interaction variables used in Models 3 and 4. The results for this analysis are presented in Table 7. Again, a log likelihood ratio test revealed that the random parameters logit is preferred. Furthermore, a log likelihood ratio test revealed that the fixed parameters male\female split model (Model 5) was preferred to Model 3 (LLR=12.04, df 1) and that the random parameters male\female split model (Model 6), was preferred to Model 4 (LLR=4.28, df 1). The signs of the refrigerator attributes in Model 6 are identical to those in Models 2 and 4 with the exception of the water only through-the-door dispenser, which was significant in Models 2 and 6 but not in Model 4. Similarly, the significance levels were consistent across all three random-parameters logits. The coefficients for the demographic, economic, and attitudinal variables, which were not effected by the three-way interaction term, have similar signs and significance levels to those reported in Model 4.

With the inclusion of the *Male*kWh*Label* interaction term, the coefficients of the effected terms can be interpreted as:

- (i) β_{Label} represents the effect of the label on the likelihood of a female respondent choosing a labeled variety of the refrigerator;
- (ii) $\beta_{Male*Label}$ represents the difference between the effect of the label on the likelihood of choosing a labeled alternative for male as opposed to female respondents (thus the effect of the label on male respondents is now $\beta_{Male*Label} + \beta_{Label}$);
- (iii) $\beta_{kWh*Label}$ represents the effect of the interaction between kWh and label on the likelihood of a female respondent choosing a labeled alternative; and
- (iv) $\beta_{Male*kWh*Label}$ represents the difference in the effect of kWh on the likelihood of choosing a labeled alternative for male as opposed to female respondents (thus the effect of the interaction between kWh and label on males is now $\beta_{kWh*Label} + \beta_{Male*kWh*Label}$).

Thus, the positive and significant sign for the coefficient of *Male*kWh*Label* suggests that the effect of the *kWh*Label* interaction is greater for males than it is for females and this

difference appears to grow as kWh rates increase, as seen in Figure 3. The histogram in the background of Figure 3 illustrates the density of respondents' with given electricity rates and the upward sloping line represents the difference in the likelihood of choosing an Energy Star refrigerator between males and females with its 95 percent confidence intervals.

By adding the interaction term, *Male*kWh*Label*, to capture the portion of male respondents motivated to choose an Energy Star labeled refrigerator for the private economic benefit, our new hypotheses are revealed. The coefficient for *kWh*label* is no longer significant, implying that electricity rates of little effect on the effect that the label has on the likelihood of female respondents choosing a labeled refrigerator. Also, the coefficient for *Male*Label*, which was positive and significant in Model 3, is negative and significant in Model 5 (but is insignificant in Models 4 and 6) provides some limited evidence that, when controlling for the effects of private benefits, males have a lower WTP for the Energy Star labeled appliances than do females. The positive and significant signs on the coefficients for *Male*kWh*Label* in Models 5 and 6 suggest that electricity rates have a greater effect on the likelihood of a male respondent choosing a labeled refrigerator than on a female respondents choosing a labeled refrigerator.

Table 8 provides estimates of WTP for the Energy Star label across the six 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 Models 3 and 5 while equation (9) was used to calculate mean WTP for Models 4 and 6. 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).¹¹ The mean WTP for the fixed parameters and random parameters logits with attributes only (Models 1 and 2) are \$254.91 and \$290.72 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 \$237.81 and \$312.32 respectively. For the male/female split logits (Models 5 and 6), mean WTP is \$290.11 for the fixed parameters logit and \$350.54 for the random parameters logit.

By introducing demographic, economic, and attitudinal variables as interactions with *Label*, the change in mean WTP for a marginal increase or decrease in the interacted term can be estimated. For example, the positive and significant signs on the coefficients for *Male*kWh*Label* in Models 5 and 6 suggest that males are willing to pay, on average, an additional \$25.05 to \$26.73 for the Energy Star label for a 1 cent/kWh increase in electricity rates.

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. Given an average inflation rate of 3 percent per year over the next 11 years, the present value of benefits for the purchase of an Energy Star refrigerator is \$129.54, which is significantly less than our mean WTP estimates. Possible explanations for the large difference in WTP and present value of benefits include expectations of increased future energy prices, 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

¹¹ The Krinsky-Robb procedure uses random draws from the estimated asymptotic normal distribution of parameter estimates to calculate confidence intervals around WTP estimates.

string of annual savings over an 11 year period. Using the lowest WTP estimate of \$237.81 and the highest WTP estimate of \$350.54, if consumers expect no real growth in future energy prices¹², the results imply discount rates ranging from -6.62% to -11.70%. These negative discount rates suggest that consumers are not only willing to pay for the private benefits associated with the Energy Star label, but also the public benefits 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 from somewhere between \$237.81 and \$350.54 for the Energy Star qualified refrigerator. If consumers expect no real growth in future energy prices, these WTP values imply discount rates ranging from -6.62% to -11.70%. These negative discount rates provide evidence that WTP was motivated by both private (energy cost savings) and public (environmental friendliness) benefits. To 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 be true for other major home appliances. Further research into the affect Energy Star labels have on other appliances might be warranted.

The results from this study also indicate that consumer demographics and attitudes influence WTP. In particular, *PCE*Label* and *ACT*Label* were positive and significant across all four models suggesting a positive relationship between individuals with positive attitudes toward

¹² Only 20% of survey respondents expected energy prices to rise faster than inflation rate.

both the effect of consumer behavior on the ambient environment and individuals expressing the need for action concerning environmental issues, and WTP for Energy Star labeled appliances. This suggests that not only do consumers factor in electricity cost savings, but also the potential environmental benefits of the Energy Star. The fraction of income spent on electricity annually (*Inc_Elec*) was consistently negative and significant across all four models, suggesting that those who spend a smaller fraction of annual income on electricity costs have a greater WTP for Energy Star appliances. 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 variables for income (*Inc50* and *Inc100*) and education (*College*) were not statistically significant factors in determining WTP and *Age* was negative and significant in some, but not significant in others.

After a few discrepancies emerged in the random parameters logit including attitudinal, demographic, and economic interactions, a new hypothesis was formed suggesting that the private benefits of the Energy Star label have a greater effect on males' choice of refrigerators than on females' choice of refrigerators. A triple interaction term (*Male*kWh*Label*) to capture the portion of male respondents motivated to choose an Energy Star labeled refrigerator for the private economic benefit was created and found to be positive and significant in both the fixed and random parameters logits. Estimates on the effect of *Male*kWh*Label* on WTP for the Energy Star label, revealed that males are willing to pay, on average, an additional \$26.78 for the Energy Star label for a 1 cent/kWh increase in electricity rates. This result reinforces the concept that males may be more heavily motivated by the private benefits of the Energy Star label than

females. 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.

References

- Abrahamse, W., L. Steg, C. Vlek, T. Rothengatter. 2005. "A Review of Intervention Studies Aimed at Household Energy Conservation." *Journal of Environmental Psychology* 25: 273-291
- Adamowicz, W., J. Louviere, and M. Williams. 1994. "Combining Revealed and Stated Preference Methods for Valuing Environmental Amenities." *Journal of Environmental Economics and Management* 26(3):271-292.
- Aguilar, F., and R.P. Vlosky. 2007. "Consumer Willingness to Pay Price Premiums for Environmentally Certified Wood Products in the U.S." *Forest Policy and Economics* 9:1100-1112.
- Anderson, R.C., and E.C. Hansen. 2004. "Determining Consumer Preference for Ecolabeled Forest Products." *Journal of Forestry* 102(44):28-32.
- Arnot, C., P.C. Boxall, and S.B. Cash. 2006. "Do Ethical Consumers Care About Price? A Revealed Preference Analysis of Fair Trade Coffee Purchases." *Canadian Journal of Agricultural Economics* 54:555-565.
- Banerjee, A., and B.D. Solomon. 2003. "Eco-labeling for Energy Efficiency and Sustainability: a Meta-Evaluation of US Programs." *Energy Policy* 31:109-123.
- Banfi, S., M. Farsi, M. Filippini, and M. Jakob. 2008. "Willingness to Pay for Energy-Saving Measures in Residential Buildings." *Energy Economics* 30:503-516.
- Barkenbus, J. N., 2006. "Putting Energy Efficiency in a Sustainability Context: The Cold Facts About Refrigerators," *Environment* 48(8): 11-20.
- Bartels, R., D.G. Fiebig, and A. McCabe. 2004. "The Value of Using Stated Preference Methods: a Case Study in Modeling Water Heater Choices." *Mathematics and Computer in Simulation* 64:487-495.
- Berger, I. and R. Corbin. 1992. "Perceived Consumer Effectiveness and Faith in Others as Moderators of Environmentally Responsible Behaviors," *Journal of Public Policy & Marketing* 11: 79-89.
- Bjørner, T.B., L.G. Hansen, and C.S. Russell. 2004. "Environmental Labeling and Consumers' Choice – an Empirical Analysis of the Effect of the Nordic Swan." *Journal of Environmental Economics and Management* 47:411-434.
- Blend, J.R., and E.O. van Ravensway. 1999. "Measuring Consumer Demand for Ecolabeled Apples." *American Journal of Agricultural Economics* 81(5):1072-1077
- Bonini, S., and J. Oppenheim. 2008. "Helping 'Green' Products Grow." *The McKinsey Quarterly*.
- Cooper, P., G.L. Poe, and I.J. Bateman. 2004. "The Structure of Motivation for Contingent Values: a Case Study of Lake Water Quality Improvement." *Ecological Economics* 50:69-82.
- Dennis, J.M. 2007. "Description of KN Capabilities." Unpublished, Knowledge Networks, Inc.
- Dunlap, R.E., K.D. Van Liere, A.G. Mertig, and R.E. Jones. 2000. "Measuring Endorsement of the New Ecological Paradigm: A Revised NEP Scale." *Journal of Social Issues* 56(3):425-442.
- EIA, 2008. End-Use Consumption of Electricity 2001. U.S. Energy Information Administration. Washington, D.C. Available online at: <http://www.eia.doe.gov/emeu/recs/recs2001/enduse2001/enduse2001.html>.
- _____, 2008a. Electric Power Monthly December 2008. Energy Information Administration. Washington, D.C. Available online at: http://www.eia.doe.gov/cneaf/electricity/epm/epm_sum.html

- Ellen, Pam Scholder, Joshua Lyle Weiner, and Cathy Cobb-Walgreen, 1991. "The Role of Perceived Consumer Effectiveness in Motivating Environmentally Conscious Behaviors," *Journal of Public Policy & Marketing* 10: 102-17.
- Farhar, B.C., and A.H. Houston. 1996. "Willingness to pay for electricity from renewable energy." Technical Report, National Renewable Energy Lab., Golden, CO. USDOE, Washington DC.
- Freeman, A. Myrick, III, 2003. The Measurement of Environmental and Resource Values: Theory and Methods. Second Edition. Washington, D.C.: Resources for the Future.
- Gardner, G., and P. Stern. 2002. *Environmental Problems and Human Behavior*. Boston: Pearson Custom Pub.
- Hausman, J. & D. McFadden. 1984. "Tests for the Multinomial Logit Model." *Econometrica* 52(5): 1219-1240.
- Hensher, D.A. & W. H. Greene. 2003. "The Mixed Logit Model: The State of Practice." *Transportation* 30: 133-176.
- Howarth, R.B., and B. Andersson. 1993. "Market Barriers to Energy Efficiency." *Energy Economics* 15(4):262-272.
- Howarth, R.B., and A.H. Sanstad. 1995. "Discount Rates and Energy Efficiency." *Contemporary Economic Policy* 13(3):101-109.
- Jensen, K., J. Menard, B. English, P. Jakus. 2004. "An Analysis of the Residential Preferences for Green Power-The Role of Bioenergy." Paper presented at Farm Foundation Conference on Agriculture as a Producer and Consumer of Energy, 24-25 June.
- Jones, J. M. 2009. "Savings Trump Environment for Making Homes Greener". Gallup. 8 December. Available at: <http://www.gallup.com/poll/124619/savings-trumps-environment-making-homes-greener.aspx>.
- Kramer, R.A., and D. E. Mercer. 1997. "Valuing a Global Environmental Good: U.S. Residents' Willingness to Pay to Protect Tropical Rain Forests." *Land Economics* 73(2): 196-210.
- Krarup, S., and C.S. Russell ed. 2005. *Environment, Information, and Consumer Behaviour*. Edward Elgar Publishing.
- Kempton, W., J.M. Darley, and P.C. Stern. 1992. "Psychological Research for the New Energy Problems." *American Psychologist* 47(10):1213-1223.
- Kotchen, M. J., and S. D. Reiling. 2000. "Environmental Attitudes, Motivations, and Contingent Valuation of Nonuse Values: A Case Study Involving Endangered Species." *Ecological Economics* 32: 93-107.
- Krinsky, I., and A. Robb. 1991. "Three methods for calculating the statistical properties of elasticities: A comparison." *Empirical Economics* 2(16): 199-209.
- Lavin, F. and W. Hanemann. Taste indicators and heterogeneous revealed preferences for congestion in recreation demand, *UCB CUDARE Working Papers Number 1075*, Department of Agricultural & Resource Economics, University of California, Berkeley (2008).
- Loureiro, M.L., J.J. McCluskey, and R.C. Mittelhammer. 2002. "Will Consumers Pay a Premium for Eco-Labeled Apples?" *The Journal of Consumer Affairs* 36(2):203-219.
- McFadden, D. Conditional logit analysis of qualitative choice behavior, P. Zarembka, (ed), *Frontiers in Econometrics*, New York: Academic Press (1973).
- Minton, A.P, and R.L. Rose. 1997. "The Effects of Environmental Concern on Environmentally Friendly Consumer Behavior: An Exploratory Study." *Journal of Business Research* 40:37-48.

- Moon, W., and S.K. Balasubramanian. 2001. "Public Preceptions and Willingness to Pay a Premium for Non-GM Foods in the US and UK." *AgBioForum* 4(3&4):221-231.
- Moon, W., W. J. Florkowski, B. Brückner, and I. Schonhof. 2002. "Willingness to Pay for Environmental Practices: Implications for Eco-Labeling." *Land Economics* 78(1): 88-102.
- Ojea, E., and M. L. Loureiro. 2007. "Altruistic, Egoistic and Biospheric Values in Willingness to Pay (WTP) for Wildlife." *Ecological Economics* 63: 807-814.
- Revelt, D., and K. Train. 1998. "Mixed Logit with Repeated Choices: Households' Choices of Appliance Efficiency Level." *The Review of Economics and Statistics* 80(4):647-657.
- Roe, B., M.F. Teisl, A. Levy, and M. Russell. 2001. "US Consumers' Willingness to Pay for Green Electricity." *Energy Policy* 29:917-925.
- Sammer, K., & R. Wüstenhagen. 2006. "The Influence of Eco-Labeling on Consumer Behavior – Results of a Discrete Choice Analysis for Washing Machines." *Business Strategy and the Environment*. 15: 185-199.
- Scholder, E., J. Weiner, and C. Cobb-Walgreen. 1991. "The Role of Perceived Consumer Effectiveness in Motivating Environmentally Conscious Behaviors," *Journal of Public Policy & Marketing* 10: 102-17.
- Shen, J. & T. Saijo. 2009. "Does an Energy Efficiency Label alter Consumers' Purchasing Decisions? A Latent Class Approach Based on a Stated Choice Experiment in Shanghai." *Journal of Environmental Management* 90: 3561-3573.
- Srinivasan, A.K., and G.C. Bloomquist. 2009. "Ecolabeled Paper Towels: Consumer Valuation and Expenditure Analysis." *Journal of Environmental Management* 90:314-330.
- Steckel, J.H., W.R. Vanhonacker. 1988. "A Heterogeneous Conditional Logit Model of Choice." *Journal of Business & Economics Statistics* 6(30): 391-398.
- Train K. 1999. "Halton Sequences for Mixed Logit" *Manuscript, Department of Economics, University of Berkeley*.
- Train K. *Discrete Choice Methods with Simulation*, New York: Cambridge University Press (2003).
- U.S. Environmental Protection Agency (USEPA). 2003. *Energy Star – The Power To Protect The Environment Through Energy Efficiency*. Office of Air and Radiation, Climate Protection Partnership Division. Washington DC, July.
- _____. 2007. *Energy Star and Other Climate Protection Partnerships: 2006 Annual Report*. Office of Air and Radiation, Climate Protection Partnership Division. Washington DC, September.
- _____. 2008. *National Awareness of ENERGY STAR® for 2007: Analysis of 2007 CEE Household Survey*. Office of Air and Radiation, Climate Protection Partnerships Division. Washington DC.
- Wandel, M., and A. Bugge. 1997. "Environmental Concern in Consumer Evaluation of Food Quality." *Food Quality and Preference* 8(1):19-26.
- Weil, W., and J.E. McMahon. 2003. "Governments Should Implement Energy-Efficient Standards and Labels – Cautiously." *Energy Policy* 31: 1403-1415.
- Zarnikau, J. 2003. "Consumer Demand for 'Green Power' and Energy Efficiency." *Energy Policy* 31:1661-1672.
- Zimmer, M.R., T.F. Stafford, and M.R. Stafford. 1994. "Green Issues: Dimensions of Environmental Concern." *Journal of Business Research* 30:63-74.

Appendix

 All refrigerators sold in the US are required to meet federal standards limiting their energy consumption. ENERGY STAR refrigerators consume at least 20% less energy than the federal standard. An ENERGY STAR refrigerator will save a household in your region of the country about \$14 per year in electricity costs over a refrigerator that only meets the federal standard. By consuming less electricity, ENERGY STAR refrigerators also reduce the emission of greenhouse gases associated with energy production. Studies suggest that greenhouse gases contribute to global climate change. Would you like more information on ENERGY STAR or are you ready to proceed with the survey? Select one answer only ☐ Ready to proceed ☒ Would like more information	ENERGY STAR is a voluntary labeling program, jointly administered by the U.S. Environmental Protection Agency and the U.S. Department of Energy to identify and promote energy-efficient products to reduce greenhouse gas emissions. ENERGY STAR, which began in 1992 with a label for computers, now applies to over 60 product categories for the home and office. Products awarded the ENERGY STAR deliver the same or better performance as comparable models while using less energy and reducing electricity costs. Next
--	---

Figure 1: Energy Star Information Screen and “More Information” Screen

If you needed to buy a refrigerator and these were your only options, 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	NONE: I wouldn't choose any of these ☐
Price	\$929	\$1,029	\$929	
Brand	General Electric	Kenmore	LG	
Configuration	Side-by-side	French door	Side-by-side	
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

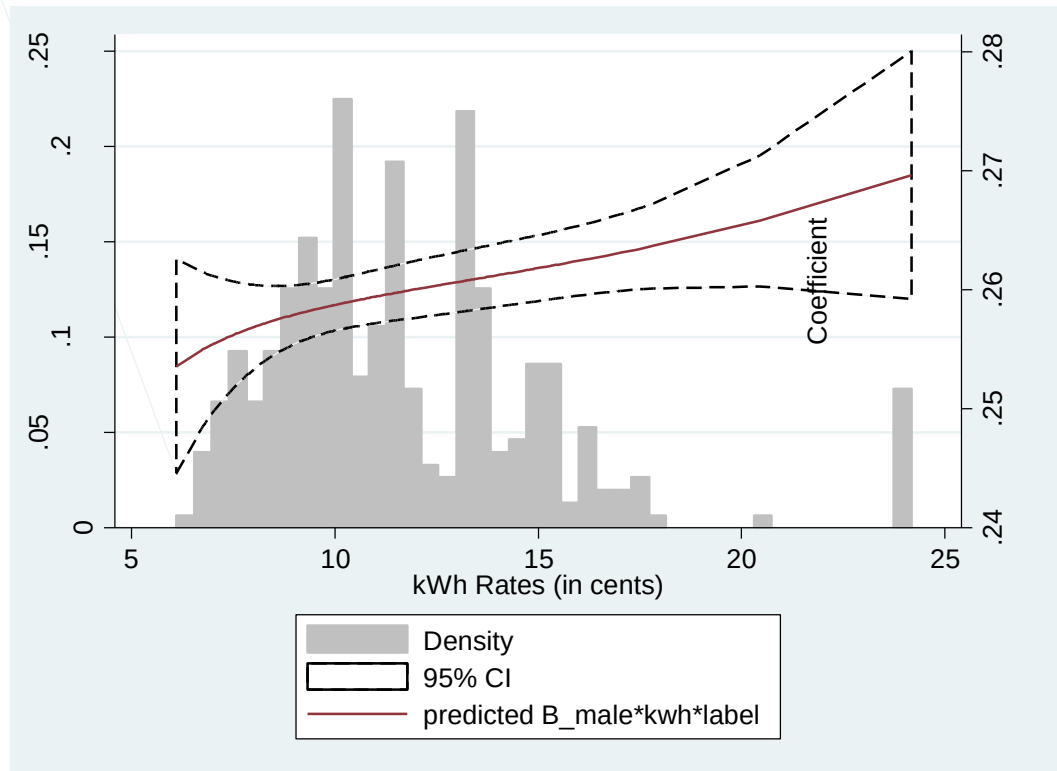


Figure 3. Male Responsiveness to Energy Star Label Relative to Female Responsiveness Over the Range of County-Level Average Electricity Rates

Table 2. Variable Names, Definitions, Hypothesized Signs, and Sample Means

Variable Name	Definition	Hypothesized Sign	Sample Means ^a
<u>Dependent Variable</u>			
<i>Chosen</i>	1 if the alternative is chosen, 0 otherwise	NA	0.3333
<u>Explanatory Product Attribute Variables</u>			
<i>Price</i>	\$879, \$929, \$979, or \$1,029	+	954.149
<i>Label</i>	1 if Energy Star qualified, 0 if not	+	0.5166
<i>Capacity</i>	23.78, 24.52, 25.34, 25.83 cubic feet	+	24.8447
<i>Frenchdr</i>	1 if French door style, 0 if side-by-side	+	0.5155
<u>Brand Choices (Whirlpool as base case)</u>			
<i>LG</i>	1 if LG brand, 0 otherwise	-	0.2682
<i>GE</i>	1 if GE brand, 0 otherwise	-	0.2470
<i>Kenmore</i>	1 if Kenmore brand, 0 otherwise	+	0.2401
<u>External Dispenser Type (No ice or water as base case)</u>			
<i>Ice</i>	1 if equipped with external ice dispenser only, 0 otherwise	+	0.2656
<i>Water</i>	1 if equipped with external water dispenser only, 0 otherwise	+	0.2387
<i>IandW</i>	1 if equipped with external ice & water dispenser, 0 otherwise	+	0.2519
<u>Demographic, Economic, and Attitudinal Explanatory Variables</u>			
<i>Age</i>	Age of respondent in years	-	45.7405
<i>Male</i>	1 if male, 0 otherwise	-	0.4337
<i>College</i>	1 if Bachelor's degree or higher, 0 otherwise	+	0.3075
<u>Income Levels (Income less than \$50,000 as base case)</u>			
<i>Inc50</i>	1 if household income is between \$50,000 - \$100,000, 0 otherwise	+	0.3555
<i>Inc100</i>	1 if household income is \$100,000 or greater, 0 otherwise	+	0.1454
<i>kWhrate</i>	Average price of electricity by county of residence (cents per kWh)	+	11.8209
<i>Inc_Elec</i>	Average annual electricity costs as a percentage of annual household income	+	0.0459
<i>ALT</i>	Factor analysis score for alternative means of combating global climate change	-	0.0150
<i>ACT</i>	Factor analysis score for desire of action to address climate issues	+	0.0302
<i>PCE</i>	Factor analysis score for perceived consumer effectiveness	+	0.0502

^aThe means are calculated using the sample weights.

Table 3. 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 4. Rotated Factor Loadings with Reliability Score

	Factor Weights
<i>Perceived Consumer Effectiveness (PCE)</i>	
Chronbach's $\alpha=0.79$	
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
<i>Alternative Measures (ALT)</i>	
Chronbach's $\alpha=0.72$	
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
<i>Need for Action (ACT)</i>	
Chronbach's $\alpha=0.68$	
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 5. Attribute Only Model Estimates of WTP for Energy Star Labeled Refrigerators

Variable	Model 1: <u>Fixed Parameters</u>			Model 2: <u>Random Parameters</u>		
	Est. Coeff.	Z		Mean of Est. Coeff.	Z	
<i>Price</i>	-0.0042	-8.46	***	-0.0082	-5.42	***
<i>Label</i>	1.0650	19.31	***	2.3974	9.33	***
<i>Capacity</i>	0.1136	3.30	***	0.2419	3.60	***
<i>Frenchdr</i>	-0.0242	-0.45		0.1704	0.88	
<i>LG</i>	-0.2806	-3.60	***	-0.5082	-4.19	***
<i>GE</i>	-0.1432	-1.87	**	-0.3072	-2.38	***
<i>Kenmore</i>	-0.2161	-2.82	***	-0.3261	-2.58	***
<i>Ice</i>	0.3155	4.15	***	0.6172	4.15	***
<i>Water</i>	0.2933	3.64	***	0.4809	2.93	***
<i>IandW</i>	1.0286	13.09	***	1.8451	7.43	***
<u>Starndard Deviations</u>						
<i>Label</i>				1.9981	11.68	***
<i>Capacity</i>				-0.4365	-4.81	***
<i>Frenchdr</i>				2.7670	8.11	***
<i>LG</i>				-0.6476	-2.91	***
<i>GE</i>				-0.7036	-4.07	***
<i>Kenmore</i>				0.7622	3.97	***
<i>Ice</i>				1.0600	6.04	***
<i>Water</i>				-0.9338	-2.73	***
<i>IandW</i>				2.2822	7.44	***
Log likelihood	-2938.53			-2383.38		

*** denotes significance of the coefficient from zero at the 95% confidence level, ** denotes significance at the 90% confidence level.

Table 6. Log-Likelihood Ratios Comparing Fixed and Random Parameters Logits

Model Number	Log-likelihood	LLR Statistics Comparing Fixed and Random Parameters Models ^c			df
<u>Attribute Only Models</u>					
1	-2938.53	1,110.30	***	9	
2	-2383.38				
<u>Models Including Demographic, Economic, and Attitudinal Variables</u>					
3	-2185.69	875.98		9	
4	-1747.7				
<u>Split Male\Female Models</u>					
5	-2179.67	868.22	***	9	
6	-1745.56				

^c The log likelihood ratio test (LLR) is calculated as -2(log likelihood restricted-log likelihood unrestricted).

Table 7. Attribute, Demographic, and Attitudinal Model Estimates of WTP for Energy Star Labeled Refrigerators

Variable	Model 3: Fixed Parameters			Model 4: Random Parameters		
	Est. Coeff.	Z		Mean of Est. Coeff.	Z	
<i>Price</i>	-0.0051	-9.27	***	-0.0097	-5.13	***
<i>Label</i>	1.1928	3.65	***	3.4444	2.46	***
<i>Capacity</i>	0.1263	3.22	***	0.2413	3.15	***
<i>Frenchdr</i>	0.1238	2.00	***	0.2801	0.90	
<i>LG</i>	-0.2853	-3.37	***	-0.5727	-3.91	***
<i>GE</i>	-0.1742	-2.02	***	-0.3855	-2.67	***
<i>Kenmore</i>	-0.2300	-2.74	***	-0.4370	-2.93	***
<i>Ice</i>	0.3633	4.26	***	0.7035	3.85	***
<i>Water</i>	0.2104	2.31	***	0.2508	1.52	
<i>IandW</i>	0.9689	10.93	***	1.8600	4.93	***
<i>Age*Label</i>	-0.0152	-3.81	***	-0.0331	-2.30	***
<i>Inc50*Label</i>	0.0160	0.11		0.2817	0.50	
<i>Inc100*Label</i>	0.0780	0.39		0.0227	0.03	
<i>Male*Label</i>	0.5217	4.19	***	0.6524	0.96	
<i>College*Label</i>	-0.2592	-1.83	**	-0.1819	-0.36	
<i>PCE*Label</i>	0.2692	3.40	***	0.6053	1.78	**
<i>ACT*Label</i>	0.3218	2.83	***	0.9946	2.24	***
<i>ALT*Label</i>	-0.1226	-1.15		-0.2953	-0.80	
<i>kWh*Label</i>	0.0703	3.53	***	0.0866	1.14	
<i>Inc_Elec*Label</i>	-5.3256	-4.33	***	-13.198	-3.38	***
<u>Standard Deviations</u>						
<i>Label</i>				1.9629	9.94	***
<i>Capacity</i>				0.4583	4.24	***
<i>Frenchdr</i>				2.8261	7.49	***
<i>LG</i>				-0.5852	-2.13	***
<i>GE</i>				-0.4449	-1.47	*
<i>Kenmore</i>				0.7859	4.11	***
<i>Ice</i>				1.0938	4.91	***
<i>Water</i>				-0.1102	-0.09	
<i>IandW</i>				2.2370	7.64	***
Log Likelihood		-2185.7			-1747.7	

*** denotes significance of the coefficient from zero at the 95% confidence level, ** denotes significance at the 90% confidence level, and * denotes 85% confidence level.

Table 8. Male/Female Split Model Estimates of WTP for Energy Star Labeled Refrigerators

Variable	Model 5: <u>Fixed Parameters</u>			Model 6: <u>Random Parameters</u>		
	Est. Coeff.	Z		Mean of Est. Coeff.	Z	
<i>Price</i>	-0.0051	-9.22	***	-0.0098	-4.98	***
<i>Label</i>	1.7171	4.50	***	4.3000	2.27	***
<i>Capacity</i>	0.1264	3.21	***	0.2598	3.28	***
<i>Frenchdr</i>	0.1274	2.05	***	0.2514	0.76	
<i>LG</i>	-0.2844	-3.37	***	-0.5440	-3.62	***
<i>GE</i>	-0.1707	-1.98	***	-0.3834	-2.62	***
<i>Kenmore</i>	-0.2320	-2.75	***	-0.4601	-3.19	***
<i>Ice</i>	0.3617	4.24	***	0.7028	3.56	***
<i>Water</i>	0.2073	2.31	***	0.2680	1.61	*
<i>IandW</i>	0.9727	10.95	***	1.8383	4.44	***
<i>Age*Label</i>	-0.0146	-3.69	***	0.0267	-1.38	
<i>Inc50*Label</i>	-0.0041	-0.03		0.8671	0.05	
<i>Inc100*Label</i>	0.1029	0.51		0.9681	0.33	
<i>Male*Label</i>	-0.9344	-2.08	***	1.7492	-1.41	
<i>College*Label</i>	-0.2810	-1.96	***	0.5671	-0.73	
<i>PCE*Label</i>	0.2704	3.39	***	0.4828	1.50	*
<i>ACT*Label</i>	0.3652	3.16	***	0.5860	1.69	**
<i>ALT*Label</i>	-0.1617	-1.49	*	0.6033	-0.88	
<i>kWh*Label</i>	0.0241	0.96		0.0899	0.35	
<i>Inc_Elec*Label</i>	-5.5193	-4.23	***	6.9526	-1.70	**
<i>Male*kWh*Label</i>	0.1283	3.29	***	0.1408	1.84	**
<u>Standard Deviations</u>						
<i>Label</i>				2.0646	5.77	***
<i>Capacity</i>				0.4594	3.95	***
<i>Frenchdr</i>				2.9425	6.59	***
<i>LG</i>				0.5167	1.90	***
<i>GE</i>				-0.4970	-2.41	***
<i>Kenmore</i>				0.8252	3.45	***
<i>Ice</i>				1.0799	4.99	***
<i>Water</i>				-0.2067	-0.57	
<i>IandW</i>				2.2529	6.05	***
Log Likelihood		-2179.7			-1745.6	

*** denotes significance of the coefficient from zero at the 95% confidence level, ** denotes significance at the 90% confidence level, and * denotes 85% confidence level.

Table 9. Estimates of WTP for Energy Star Labeled Refrigerators

Model Number	Variable	WTP (\$)	Std. Error (\$)	
<u>Attribute Only Models</u>				
1	Label	254.91	64.22	***
2	Label	290.72	130.97	***
<u>Models Including Demographic, Economic, and Attitudinal Variables</u>				
3	Label	237.81	81.30	***
4	Label	312.32	193.04	*
<u>Split Male\Female Models</u>				
5	Label	290.11	96.99	***
6	Label	350.54	224.46	*

*** denotes significance at the 95% confidence level and * denotes significance at the 85% level

Part 3: Willingness to Pay for Appliances Produced With Green Power

Abstract

The U.S. Environmental Protection Agency's Green Power Partnership (GPP), has over 1,200 members purchasing nearly 18 billion kilowatt hours of green power annually. For this research, the GPP program was presented in a survey as a form of energy label on household appliances. The objective of this study is to ascertain willingness-to-pay (WTP) for a label signifying to consumers that the product they are purchasing was produced, or partially produced, using green power and how WTP would be affected by other characteristics of the product as well as consumers' demographic characteristics and attitudes about environmental issues. The data were obtained from a survey conducted in March and April of 2009 via an online research panel, which was constructed to be representative of the U.S. population. Analysis of the data was conducted using conditional logit regression models with fixed parameters and mixed logit regression models with random parameters. Results revealed that consumers, on average, have a willingness to pay ranging from \$48.52 to \$70.95 for the GPP label on refrigerators. Attitudes toward environmental issues and the region of the country in which respondents' live were significant factors influencing WTP for the GPP label. Furthermore, using life-cycle energy estimates for refrigerators, these results suggest that, on average, consumers are willing to pay more for the GPP label on refrigerators than the additional costs incurred by the manufacturers to use green power instead of conventional power. These results provide evidence that as labeled alternatives continue to penetrate the market, there is promising potential for a future green power labeling program on household appliances.

Introduction

Reducing the use of fossil fuels is arguably one of the most important and most talked about initiatives for many global leaders. The burning of fossil fuels to produce energy also produces an abundance of carbon-dioxide, which is considered to be a leading contributor to global climate change. Carbon-dioxide and as many other gasses created and emitted through human activity that trap heat in the atmosphere are often referred to as greenhouse gasses (GHGs). Globally, fossil fuels, especially petroleum and coal, account for more than 63 percent of energy production, while renewable sources such as wind, solar, geothermal, and wood and other waste account for only 1 percent (EIA 2008a). In the United States, since 1978 total energy consumption has been growing at a rate of 0.72 percent annually while energy production from non-hydro renewables (NHR) has been growing at a rate of 2.82 percent annually (Schmalensee 2009). In part, the relatively large growth rate for NHR can be attributed to a rise in voluntary markets for renewable energy, or “green energy,” across the US in recent years (Swezey, Aabakken, and Bird 2007).

In the late 1990s and early 2000s, green power programs targeted residential consumers to entice those who were willing to pay a small premium on their electric bill each month to purchase energy specifically generated from renewable sources such as wind, solar, or biomass. More recently, growth in green energy sales accrued from actions taken by large corporations and government institutions¹³ (Bird, Holt, and Carroll 2008). These institutions and over 1,200 others are part of a program initiated by the US Environmental Protection Agency (USEPA) in 2001 called the Green Power Partnership (GPP). The focus of this program is to encourage the purchase of green power as a way to reduce the environmental impacts associated with energy

¹³ A complete list of the top purchasers of green power can be found at <http://www.epa.gov/grnpower/toplists/index.htm>

use (USEPA 2009). Currently, USEPA reports the partners are purchasing nearly 18 billion kilowatt hours (kWh) of green power annually (USEPA 2010). The top 25 participants in the GPP, which account for about 60% of the green power commitments by Green Power Partners, use about 6.24 billion kWh of green power. This is about 6.6% of net generation of non-hydro renewable electricity in the U.S. (95 billion kWh in 2005) and less than 1% of total net electrical generation.

Another trend in energy markets has been the introduction of energy labels that tell potential purchasers of appliances something about the energy consumption characteristics of the alternatives they are examining. Of the two major labeling types, one, the “seal-of-approval,” promises that certain standards have been met - for example that a particular appliance model uses at least X% less energy to do the same job as does the typical version, or in the case of green power, certify to the consumer that the green power they are purchasing for a premium is in fact green power. Examples of this type of label are the Energy Star and the Green-e labels. “Report card” labels, on the other hand, like the EnergyGuide provide comparative test data on energy consumption for that specific product and typically compare its energy consumption to products of a similar nature.

While the majority of the energy labels in the marketplace today are focused on energy efficiency, there are a few beginning to emerge for green power. One such program, which has been around since 2001, is the Green-e (Banerjee and Solomon 2003). This is a voluntary labeling program initiated and operated by the Center for Resource Solutions (CRS). The purpose is to provide third party assurance that electricity being marketed as “green” power for a premium price by utility providers is in fact being produced from renewable energy sources. This label is different from others, because is that it promotes sustainability through renewable energy

resource development, while most energy labels promote energy savings through energy efficiency. More recently, the CRS has created what is called the Green-e Marketplace. This program, similar to the GPP, encourages companies to purchase certain amounts of green power and in return these companies are allowed to display the Green-e logo (CRS 2010).

For the purpose of the research reported in this paper, we have modified the actual GPP program and presented it to survey respondents as a form of energy label on household appliances. Our interest is in examining how prospective consumers would react to a label signifying that the product they are purchasing was produced, or partially produced, using green power and how their reactions would be affected by other characteristics of the product as well as by their own characteristics and attitudes about environmental issues. This line of inquiry is potentially of interest to marketers and government agencies who might wish to design and test a new type of energy label implying purely public attributes.

Previous Studies

Estimates are that nearly half of the population has the option of purchasing retail green power from a local utility provider, and everyone has the ability to purchase renewable energy credits (RECs) (Bird, Kreycik, and Friedman 2009). Actual participation in green power programs, on the other hand, is quite low. Average participation rates among utility green pricing programs has a median value of 1.2 percent with top performing programs achieving rates ranging from 5 percent to 21 percent. Overall, retail sales of renewable energy in voluntary purchase markets account for only 0.6% of total U.S. electricity sales (Bird, Kreycik, and Friedman 2009). The prices of green power for residential customers in utility programs can range from -1.0¢/kWh (a savings compared to standard service) to 8.8¢/kWh above standard electricity rates, with an average premium of about 1.8¢/kWh in 2008 (Bird, Kreycik, and

Friedman 2009). These premiums translate into an average consumer spending of about \$5.40 per month above standard electricity rates for green power through utility programs.

There are a number of analyses of consumer perceptions of the provision of energy from renewable sources (e.g., Farhar and Houston 1996; Byrnes, Jones and Goodman 1999; Holt and Wiser 1999; Wiser, Bolinger, and Holt 2000; Roe, Teisl, Levy, and Russell 2001; Clark, Kotchen, and Moore 2003; Rowlands, Parker and Scott 2002; Rowlands, Scott and Parker 2003; Zarnikau 2003; Harmon and Starrs 2004; Kotchen and Moore 2004; Kotchen and Moore 2007; Whitehead and Cherry 2007). The results have suggested a positive willingness to pay for green power, and several of these studies have revealed a preference for solar and wind over other types of renewable energy.

Several of the above studies examined the effects demographics and behaviors have on stated WTP for green power, and/or actual participation in green pricing programs. The findings suggest:

- that education has positive impacts on consumers' stated WTP for green power (Roe, Teisl, Levy, and Russell 2001; Rowlands, Scott, and Parker 2003; Zarnikau 2003);
- that income is positively related to WTP for green power and actual participation in green pricing programs (Roe, Teisl, Levy, and Russell 2001; Clark, Kotchen, and Moore 2003; Rowlands, Scott, and Parker 2003; Zarnikau 2003; Kotchen and Moore 2004; Whitehead and Cherry 2007); and
- that environmental behaviors, such as membership in environmental organizations, or stated concerns about environmental issues have a positive influence on consumers' WTP for green power (Roe, Teisl, Levy, and Russell 2001; Kotchen and Moore 2004; Rowlands, Scott, and Parker 2003).

In addition, Wiser, Fowlie, and Holt (2001) examined non-residential demand for green power, including that by businesses. Their results suggested that organizational values and civic responsibility were more important motivators than perceived green marketing opportunities in the decision to make green power purchases. Thus, only about 10 percent of the respondents had used the fact that they purchased green power in their point-of-sale marketing.

Borchers, Duke, and Parsons (2007) conducted a contingent choice study in New Castle County, Delaware to elicit consumers' WTP for green power by generation source and as a generic label. Furthermore, they estimated welfare effects based on whether participation in a green power program was voluntary or mandatory. The variables associated with green power were cost, quantity of alternative energy supplied, and source (solar, wind, biomass, farm methane, or simply "green"). Demographics included were age, income, monthly electric bill, stated environmental concern, and gender. Results showed that respondents over 50 or less than 30 years of age preferred green power over the status quo as did respondents who have greater stated concern for the environment. They also found significant differences in stated WTP depending on whether the green pricing program was voluntary or mandatory. For voluntary programs, mean WTP for generic green energy is estimated at \$14.77 per month while with a mandatory program mean WTP drops to \$8.44 per month with many consumers expressing negative WTP values.

A 2001 study by Roe et al. looked at demand and willingness to pay for deregulated residential electricity services that promised more favorable environmental outcomes. They administered a conjoint analysis survey to over 1,000 individuals across eight cities. The survey revealed a range of median stated WTP values across all survey respondents from \$0.38 - \$5.66 per year for a one percent decrease in air emissions. Furthermore, their analysis showed that

higher levels of education and income, and affiliation with an environmental organization are generally associated with higher levels of stated WTP for a one percent reduction in air emissions. The effect of respondents' place of residence on WTP varied depending on the environmental outcome. For example, for a one percent decrease in emissions, respondents in the Midwest, Southeast, and Northeast generally have a higher WTP than respondents in the Northwest. On the other hand, for a one percent increase in renewable fuel and a one percent decrease in emissions, respondents in the Northwest generally have a higher WTP than respondents in the Midwest, Southeast, and Northeast. A hedonic price analysis was also conducted on a number of green electricity programs. Results from that analysis revealed that green pricing programs acquiring the Green-e certification often charge higher annual premiums than non-certified green pricing programs. On average, the Green-e certification increases green pricing premiums by \$60.86 per year and were attributed, in part, to the 'name brand' status of the Green-e program (Roe et al. 2001).

Survey Methods and Data

The data for this study 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 essential demographic information is maintained for each panel member. More information on the online research panel and the recruitment methodologies can be found in Dennis (2007).

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 338 completed the version relevant to this analysis. A survey weight designed to compensate for non-response to the survey was calculated by comparing respondent demographics with benchmark demographics from the Current 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 were adjusted with these weights.

A conjoint analysis choice experiment was employed in the survey to gather data from which could be inferred consumer WTP for a refrigerator produced by a company that is a Green Power Partner. 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, permitted the construction of an instrument that had the look and feel of a product design exercise and not an environmental-information-gathering exercise. The choice of a refrigerator as the choice product was based on a number of factors, including its high energy consumption, its pervasiveness, and its apparently high relevance to buyers for this appliance. It is estimated that refrigerators are responsible for nearly 14 percent of the electricity consumed in US households

(EIA 2008) and that nearly 99 percent of households contain at least one refrigerator (Barkenbus, 2006).

The survey began with general background questions on the respondents' home and refrigerator ownership. Following these questions, 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 4 in the Appendix, provided general information about the Green Power Partnership program and its aims to reduce GHG emissions by promoting energy production using renewable prime movers. Lastly, a screen provided information about internal capacity for refrigerators. Each of the information screens consisted of a three or four 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 or select a "none" option if they would not choose any of the three. 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.

The refrigerator attributes varied in the choice experiments were price, internal capacity, whether the refrigerator had an external ice and water dispenser, brand, configuration, and whether or not the company was a Green Power Partner. 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, Whirlpool, and Kenmore¹⁴. 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 company producing the refrigerator is a Green Power Partner, was indicated by simple “Yes” or “No” identification. An example of one of the choice tasks is provided in Figure 5. 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.

Each of the 388 respondents to the survey was asked to complete 14 choice tasks yielding a possible 4,732 individual choice tasks, of which 4,721 were obtained. Given that each choice task contained 3 different alternatives and a “none” option, there were a possible 18,928 individual observations (18,884 were obtained). Responses to the survey questions were supplemented with demographic information from the panel member profile maintained by KN.

Economic Model

Choice-based modeling is based on the theory of utility maximization. It can also 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. An additional assumption is that the utility received from a particular alternative is related to a set of observable attributes associated with the choice. Thus, the utility individual n receives from alternative j can be expressed as:

¹⁴ The internal capacity options and brand options were chosen based on market popularity.

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

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 1973), the probability individual n chooses alternative j can be expressed as

$$(2) \Pi_{nj} = \frac{\exp(\beta' X_{nj})}{\sum_{j=1}^J \exp(\beta' X_{nj})}.$$

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

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

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, Wilfried, and Vanhonacker (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

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

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):

$$(5) \quad WTP_k = -\frac{\bar{\beta}_k}{\beta_P}.$$

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

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

where Y_n are demographic characteristics and Z_n are attitudinal variables and γ and φ are their associated parameters. The demographic and attitudinal variables enter the model as interactions with the product attributes. 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:

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

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:

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

where, as in equation (5), Y_n are demographic characteristics and Z_n are attitudinal variables 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):

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

Four models are used in our analysis - two fixed parameters 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 GPP 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 GPP label variable. 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, while only non-price attributes have random coefficients.

The product attributes, demographic characteristics, and attitudinal variable definitions, hypothesized signs, and sample means are presented in Table 10 in the Appendix. The refrigerator attributes are *Price*, presence of absence of GPP label (*Label*), *Capacity*, brand (*LG*, *GE*, and *Kenmore*, with *Whirlpool* as the base case), configuration of French door (*Frenchdr*) with Side-by-Side (*sbs*) as the base case, and external dispenser type (*Ice* only, *Water* only, and ice and water (*IandW*), with no dispenser (*No_iw*) as the base case). In the random parameters models, the price coefficient is specified to be fixed so that estimates of WTP for non-price attributes are normally distributed (Train 1999). The demographic characteristics included in the analysis are gender (*Female*), whether household income was between \$50,000 and \$100,000 (*Inc50*) or greater than \$100,000 (*Inc100*), whether the respondent was over or under 45 years of age (*Age45*), and whether the respondent possessed a Bachelor's degree or higher (*College*).

Dummy variables for the region of the country in which the respondent resided (*Northeast*, *Midwest*, *South*, and *West* as base case) were also included. Lastly, a variable was created to reflect the percentage of energy produced from NHR in each respondent's state of residence¹⁵.

Several Likert scale questions were used to measure respondents' attitudes toward a variety of environmental issues such as global climate change, the use of green energy, and perceived consumer effectiveness. A list of these questions can be seen in Table 11. Since the exact combination of questions was not derived from previous research, there are 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 seven of the twelve items. This reduced set was then analyzed again and the results are presented in Table 12. This analysis produced weights on the seven responses defining two variables, one capturing perception of consumer effectiveness in affecting product design and manufacturing and the ambient environment (*Effect*); and the other reflecting views of the reality, severity, and need for action against global climate change (*Climate*). A Chronbach's alpha test¹⁶, which tests the reliability and acceptability of indexed variables, was also conducted for both variables and is presented in Table 3 along with their loadings. Furthermore, a dummy variable (*Green*) was created to represent those individuals who believed producing refrigerators from green power would lead to the greatest reduction in GHG emission compared to producing more efficient refrigerators or using less energy to produce refrigerators.

¹⁵ Data was from 2003 and can be obtained at:
http://www.eia.doe.gov/cneaf/solar/renewables/page/rea_data/tablec1.html

¹⁶ More information on Chronbach's Alpha can be found in Cortina (1993) and Nunnally (1967).

Based on prior research on green power, WTP is expected to be positive for the GPP label (Farhar and Houston 1996; Byrnes, Jones and Goodman 1999; Holt and Wiser 1999; Wiser, Bolinger, and Holt 2000; Roe, Teisl, Levy, and Russell 2001; Clark, Kotchen, and Moore 2003; Rowlands, Parker and Scott 2002; Rowlands, Scott and Parker 2003; Zarnikau 2003; Harmon and Starrs 2004; Kotchen and Moore 2004; Kotchen and Moore 2007; Whitehead and Cherry 2007). Furthermore, females, individuals' with higher disposable incomes, and those with higher levels of education are expected to have a greater WTP for the GPP label. Based on findings from Roe et al. (2001) we expect that respondents with residence in the West will have a greater WTP for the GPP label than respondents residing in the Midwest, Northeast, and South. Lastly, we expect that respondents residing in states with a greater percentage of power being produced from NHR will have a greater WTP for the GPP label. The other attributes associated with refrigerators and their hypothesized signs are listed in Table 10.

While the relationship between environmental concern and WTP for household appliances has not, to our knowledge, been investigated, a number of other studies have analyzed the relationship between environmental concern and WTP for other public and private goods (Farhar and Houston 1996; Kotchen and Reiling 2000; Roe et al. 2001; Moon et al. 2002; Zarniaku 2003; Cooper, Poe, and Bateman 2004). In general, the results of these studies have shown a positive relationship between environmental concern and WTP for products with positive environmental externalities. Thus, we expect a positive relationship between WTP and those with a higher degree of percieved of consumer effectiveness in affecting product design and manufacturing and the ambient environment (*Effect*) and those stating strong views toward the reality, severity, and need for action against global climate change (*Climate*).

The means of the independent (explanatory) variables are presented in Table 10. Approximately 53 percent of respondents were female and similarly, 53 percent of respondents possessed a Bachelor's degree or higher. Thirty-six percent had incomes between \$50,000 and \$100,000 while just under 12 percent had incomes greater than \$100,000. Age was split down the middle with a little over 52 percent being 45 or older. Lastly, approximately 19 percent live in the Northeast, 22 percent in the Midwest, 37 percent in the South, and 21 percent in the West.

Results

The results of a log-likelihood ratio test revealed that the random parameters logits were preferred to the conditional logits for both the attributes-only models (Models 1 and 3) and the models with interactions between individual characteristics and the GPP label (Models 2 and 4). The results for those tests can be seen in Table 13. Furthermore, comparison of the log-likelihood functions indicated that the inclusion of demographic and attitudinal variables were significant in both the fixed parameters (LLR=464.06, df 13) and the random parameters logits (LLR=259, df 13)

Table 14 lists the estimated coefficients and significance levels for all variables across the four models. As expected, the coefficient for *Price* was negative and highly significant across all models, suggesting respondents were sensitive to price changes. The coefficient for *Label* was positive and significant across all four models suggesting that respondents were more likely to choose a refrigerator that had been awarded the GPP label. Other positive and significant variables included *Capacity*, *Ice*, *Water* and *IandW*, showing that respondents preferred larger refrigerators and those equipped with external dispensers. The only brand name that was significant was *LG* and it consistently had a negative coefficient, indicating consumers preferred the base case, *Whirlpool*, to *LG*.

The coefficients for *Age45*Label*, *Inc50*Label*, and *Inc100*Label* were not significant in either the fixed or random parameters logits; however, *College*Label* was negative and significant in the fixed parameters logit. *Female*Label* was not significant in the fixed parameters logit, but positive and significant in the random parameters logit, suggesting that females have a greater likelihood of choosing GPP labeled refrigerator than males do. All three regions included in the analysis (*Northeast*, *Midwest*, and *South*) had negative and significant coefficients compared to the base case (*West*) for all models. This result indicates the greatest WTP in the West region.

For attitudes and beliefs toward different environmental issues, there were a total of four variables used. The factor analysis variables (*Effect*Label* and *Climate*Label*) were both positive and highly significant suggesting that as an individual's stated concern for the environment and/or belief in consumer effectiveness increased, his/her likelihood of choosing a labeled refrigerator also increased. These results are consistent with previous studies on the effect environmental concern and perceived consumer effectiveness¹⁷ have on individuals' WTP for environmentally friendly products. The coefficient for *Green*Label* was also positive and highly significant meaning that individuals who believe green power is an effective way to combat global climate change have a greater likelihood of choosing a refrigerator awarded the GPP label. The coefficient for *Altru*Label* was also positive and significant suggesting that those who feel buying products from the GPP helps protect the environment for future generations will have a greater WTP than those who do not have strong altruistic attitudes.

As the percentage of electricity produced from renewable sources increased in each state, it was hypothesized that likelihood of choosing a GPP labeled refrigerator would increase.

¹⁷ More information on perceived consumer effectiveness can be found in Scholder, Weiner, and Cobb-Walgreen 1991; Ellen et al. 1991; Berger & Corbin 1992.

However, results from the fixed parameters logit suggest that there is a negative relationship between likelihood of choosing a GPP labeled refrigerator and percentage of renewable energy produced and in the random parameters logit it was not significant. One possible cause of the negative relationship revealed in the fixed parameters logit could be that consumers living in states with a greater percentage of renewable energy have more opportunities to invest in green power directly and therefore have less of a desire to support green power production through the purchase of products produced elsewhere from green power.

Table 15 provides estimates of WTP for the GPP label across the four models. The WTP estimates for the fixed parameters logits are positive and significantly different from zero; however, in this instance, the WTP estimates for the random parameters logits were not significantly different from zero. For the product attribute-only fixed parameters model, mean WTP was calculated by using equation (3) while equation (5) was used to calculate WTP for the attribute-only random parameters model. Similarly, equation (7) was used to calculate mean WTP for the conditional logit including demographic and attitudinal interaction terms while equation (9) was used to calculate mean WTP for the random parameters logit including demographic and attitudinal interaction terms. These are calculated at the sample means and at the estimated mean parameters. Standard errors for the WTP estimates are calculated using the Krinsky-Robb method for parametric bootstrapping with 15,000 draws (Krinsky and Robb, 1991).¹⁸ The mean WTP for the fixed parameters and random parameters logits with attributes only (Models 1 and 3) are \$48.52 and \$65.26 respectively, while the mean WTP for the fixed parameters and random parameters logits with attributes, demographics, environmental, and budgetary constraints (Models 2 and 4) are \$63.49 and \$70.95 respectively.

¹⁸ The Krinsky-Robb procedure uses random draws from the estimated asymptotic normal distribution of parameter estimates to calculate confidence intervals around WTP estimates.

In order to estimate the additional marginal costs incurred in producing refrigerators with green power, the average price premium for green power (\$0.018) and the maximum price premium for green power (\$0.088) in 2008 were combined with data from a study on life-cycle energy requirements for refrigerators (Engelenburg et al. 1994). These estimates are presented in Table 16. Since the GPP program does not actually apply to individual products, there are not any standards that specifically say how much of the production process has to use green energy. Therefore, four different standards are presented, each associated with a different level in the life-cycle production of a refrigerator, in our estimates along with the estimated kWh requirement for each level. At the lowest standard, manufacturing and assembling, the direct energy requirements estimated by Engelenburg et al. (1994) are 351MJ (or 97.5 kWh). At this level of production, the marginal cost to produce a refrigerator with green power is \$1.76 at the mean price premium and \$8.58 at the maximum price premium for green power reported in 2008. The next level of energy inclusion reflects the direct energy requirements used in manufacturing and assembling plus the energy requirement needed to process residual goods and depreciation. The estimated cost for using green power at this level of production is \$3.92 using the mean price premium and \$19.14 using the highest premium.

The next level of energy inclusion reflects the total “in-house” energy requirements plus the energy required to transport the refrigerator to a retailer or distributor and the energy required to store the refrigerator until it is purchased by a consumer. Marginal costs at this level are estimated to be \$7.24 and \$35.40 at the mean and max premium respectively. The highest level of inclusion reflects all of the energy required for the production of the basic materials, the total “in-house” energy required, and the energy required to transport and store the refrigerator until it

is plugged into someone's kitchen. The marginal costs for using green power at this level of production are \$19.52 using the mean price premium and \$95.43 using the highest premium. These estimated costs make for an interesting comparison to the WTP estimates in Table 15, which range from \$48.52 to \$70.95. These results suggest that, on average, consumers are willing to pay more for the GPP label on refrigerators than the additional costs incurred by the manufacturers to use green power instead of conventional power, with the exception of the highest level of inclusion at the highest price in which consumers, on average, are willing to pay between 51 to 74 percent of those costs.

Summary & Conclusions

The results from this study suggest that consumers have a positive WTP for a label indicating that a product is produced by a company that is a Green Power Partner. More specifically, they suggest that an individual, when faced with a choice between two refrigerators, identical except that one has a GPP label and one does not, would be willing to pay a premium from \$48.52 to \$70.95 for the GPP labeled refrigerator. In comparison, it is estimated that a household participating in a green pricing program will spend, on average, \$5.40 extra per month (or \$64.80 per year) to purchase green power from their utility providers. Furthermore, these results suggest that, on average, consumers are willing to pay more for the GPP label on refrigerators than the additional costs incurred by the manufacturers to use green power instead of conventional power with the exception of the highest level of inclusion at the highest price in which consumers, on average, are willing to pay between 51 to 74 percent of those costs.

The results from this study also indicate that consumer demographics and attitudes influence WTP. In particular, attitudes toward environmental issues, which were captured in the variables *Effect*, *Climate*, *Green*, and *Altru*, had a positive effect on respondents' WTP for

refrigerators with a GPP label. Furthermore, the results indicate a negative relationship between the choice of a GPP label and places of residence in the *Northeast Midwest*, and *South* when compared to residence in the *West*. Hence, a Green Power Partnership labeling program may be more successful in the west.

The results presented in this paper reflect mean estimates of WTP for a label indentifying that a refrigerator was produced by a Green Power Partner and may differ for other appliances. Thus, an area for further research would be to look at the effect a GPP label has on WTP for other major appliances used in the home. Nonetheless, as labeled alternatives continue to penetrate the market, the results of this study show promising potential for a future green power labeling program on household appliances.

References

- Banerjee, A., and B.D. Solomon. 2003. "Eco-labeling for Energy Efficiency and Sustainability: a Meta-Evaluation of US Programs." *Energy Policy* 31:109-123.
- Barkenbus, Jack N., 2006. "Putting Energy Efficiency in a Sustainability Context: The Cold Facts About Refrigerators," *Environment* 48(8): 11-20.
- Bird, L.A., E. Holt, and G. L. Carroll. 2008. "Implications of Carbon Cap-And-Trade for US Voluntary Renewable Energy Markets." *Energy Policy* 36: 2063-2073.
- Bird, L., C. Kreycik, and B. Friedman. 2009. *Green Power Marketing in the United States: A Status Report (2008 Data)*. Golden, CO: National Renewable Energy Laboratory, Technical Report NREL/TP-6A2-46581, September.
- Borchers, A.M., J.M. Duke, and G.R. Parsons. 2007. "Does Willingness to Pay for Green Energy Differ by Source?" *Energy Policy* 35: 3327-3334.
- Byrnes, B., C. Jones, and S. Goodman, 1999. "Contingent valuation and real economic commitments: evidence from electric utility green pricing programmes," *Journal of Environmental Planning and Management* 42(2): 149-166
- Center for Resource Solutions (CRS). 2009. *2008 Green-e Verification Report*. San Francisco, CA. September.
- Clark, C., M. Kotchen, and M. Moore. 2003. "Internal and External Influences on Pro-Environmental Behavior: Participation in a Green Electricity Program," *Journal of Environmental Psychology* 23: 237-246.
- Dennis, J.M. 2007. "Description of KN Capabilities." Unpublished, Knowledge Networks, Inc.
- EIA, 2008. End-Use Consumption of Electricity 2001.U.S. Energy Information Administration. Washington, D.C. Available online at: <http://www.eia.doe.gov/emeu/recs/recs2001/enduse2001/enduse2001.html>.
- EIA. 2008a. World Energy Overview: 1996-2006. Washington, D.C. Available online at: <http://www.eia.doe.gov/emeu/iea/overview.html>
- Engelenburg, B.C.W., T.F.M. van Rossum, K. Blok, and K. Vringer. 1994. "Calculating the Energy Requirements of Household Purchases." *Energy Policy* 22(8): 648-656.
- Farhar, B. and A. Houston. 1996. Willingness to Pay for Electricity from Renewable Energy. Golden, CO: National Renewable Energy Laboratory, (NREL/TP-460-21216).
- Freeman, A. Myrick, III, 2003. The Measurement of Environmental and Resource Values: Theory and Methods. Second Edition. Washington, D.C.: Resources for the Future.
- Hart, Stuart, and Ahuja Gautum, 1996. "Does It Pay to be Green? An Empirical Examination of the Relationship Between Emission Reduction and Firm Performance," *Business Strategy and the Environment* 5: 30-7.
- Hensher, D.A. & W. H. Greene. 2003. "The Mixed Logit Model: The State of Practice." *Transportation* 30: 133-176.
- Holt, E. and R. Wiser. 1999. Understanding Consumer Demand for Green Power. Report prepared for the National Wind Coordinating Committee.
- Kotchen, M. and M. Moore. 2004. Conservation Behavior: From Voluntary Restraint to a Voluntary Price Premium. Williamstown, MA: Williams College, October.
- Kotchen, M. and M. Moore. 2007. "Private Provision of Environmental Public Goods: Household Participation in Green Electricity Programs," *Journal of Environmental Economics and Management* 53, 1:1-16.
- Krinsky, I., and A. Robb. 1991. "Three methods for calculating the statistical properties of elasticities: A comparison." *Empirical Economics* 2(16): 199-209.

- Lavin, F. and W. Hanemann. Taste indicators and heterogeneous revealed preferences for congestion in recreation demand, *UCB CUDARE Working Papers Number 1075*, Department of Agricultural & Resource Economics, University of California, Berkeley (2008).
- McFadden, D. Conditional logit analysis of qualitative choice behavior, P. Zarembka, (ed), *Frontiers in Econometrics*, New York: Academic Press (1973).
- Revelt, D., and K. Train. 1998. "Mixed Logit with Repeated Choices: Households' Choices of Appliance Efficiency Level." *The Review of Economics and Statistics* 80(4):647-657.
- Roe, B., M. F. Teisl, A. Levy, and M. Russell. 2001. "US Consumers' Willingness to Pay for Green Electricity," *Energy Policy* 29 (11): 917-925.
- Rowlands, I., D. Scott, and P. Parker. 2003. "Consumers and Green Electricity: Profiling Potential Purchasers," *Business Strategy and the Environment* 12: 36-48.
- Rowlands, Ian, Paul Parker, and Daniel Scott. "Consumer Perceptions of 'Green Power'." *Journal of Consumer Marketing* 19(2) (April 2002): 112-129.
- Schmalensee, R. 2009. "Renewable Electricity Generation in the United States." Center for Energy and Environment Policy Research. November.
- Steckel, J.H., W.R. Vanhonacker. 1988. "A Heterogeneous Conditional Logit Model of Choice." *Journal of Business & Economics Statistics* 6(30): 391-398.
- Swezey, B., J. Aabakken, and L. Bird. 2007. *A Preliminary Examination of the Supply and Demand Balance for Renewable Electricity*. Washington DC: National Renewable Energy Laboratory, NREL/TP-670-42266, October.
- Train K. 1999. "Halton Sequences for Mixed Logit" *Manuscript, Department of Economics, University of Berkeley*.
- Train K. *Discrete Choice Methods with Simulation*, New York: Cambridge University Press (2003).
- USEPA. 2009. EPA's Green Power Partnership: Partnership Requirements. Washington, D.C. April.
- _____. 2010. Green Power Usage Edged Higher in 2009 among EPA Partners. Available at: <http://yosemite.epa.gov/opa/admpress.nsf/d0cf6618525a9efb85257359003fb69d/f74df277c3c6c40f852576b60064db10!OpenDocument>
- Whitehead, J. and T. Cherry. 2007. "Willingness to Pay for a Green Energy Program: A Comparison of Ex-ante and Ex-post Hypothetical Bias Mitigation Approaches," *Resource and Energy Economics* 29: 247-261.
- Wiser, R., Bolinger, M., Holt, E. 2000. "Customer Choice and Green Power in the United States: How Far Can It Take Us?" *Energy and Environment* 11(4): 461-477.
- Wiser, R., M. Fowlie and E. Holt. 2001. "Public Goods and Private Interests: Understanding Non-Residential Demand For Green Power," *Energy Policy* 29(13):1085-1097.
- Zarnikau, J. 2003. "Consumer Demand for 'Green Power' and Energy Efficiency," *Energy Policy*, 31: 1661-1672.

Appendix



Another feature that you may consider is whether the refrigerator is manufactured by a company that is a GREEN POWER PARTNER.

GREEN POWER PARTNERS are businesses that purchase electricity generated from renewable sources, such as solar or wind.

By purchasing electricity generated from renewable sources, manufacturers reduce the emission of greenhouse gases associated with refrigerator production. Studies suggest that greenhouse gases contribute to global climate change.

Would you like more information on GREEN POWER PARTNERS or are you ready to proceed with the survey?

Select one answer only

- ☐ Ready to proceed
- ☐ Would like more information

Next

GREEN POWER PARTNERS is a voluntary program sponsored by the U.S. Environmental Protection Agency as a way to increase the use of renewable energy and, thus, reduce greenhouse gas emissions from conventionally-generated electricity.

Green power is electricity generated from environmentally preferable renewable resources, such as solar, wind, geothermal, and some biomass (i.e., plant material) and hydrological resources.

To qualify as a GREEN POWER PARTNER, a manufacturer must buy enough green power to meet a specified percentage of its total electricity consumption. This percentage varies depending upon the total amount of electricity consumed by the manufacturer.

Next

Figure 4. Information Screen for Green Power Partners

If you needed to buy a refrigerator and these were your only options, 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. You may also assume that there are no significant differences in energy efficiency between these choices.

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

	Alternative 1	Alternative 2	Alternative 3	
Price	\$929	\$929	\$979	NONE: I wouldn't choose any of these ☐
Brand	Kenmore	Whirlpool	General Electric	
Configuration	French door	Side-by-side	Side-by-side	
Capacity (cu. ft.)	24.52	25.34	25.34	
Through-the-Door Dispenser	Ice	Ice	Water	
Green Power Partners	No	No	Yes	
Your choice	☐	☐	☐	

Next

Figure 5. Sample Choice Experiment

Table 10. Variable Names, Definitions, Hypothesized Signs, and Sample Means

Variable	Description	Hypothesized Sign	Sample Mean ^d
<u><i>Dependent Variable</i></u>			
<i>Chosen</i>	1 if the alternative is chosen, 0 otherwise	NA	0.3333
<u><i>Product Attribute Variables</i></u>			
<i>Price</i>	\$879, \$929, \$979, or \$1,029	-	954.0932
<i>Label</i>	1 if refrigerator is produced by a Green Power Partner, 0 otherwise	+	0.5091
<i>Capacity</i>	23.78, 24.52, 25.34, 25.83 cubic feet	+	24.8407
<i>Frenchdr</i>	1 if French door, 0 if side-by-side	+	0.5099
<u>Brand Choices (Whirlpool as base case)</u>			
<i>LG</i>	1 if LG brand, 0 otherwise	-	0.2670
<i>GE</i>	1 if GE brand, 0 otherwise	-	0.2470
<i>Kenmore</i>	1 if Kenmore brand, 0 otherwise	-	0.2397
<u>External Dispenser Type (No ice or water as base case)</u>			
<i>Ice</i>	1 if equipped with external ice dispenser only, 0 otherwise	+	0.2670
<i>Water</i>	1 if equipped with external water dispenser only, 0 otherwise	+	0.2367
<i>IandW</i>	1 if equipped with external ice & water dispenser, 0 otherwise	+	0.2561
<u><i>Attitudinal and Demographic Variables Interacted with label</i></u>			
<i>Effect</i>	Factor analysis score for perceived consumer effectiveness	+	-0.0217
<i>Climate</i>	Factor analysis score for global climate change	+	-0.0396
<u>Income Levels (Income less than \$50,000 as base case)</u>			
<i>Inc50</i>	1 if household income is between \$50,000 - \$100,000, 0 otherwise	+	0.3804
<i>Inc100</i>	1 if household income is \$100,000 or greater, 0 otherwise	+	0.1458
<i>Green</i>	1 if agree that using green energy to produce refrigerators leads to greater reduction in GHG emissions	+	0.1941
<i>Female</i>	1 if female, 0 if male	+	0.4993

Table 10. Continued

Variable	Description	Hypothesized	
		Sign	Sample Mean*
<i>College</i>	1 if Bachelor's degree or higher, 0 otherwise	+	0.5494
<i>Age45</i>	1 if 45 or older, 0 otherwise	-	0.5060
<i>Altru</i>	1 if at least somewhat agrees with altruism statement, 0 otherwise	+	0.5789
<u>Region of the Country (West as base case)</u>			
<i>Northeast</i>	1 if lives in Northeast, 0 otherwise	+	0.0976
<i>Midwest</i>	1 if lives in Midwest, 0 otherwise	+	0.1088
<i>South</i>	1 if lives in South, 0 otherwise	-	0.3584
<i>Renewable</i>	Percentage of total state energy produced with renewable sources	+	0.1043

^dThe means are calculated using the weighted data.

Table 11. Environmental Concern Questions

<i>Variables Included In Factor Analysis^e</i>	
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.
 <i><u>Other Environmental Variables</u></i>	
Altru ^e	Buying products from companies that participate in the Green Power Partners program makes me feel like I'm helping to protect the environment for future generations
Green	Which of the following do you think has the potential to lead to the greatest reduction in greenhouse gas emissions?
	1. Producing refrigerators that use less energy
	2. Using less energy to produce refrigerators
	3. Using renewable or "green" energy to produce refrigerators
	4. Don't know

^e Response options were 1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, and 5=Strongly Agree

Table 12. Rotated Factor Loadings with Reliability Score

<i>Perceived Consumer Effectiveness (Effect)</i>	Factor Weights
Chronbach's $\alpha=0.79$	
When I buy products, I consider how my use of them will affect the environment	0.7493
By choosing environmentally friendly products, I signal to manufacturers the types of products they should be producing.	0.7619
<i>Views toward Climate Issues (Climate)</i>	
Chronbach's $\alpha=0.79$	
We need more government regulations to force people to protect the environment.	0.5821
There is no urgent need to take measures to prevent global climate change today.	-0.5948
The most effective way to combat global climate change is to reduce energy consumption	0.5849
Global climate change will have a noticeably negative impact on the environment in which my family and I live	0.5769
The production of electricity from renewable sources such as solar, wind, and biomass is an effective way to combat global climate change.	0.5817

Table 13. 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	-3198.18	1187.52	***	9
3	Random Parameters-Product Attributes Only	-2604.42			
2	Fixed Coefficients-Product Attributes, Demographic Characteristics, and Environmental Concern Variable	-2966.15	982.46	***	9
4	Random Parameters- Product Attributes, Demographic Characteristics, and Environmental Concern Variable	-2474.92			

^fThe log likelihood ratio test (LLR) is calculated as $-2(\log \text{likelihood restricted} - \log \text{likelihood unrestricted})$.

Table 14. Estimated Models of WTP for GPP Labeled Refrigerators

Variable	<u>Conditional Fixed Parameters Logits</u>				<u>Random Parameters Logits</u>			
	Model 1		Model 2		Model 3		Model 4	
	Est. Coeff.	Z	Mean of Est. Coeff.	Z	Est. Coeff.	Z	Mean of Est. Coeff.	Z
<i>Price</i>	-0.0068	-13.74 ***	-0.0071	-13.99 ***	-0.0116	-8.26 ***	-0.0120	-8.24 ***
<i>Label</i>	0.3299	6.32 ***	0.5666	2.88 ***	0.7538	1.95 **	0.9739	1.71 **
<i>Capacity</i>	0.0837	2.39 ***	0.0917	2.57 ***	0.2137	3.09 ***	0.2175	3.31 ***
<i>Frenchdr</i>	-0.2671	-4.94 ***	-0.3156	-5.75 ***	-0.6910	-2.17 ***	-0.7953	-3.19 ***
<i>LG</i>	-0.3156	-4.16 ***	-0.2818	-3.71 ***	-0.6347	-3.88 ***	-0.5380	-3.51 ***
<i>GE</i>	-0.0788	-1.07	-0.0723	-0.98	-0.2054	-1.26	-0.1782	-1.18
<i>Kenmore</i>	-0.0999	-1.33	-0.0783	-1.04	-0.1994	-1.43	-0.2128	-1.61 *
<i>Ice</i>	0.4472	5.71 ***	0.4438	5.61 ***	0.6783	4.52 ***	0.6112	4.08 ***
<i>Water</i>	0.2516	3.15 ***	0.2402	3 ***	0.3675	2.91 ***	0.3395	2.59 ***
<i>IandW</i>	1.0585	13.65 ***	1.1197	14.3 ***	2.0180	8.09 ***	2.0204	8.7 ***
<i>Effect*label</i>			0.3538	5.56 ***			0.6025	3.4 ***
<i>Climate*label</i>			0.2126	3.06 ***			0.3905	2.23 ***
<i>Inc50*label</i>			-0.0871	-0.71			-0.0091	-0.03
<i>Inc100*Label</i>			0.1792	1.06			0.6028	1.13
<i>Green*label</i>			0.4090	2.97 ***			0.5941	1.17
<i>Female*Label</i>			-0.0036	-0.03			0.4136	1.48 *
<i>College*Label</i>			-0.2269	-1.78 **			-0.5448	-1.24
<i>Age45*Label</i>			0.0908	0.83			0.0398	0.12
<i>Altru*label</i>			0.2438	2.06 ***			0.4680	1.26
<i>NE*Label</i>			-0.3198	-1.88 ***			-0.3621	-0.71
<i>MW*label</i>			-0.6765	-3.85 ***			-1.3174	-2.31 ***
<i>South*label</i>			-0.2875	-1.77 **			-0.5629	-1.09
<i>Renewable*label</i>			-0.8914	-2.28 ***			-1.8152	-1.2
<u>Standard Deviations</u>								
<i>Label</i>					1.7050	7.24 ***	1.6102	7.48 ***
<i>Capacity</i>					-0.4860	-5.17 ***	0.4395	4.49 ***
<i>Frenchdr</i>					2.4795	7.03 ***	2.6558	8.58 ***
<i>LG</i>					0.9343	3.63 ***	1.1148	5.74 ***
<i>GE</i>					1.0424	2.6 ***	1.1254	3.88 ***
<i>Kenmore</i>					-0.4791	-0.86	-0.6532	-4.17 ***
<i>Ice</i>					-0.9300	-4.84 ***	0.9628	5.54 ***
<i>Water</i>					-0.1909	-0.09	-0.5002	-2.1 ***
<i>IandW</i>					1.8319	4.44 ***	2.0397	7.41 ***
Log likelihood	-3198.18		-2966.15		-2604.42		-2474.92	

*** denotes significance of the coefficient from zero at the 95% confidence level, ** denotes significance at the 90% confidence level, and * denotes significance at the 85% confidence level.

Table 15. Estimates of WTP for GPP Labeled Refrigerators

Variable	<u>Conditional Fixed Parameters Logits</u>				<u>Random Parameters Logits</u>			
	Model 1: Attributes		Model 2: Attributes, Demographics, Attitudes		Model 3: Attributes		Model 4: Attributes, Demographics, Attitudes	
	Std.		Std.		Std.		Std.	
	Mean.	Error	Mean.	Error	Mean.	Error	Mean.	Error
Label	48.52	16.88 ***	63.49	31.41 ***	65.26	64.67	70.95	55.69

*** denotes significance of the coefficient from zero at the 95% confidence level.

Table 16. Electricity costs to Produce 1 Refrigerator With Green Power

Level of Production Using Green Power	Energy Required (in kWh)	\$/kWh ^g	Cost
Direct "in-house" Energy Requirement	97.5	\$0.018	\$1.76
		\$0.088	\$8.58
Total "in-house" Energy Requirement	217.5	\$0.018	\$3.92
		\$0.088	\$19.14
Total "in-house" Energy Requirement Plus Transportation and Trade	402.22	\$0.018	\$7.24
		\$0.088	\$35.40
Production of Basic Materials to Retail Outlet	1084.42	\$0.018	\$19.52
		\$0.088	\$95.43

^g The prices are the average and the highest premium for green power reported in 2008.

Part 4: Summary and Conclusions

Summary

Voluntary environmental labeling or certification programs that provide information about the environmental characteristics of one or more aspects of a product's life cycle to consumers have been widely adopted around the world in one form or another. This study examined two such labels – the Energy Star and the Green Power Partnership, and the effect they had on consumers' WTP for refrigerators. A conjoint analysis choice experiment was designed to replicate the purchase decisions consumers' face in an actual marketplace setting as closely as possible.

The results of this study suggest that consumers are willing to pay a premium for energy labels, whether they offer purely public benefits or a combination of both public and private benefits. For the Energy Star label, our analysis revealed 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 from \$255.10 to \$313.51 for the Energy Star qualified refrigerator. If consumers expect no real growth in future energy prices, these WTP values imply discount rates ranging from -6.62% to -11.70%. These negative discount rates provide evidence that WTP was motivated by both private (energy cost savings) and public (environmental friendliness) benefits.

After a few discrepancies emerged in the random parameters logit including attitudinal, demographic, and economic interactions, a new hypothesis was formed suggesting that the private benefits of the Energy Star label have a greater effect on males' choice of refrigerators than on females' choice of refrigerators. A triple interaction term (*Male*kWh*Label*) to capture the portion of male respondents motivated to choose an Energy Star labeled refrigerator for the private economic benefit was created and found to be positive and significant in both the fixed

and random parameters logits. Estimates on the effect of *Male*kWh*Label* on WTP for the Energy Star label, revealed that males are willing to pay, on average, an additional \$26.78 for the Energy Star label for a 1 cent/kWh increase in electricity rates. This result reinforces the concept that males may be more heavily motivated by the private benefits of the Energy Star label than females.

Similarly, for the GPP label, an individual faced with a choice between two refrigerators, identical except that one has a GPP label and one does not, would be willing to pay a premium from \$48.52 to \$70.95 for the GPP labeled refrigerator. In comparison, it is estimated that a household participating in a green pricing program will spend, on average, \$5.40 extra per month (or \$64.80 per year) to purchase green power from their utility providers. Furthermore, these results suggest that, on average, consumers are willing to pay more for the GPP label on refrigerators than the additional costs incurred by the manufacturers to use green power instead of conventional power with the exception of the highest level of inclusion at the highest price in which consumers, on average, are willing to pay between 51 to 74 percent of those costs.

The results from this study also reveal that consumer demographics and attitudes influence WTP for both labels. In particular, individuals with greater levels of stated concern for the environment or individuals exhibiting strong perceptions on the effectiveness of consumers to affect product design and the ambient environment had a greater likelihood, and thus, a greater WTP for both the Energy Star label and the GPP label. Furthermore, after controlling for the portion of male respondents motivated to choose an Energy Star labeled refrigerator for the private economic benefit, our analysis revealed that females, in general, have a greater likelihood of choosing an Energy Star labeled refrigerator than males. Similarly, the results for the GPP

label provide mixed evidence that females, in general, have a greater likelihood of choosing a GPP label refrigerator than males.

To manufacturers and government regulators, these results suggest that energy labels play a significant role in consumer's decision making process when selecting a new appliance. For the Energy Star label, our results provide evidence that WTP was motivated by both public and private benefits. However, these results are solely based on refrigerators and may or may not be true for other major home appliances. Thus, further research into the affect these and other energy labels have on consumers' choice of energy using durables might be warranted.

Vita

David Oakley Ward was born in Knoxville, Tennessee, on December 13, 1985 to Jeff and Diane Ward. He graduated from William Blount High School in Maryville, Tennessee in 2004. He attended the University of Tennessee, Knoxville and received a B. S. in Agricultural Economics in 2008 and a M. S. in Agricultural Economics in 2010.