

THE ROLE OF ETHNICITY AND EDUCATION IN
ENERGY EFFICIENT TECHNOLOGY ADOPTION

A Thesis
submitted to the Faculty of the
Graduate School of Arts and Sciences
of Georgetown University
in partial fulfillment of the requirements for the
degree of
Master of Public Policy
in Public Policy

By

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Washington, DC
April 15, 2014

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ABSTRACT

The Energy Star program is a voluntary labeling scheme used to promote the purchase of energy efficient products. In this paper, I studied U.S. consumer choices to purchase Energy Star refrigerators. I predicted that different levels of education, Hispanic ethnicity, and the interaction between education and Hispanic ethnicity would have significant effects on energy efficient technology purchases. To research this relationship, I conducted a probit regression model controlling for income, age and regional energy efficiency awareness. Post estimation for hypothetical households showed that Hispanic ethnicity predicted a lower propensity for Energy Star refrigerator purchase for consumers that had replaced their refrigerator in the last 5 years and had completed some schooling up to the high school level. These results have implications for the design and implementation of U.S. energy efficiency labeling programs.

I'd like to dedicate the research and writing of this thesis to my adviser Micah, my family and friends, Ashley, Mimi, Natalie, and the kind folks at EIA and MSPP who supported me throughout this process.

Best regards,
RAISA S LEDESMA-RODRIGUEZ

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INTRODUCTION

Energy conservation has been a feature of U.S. energy policy since the 1970s (“Timeline of Events: 1971-1980,” 2013). Rising concerns over environmental pollution and energy dependence led to the creation of the Environmental Protection Agency (EPA) in 1970 and the Department of Energy (DOE) in 1977. These agencies consolidated research and programs across the federal government to promote energy conservation (U.S. Environmental Protection Agency, 2013; U.S. Department of Energy, 2013). Over the last few decades, research and development in technology have significantly improved energy efficiency across a wide range of buildings, equipment and appliances generating vast amounts of energy savings.

However, the potential gains from these savings have not been realized. Energy consumers continue to opt for less energy efficient technologies despite government efforts to change behavior. In 1992, for example, the EPA started the Energy Star program to reduce U.S. residential, commercial and industrial energy consumption (U.S. Environmental Protection Agency, 2012). The program promotes the development and purchase of energy-efficient items through a voluntary labeling scheme, currently on a range of products from computers and monitors, to major appliances, lighting and other categories (Energy Star, 2013). A product receives the Energy Star label when it passes an energy efficiency threshold and reduces costs for consumers (Energy Star, 2014). These products may be more expensive than less energy efficient models at the purchasing price, but are required to yield financial savings for consumers over a specified period of time. Thus, when consumers purchase Energy Star products, they reduce their energy consumption and costs by making a choice for energy efficiency.

Promoting the use of energy efficient appliances and devices is important because they constitute a large part of energy consumption. In 2012, U.S. residential and commercial sectors

made up about 40% of total U.S. energy consumption (U.S. Energy Information Agency, 2013). At the household level, appliances consumed about 13% of total household energy use (U.S. Department of Energy, 2012). This extraneous use of energy by inefficient appliances adds up to vast amounts of wasted energy in operation and transmission losses.

The question is: If consumers pay for their energy consumption and are aware of energy efficient labeling that would lower their costs, what prevents some of them from purchasing technologies with the Energy Star label?

One explanation is price. Energy efficient technologies can be more expensive than less efficient products in the short run. However, if consumers are driven by motivations to spend less money, energy efficient purchases are less costly over time so this explanation could only apply to consumers with short-term savings goals. An alternative explanation is based on consumer preferences for product features, which might not be very efficient or widely available among energy efficient models. Still, other factors can include consumers' timeline and product availability.

Consumer purchasing decisions are complex, extending beyond factors affecting individuals at the moment of purchase. I studied why gaps in energy efficient purchasing behavior exist, with particular attention to the differences between Hispanic and non-Hispanic households in the US, and whether varying levels of education were a moderating influence on purchasing behavior.

Since 1990, U.S. demographic trends have shown significant changes in educational attainment and ethnic composition. From 1990 to 2012, the percentage of 25 to 29 year olds who received at least a high school diploma or an equivalent increased from 86 percent to 90 percent, and the percentage of adults who completed at least a bachelor's degree jumped from 23 to 33

percent (U.S. Department of Education, 2013). For White Americans, the increase in the proportion receiving a high school diploma was 90 to 95 percent, while for Hispanic Americans the increase was 58 to 75 percent (U.S. Department of Education, 2013). Completing a bachelor's degree, the percentage of White Americans climbed from 26 to 40 percent; meanwhile for Hispanic Americans, the increase was smaller: 8 to 15 percent (U.S. Department of Education, 2013).

The White-Hispanic American high school level attainment gap narrowed from 32 to 20 percentage points, yet the gap in bachelor's degree level completion between White Americans and Hispanic Americans widened from 18 to 25 percentage points (U.S. Department of Education, 2013). These statistics show higher education attainment trends overall, but marked differences between ethnic groups.

At the same time, the U.S. Hispanic population has grown rapidly. In 1990, there were about 22.4 million self-identified Hispanic Americans in the United States, which constituted 9% of the total U.S. population (Guzman, 2001). In 2000, there were 35.3 million Hispanic Americans constituting 13% of the total U.S. population. By 2010, this population increased to 50.5 million making up 16% of the U.S. population and the majority of total U.S. population growth (Ennis et al., 2011). As the Hispanic population grows and their share of energy consumption increases with it, it is important to understand differences in purchasing decisions and behavior to inform energy conservation policy in the near future.

How does ethnicity and education affect energy efficient purchasing decisions? Separately, education and Hispanic ethnicity have been associated with opposite directions in the propensity to purchase energy efficient technology. Education is associated with higher levels of energy efficient behavior (Mills & Schleich, 2010, 2012), and Hispanic ethnicity is associated with

lower propensities for energy efficient technology adoption (Murray & Mills, 2011). Mills & Schleich state that higher education may be correlated with a higher propensity for energy efficient purchases due to lower barriers to information acquisition such as understanding labeling schemes, preferences for long-term investments, or association in groups that are environmentally conscious. Meanwhile, Murray & Mills found that Hispanic Americans are less aware of the Energy Star label than their non-Hispanic counterparts and thus less likely to purchase a product that is more energy efficient.

Based on this research, I theorize that the impact of education on energy efficient technology adoption is different between Hispanic and non-Hispanic populations due to differences in culture. Education affects ethnic groups in different ways because social norms that vary by ethnic affiliation may moderate educational benefits and consumer behavior. For some consumers, cultural norms may override the influence of education's association with energy efficient behavior.

Past research studies have explored the relationship between household characteristics and purchasing behavior; however, to my knowledge, none have explored the interactions between Hispanic ethnicity and education in Energy Star appliance purchasing with a large, nationally representative sample. If education and ethnicity moderate purchasing decisions for household appliances, policymakers can consider subpopulation marketing strategies for more effective outreach and higher energy savings.

LITERATURE REVIEW

Theories explaining energy efficient technology adoption

Three types of theories dominate research pertaining to energy efficient technology adoption: economic models, psychological models and social models. Economic models assert that budget

constraints and rational decision-making are the primary influence on individuals' purchasing choices. Psychological models that take a closer look at individuals and the motivations behind behavior, including but not limited to, personal beliefs and attitudes. Psychological models acknowledge that social norms may affect individuals' behavior, but the social interactions of an individual as a consumer and decision-maker are further explored in cultural models of consumption. Past research has provided evidence to support all three theories.

Economic models

As noted, economic models of behavior view the individual as an economic agent influenced primarily by the cost of energy and maximizing utility. Price is an important driver for purchasing decisions as higher prices result in lower utility. Several studies have used an economic model to measure the effect of household thermal improvements such as home insulation on residential energy demand (Hsueh & Gerner, 1993; Schwarz & Taylor, 1995). This theory views the household as a unit with purchasing power constrained by its budget, in the form of income. Research strongly suggests that thermal improvements lower overall energy consumption and hence the total cost of energy to consumers. Ironically, efficiency gains lower energy prices as perceived by the household and then lead to higher energy consumption, a phenomenon known as the rebound or takeback effect. Nevertheless, rebound effects are smaller than efficiency savings (Greening, et al, 2000) suggesting that individuals should adopt cost-saving technologies. If this is the case, why do some individual households not purchase energy efficient products?

Psychological models

From a psychological perspective, multiple factors, including but not limited to cost considerations, drive individual decisions and actions. In these models, mechanisms acting either

prior to or after individual actions can influence energy efficient behavior. In the applied behavioral model, for example, stimuli such as peer pressure, can elicit certain behaviors. Similarly, consequences, such as fees or social disapproval, can deter undesired actions. The applied behavioral model assumes, similar to the economic model, that individuals seek to maximize their utility, and so they will respond to rewards and punishments. (Pelton, Strutton, Barnes & True, 1993; Olander & Thorngesen, 1995). This model does not consider the variances of individual characteristics, which have been the focus of personality and attitude research explaining consumer behavior.

The attitudinal theories postulate that individual attitudes precede behavior. Variants of this theory propose that the presence of intent, motivation and opportunity also moderate behavior (Olander & Thorngesen, 1995; Abrahamse and Steg, 2005, 2011). These mechanisms suggest that in order to change behavior, values and attitudes must be changed first. In one research study, Abrahamse & Steg (2009) found that attitudes and beliefs of behavioral control, in conjunction with personal norms, an awareness of consequences, and sense of responsibility explained a significant amount of energy savings in a survey of Dutch households. The evidence suggests that these mechanisms are important in predicting consumer behavior.

Furthermore, personality research suggests that energy consumption behavior is mediated by environmental concerns that are a product of demographic characteristics such as education, income and political ideology. These characteristics form part of social class hypotheses that associate individual attributes to wider concerns about collective environmental problems through social class experience and identification (Van Liere & Dunlap, 1980). These models combine personality and individual attitudes with social effects to explain behavior. They acknowledge that individual characteristics are often shaped by social group identification and

interaction, but focus on the mechanisms at work at the individual level (Lutzenhiser, 1991; Pelton, Strutton, Barnes & True, 1993).

Social models

Social models place economic and psychological models in context of social processes focusing on the dynamic behavior of human groups to explain energy consumption. Social models view the individual as part of a social group, which influences individual attitudes, strategies, symbols and preferences (Lutzenhiser, 1991). The social group provides the culture within which energy technologies are adopted, used and changed. This theory suggests that it is important to study the social group to understand individual energy choices and behavior.

My theory used assumptions from social and psychological models to assert that ethnicity and education have an effect on energy efficient technology adoption. I took a holistic approach to energy efficient choices by addressing the limitation of most economic models that confine themselves to individual decision-making. In the next section, I provide an overview of the research conducted on demographic characteristics and energy efficient technology adoption.

Research on energy efficient consumer behavior

Both individuals and households have been studied to predict significant associations between demographic characteristics and energy efficient consumer behavior. The following studies paid particular attention to education and ethnicity, as well as covariates whose omission could bias results.

Educational attainment and energy efficient consumer behavior

A number of studies have shown a positive correlation between higher education and energy-saving activities. Three of the most commonly cited explanations for this correlation are: (1) higher education lowers barriers to information and awareness (Murray & Mills, 2011); (2)

investments in education are associated with lower, future discount rates (Mills & Schleich, 2010, 2012); and (3) education is correlated with attitudes towards the environment and association with environmentally-conscious social groups (Van Liere & Dunlap, 1980; Mills & Schleich, 2010, 2012). Recent research on household energy efficient behavior suggests that this association is significant, though shortcomings with data have limited the applicability of their findings.

In one study, Mills & Schleich (2010) examined the effects of various household characteristics, including education, on the propensity of appliance label knowledge and purchase using a 2002 mail survey of German residents. The EU labeling scheme at the time of the study graded all appliances on a class scale, with class-A appliances being the most efficient. With regards to class-A refrigerator purchase, Mills & Schleich found evidence suggesting that individuals with secondary school education were more likely to purchase more energy efficient appliances. Nevertheless, missing information on social norms and educational attainment in the dataset limited the study's generalizability.

In another study, Mills & Schleich (2012) analyzed the effect of education, country characteristics, and the interaction between education and country characteristics on energy-efficient technology adoption in European households. Using data from the Residential Monitoring to Decrease Energy Use and Carbon Emissions in Europe Project survey, data collection methods by country were somewhat inconsistent but rendered household information across 11 countries in 2007. The authors regressed education and country indicators on energy efficient attitudes and behaviors. They found that without the interaction variable, households with higher levels of education had higher compact fluorescent light bulb adoption rates. With the interaction variable, the country indicators and the interaction term were significant, but the

education variables (i.e. high school, vocational and university attainment) alone were not. These results were particularly relevant to my study as I measured the interaction between education and ethnicity on Energy Star appliance adoption among US households.

Hispanic ethnicity and energy efficient consumer behavior

Several studies have cited differences between Hispanic households and non-Hispanic households in the U.S. and identified associations between Hispanic ethnicity and purchasing decisions (McCabe & Corona, 2011; Saegert, Hoover, & Hilger, 1985). Evidence suggests that the U.S. Hispanic consumer market differs from the non-Hispanic consumer market as it has a higher price consciousness and a preference for brand familiarity (Saegert, Hoover, & Hilger, 1985), as well as prestige goals (Deshpande, Hoyer, & Donthu, 1986) and a preference toward word-of-mouth communications (McCabe & Corona, 2011). However, it should be noted that a few of these studies only surveyed Mexican American individuals limiting the applicability of results (Saegert, Hoover, & Hilger, 1985; Deshpande, Hoyer, & Donthu, 1986).

In Saegert, Hoover, & Hilger's study (1985), two surveys were conducted in South Texas to measure differences between Hispanic and non-Hispanic consumers. The first survey was mailed to households, and the second survey was conducted through personal household interviews. Both surveys asked respondents questions about shopping ease, familiarity, convenience-store features, product quality, and price for supermarkets. Comparing mean rating scale scores, the authors found statistically significant differences between Mexican Americans and non-Hispanic consumers. Results from the first survey provided evidence to suggest that Hispanic consumers were more partial to familiar stores and were more price-conscious when controlling for income. Results from the second survey suggested that familiarity and convenience-store features were

statistically significant. Combined, these results suggested that Hispanic consumers at least had a preference for familiar stores.

Nevertheless, in terms of relative importance, Saegert, Hoover, & Hilger indicated that price, product quality and shopping ease topped the list of factors for Hispanic consumers so familiarity was not as important. Additionally, limitations to the study included the possibility of selection bias in the mail survey and the almost exclusive surveying of Mexican American consumers. The survey used in my study addresses the latter limitations by gathering data from a nationally representative sample.

Additionally, Hispanic ethnicity tends to be associated with lower levels of energy efficient technology adoption (Murray & Mills, 2011). Using probit regressions, Murray & Mills (2011) found that Hispanics were significantly less likely to be aware of the Energy Star label on dishwashers and refrigerators than non-Hispanics. This research suggests that Hispanic households may have unique cultural attributes that affect energy efficient consumption behavior. Murray & Mills (2011) used the 2005 Residential Energy Consumption Survey (RECS) to examine this association along with income, household size and residence location. The survey had comprehensive information on energy consumption, but did not include information on the price paid for Energy Star appliances. Furthermore, the 2005 survey did not measure educational attainment for survey respondents. I address this limitation in my study by using the 2009 RECS, which collected information on survey respondents' education.

Income, household size, regional awareness and energy efficient consumer behavior

Income and household size have frequently been cited as significant household characteristics in predicting energy saving behavior. Abrahamse & Steg (2009) examined a cohort of Dutch households and found significant correlations between income and household

size on overall energy use, including purchasing decisions and conservation behaviors.

Households with higher incomes and those larger in size were more likely to have higher levels of energy consumption, suggesting that budget constraints may play an important role in decisions to use energy and adopt energy efficient technology.

Similarly, Murray & Mills (2011) examined the effect of household characteristics on Energy Star label awareness and purchasing in U.S. households. They found that income is a significant factor in awareness of the label and purchase propensity using probit regression models and maximum likelihood estimation. In terms of purchasing Energy Star dishwashers and refrigerators, income, ownership status of household unit, and geographic region were also significant characteristics. They theorize that an individual household will be more likely to know of and purchase the Energy Star appliance if regional awareness is greater.

In summary, the research conducted over the past few decades suggests that further inquiry is still needed to understand the motivations behind energy efficient technology adoption at the household level. To date, much of this research has been limited by inconsistent collection of data and limited samples of the population, as well as a focus on separate socio-demographic characteristics and their effects on purchasing decisions. To my knowledge, no research has specifically explored the relationship between ethnicity and education, and purchasing decisions for major household appliances due to limited information on householders' educational attainment. The new education variable in the 2009 RECS dataset provides an opportunity to conduct this research and provide evidence to assess my theoretical model.

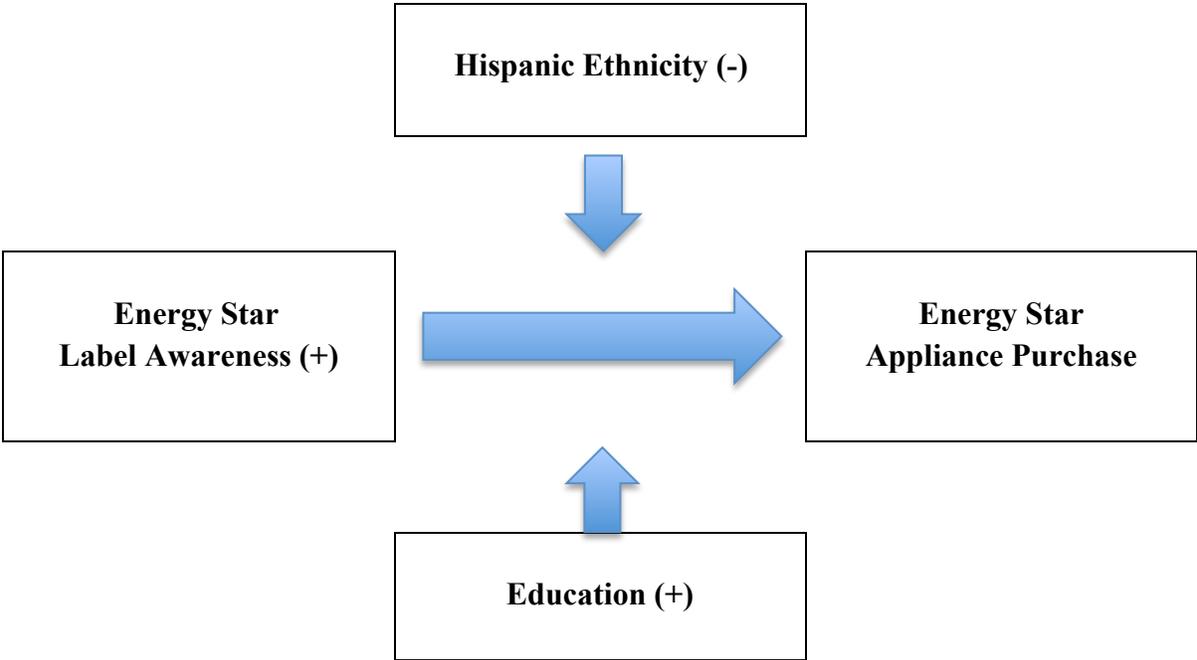
THEORETICAL MODEL

My theory asserts that education and ethnicity will affect the relationship between Energy Star label awareness and Energy Star appliance purchase. I predicted that once an individual

becomes aware of the Energy Star label, both individual and social processes affect her or his decision about energy purchases. Education and ethnicity provide different mechanisms for individuals to process information, likely resulting in significant effects on purchasing decisions. Education results in more individual analysis due to skeptical attitudes and propensities for objective information gathering. Ethnicity provides the cultural context for more social analysis where decisions are based on social group norms and trust of others. Hence, both education and ethnicity shape individual attitudes and purchasing decisions, though they may have opposing effects due to differences in values and information acquisition methods.

In my theory, education increases the probability of purchasing Energy Star appliances and Hispanic ethnicity lowers it. The interaction between Energy Star label awareness and purchase is modeled in Figure 1.

Figure 1. Conceptual model



As noted earlier, research suggests that people with more education may be more

receptive to energy efficient labeling and purchasing since they are better prepared to read and interpret the Energy Star label, as well as consider energy efficiency in purchasing decisions. Furthermore, social marketing research suggests that Hispanic consumers are more likely not to purchase energy efficient technologies because their preference for prestige products and word of mouth recommendations may override efficiency considerations. For Hispanic consumers, a value for prestige in consumption suggests preferences for social acceptance and recognition over environmental and economic concerns when both are in conflict. Meanwhile, word of mouth communications lowers barriers to information access and acquisition through social interactions and trust.

Hypotheses

To test my theory, I proposed the following hypotheses:

H₀: Education is not a useful predictor of Energy Star refrigerator purchase in the population.

H₁: Education is a useful predictor of Energy Star refrigerator purchase in the population.

H₀: Hispanic identity is not a useful predictor of Energy Star refrigerator purchase in the population.

H₁: Hispanic identity is a useful predictor of Energy Star refrigerator purchase in the population.

H₀: The effect of education on Energy Star refrigerator purchase in the population does not depend on Hispanic identity (and vice versa).

H₁: The effect of education on Energy Star refrigerator purchase in the population depends on Hispanic identity (and vice versa).

The following section describes the data and methods used to test these hypotheses.

DATA AND METHODS

Description of the datasets

I used data from the U.S. Energy Information Agency's Residential Energy Consumption Survey (RECS) of 2009 and the American Council for an Energy Efficient Economy's 2009

State Energy Efficiency Scorecard to test the effects of education and Hispanic identity on Energy Star refrigerator purchase. The RECS administrators interviewed 12,083 U.S. consumers in household units using a complex, multistage probability sample design to represent the national U.S. population of households. In the survey, a household is defined as an “individual, or a group of up to nine unrelated persons, occupying the same housing unit.” (In turn, a housing unit is described as “A house, an apartment, a group of rooms, or a single room if it is either occupied or intended for occupancy as separate living quarters by a family, an individual, or a group of one to nine unrelated persons.”) Data on ethnicity and education level were gathered from the householder, which was the person who owned or rented the housing unit, or if that person was not living there, then the person who paid the bills (RECS terminology, 2013).

I examined a sample of 2,873 household respondents who purchased a refrigerator within the preceding 5 years and who answered positively or negatively to questions about Energy Star labeling on their refrigerator. Since my theory looks at educational and cultural effects on Energy Star label awareness and purchase, I excluded respondents that did not purchase their refrigerator, did not know whether the appliance had this energy efficient label, or for which this information could not be determined. Furthermore, I was unable to measure Energy Star label awareness from those respondents that refused to answer so I dropped these responses as well.

A total of 9,210 respondents were dropped from the sample. These exclusions limited the external validity of my study and introduced concerns over selection bias. First, the requirements for households in the sample made results applicable only to a population of U.S. consumers that had most recently purchased a refrigerator and knew whether or not their appliance had an Energy

Star label. Nevertheless, the sample still represents a cohort that will purchase new appliances in a future time period when appliance lifecycles expire.

Second, I excluded respondents who refused to answer questions about Energy Star labeling because the effects on education and Hispanic identity could not be measured on label awareness. It may have been the case that respondents were refusing to answer because they were more likely to own inefficient appliances. I could not determine this information from the data so it is another limitation in my study.

In addition, I used the American Council for an Energy Efficient Economy's (ACEEE) 2009 State Energy Efficiency Scorecard to control for regional energy efficiency awareness. In this dataset, states are ranked according to six different criteria, including an appliance efficiency standards score. The appliance efficiency standards score gives states a score from 0 to 3 based on the number of appliance efficiency standards not currently preempted by federal legislation (Eldridge et al., 2009). These scores were used to indicate which survey respondents reside in states that have appliance efficiency standards and those that do not.

Regression model

I used probit regressions to investigate the effects of education and ethnicity, as well as the interaction effects of education and ethnicity on the purchase of Energy Star refrigerators in the sample. My theoretical model is:

$$\text{Pr}(\text{Energy Star appliance purchase}) = \beta_0 + \beta_1(\text{education}) + \beta_2(\text{Hispanic ethnicity}) + \beta_3(\text{education X Hispanic ethnicity}) + \beta_4(\text{household income}) + \beta_5(\text{age}) + \beta_6(\text{state appliance efficiency standard}) + \varepsilon$$

where the dependent variable is the probability that the household purchased an Energy Star refrigerator. The main independent variables are: (1) education levels, operationalized as indicator variables for educational attainment in five categories with a baseline category of no schooling;

(2) Hispanic identity, an indicator for Hispanic ethnicity with a baseline category of non-Hispanic; and (3) the interaction variables for education level X Hispanic identity. The control variables are: (1) household income, coded as indicators for household gross income in quartiles, (2) age, coded as indicators for householders' age in quintiles, and (3) state appliance energy efficiency standards, an indicator variable that indicates whether or not a survey respondent resides in a state that has appliance efficiency standards not preempted by federal standards. Last, ϵ represents the error not accounted for by the model. (See Table 1 for a description of variables.)

Model specifications

Dependent variable

Knowledge and adoption of energy efficient technology was measured by household awareness and purchase of Energy Star refrigerators. The surveyors asked households whether they carried a refrigerator(s), how old it was, and whether it was recently replaced upon moving into the residence. Furthermore, respondents were asked whether the appliance was labeled as an Energy Star appliance. Responses to this question were recorded as “yes,” “no,” “don’t know,” or “refusal” by the surveyors. Only those responses that confirmed Energy Star label awareness and refrigerator purchase were included in the sample.

I selected the purchase of Energy Star refrigerators as the dependent variable due to its relevance to my theoretical model and U.S. energy policy. When compared to other appliances, the price range for refrigerators is higher than other household appliances like clothes washers and dishwashers making it a significant purchase for consumers. I assume that consumers are more likely to access information gathering strategies from educational and cultural associations when making larger purchases than smaller ones. Furthermore, refrigerators are prominently displayed in kitchens making aesthetics and prestige potential factors for decision-making. Since

prestige seems to be an important purchasing consideration for Hispanic Americans, testing refrigerator purchase might help explain if and why Hispanic Americans are less likely to purchase Energy Star refrigerators than non-Hispanic Americans.

In terms of policy relevance, refrigerators are one of the top energy consumption appliances in households making them an important policy concern. According to the Consumer Energy Center, on average, a refrigerator uses 13.7% of a home's energy use (second only to air conditioners). While air conditioners were considered for this research, sample sizes for recently replaced air conditioning units yielded too few observations to analyze the data with significant results. Thus, given policy and model relevance, as well as data constraints, refrigerators were the best fit for analysis.

Independent variables

Cultural attributes of prestige goals and word of mouth communication strategies were measured by household responses to a self-identification question on ethnicity. Specifically, householders were asked, "Are you Hispanic or Latino?" (Berry, 2013, p. 84). Responses were recorded as "yes" or "no."

Similarly, objective information-gathering and decision-making strategies were measured by household responses to a question on education level. Surveyors asked householders to identify the highest level of education they had completed. Responses ranged from no schooling to a doctorate degree. Differing levels of educational attainment were collapsed into categories because distinctions among certain levels were not predicted to have different effects. For example, respondents that answered they had completed kindergarten through grade 12 and those that answered they had a high school diploma or GED equivalent were represented in the same category. Additionally, those respondents that answered they had completed some college, but no

degree or completed an associate's degree were also represented in the same category. Lastly, respondents that reported completing a master's degree, professional degree, or doctorate degree were represented in the same category as the differences in educational effects on decision-making at these levels were predicted to be marginal.

Respondents that completed a bachelor's degree remained in a separate category to account for educational gains from completing a four-year program. The baseline category for this variable, "no schooling," also remained a separate category because these respondents represented a control for the sample not having completed any level of schooling (J. Berry, personal communication, January 21, 2014).

Operationalization of interaction variables

Interaction variables were added to the model specification to measure the direction of the effect between education and Hispanic ethnicity on energy efficient appliance knowledge and purchase. These variables were derived by multiplying the self-reported Hispanic ethnicity indicator and education level variables.

Control variables

Household income, age and regional awareness were included in the model as they could be correlated with cultural attributes, lower barriers to information acquisition, and the adoption of energy efficient technology. First, a household's income may account for differences in culture, education and energy efficient technology purchase. In terms of culture, income plays a major role in choice of residence and influences association in social groups. Income also constrains or expands choices for education and appliance purchase. To control for these effects, respondents were asked to estimate their 2009 gross household income in one of 24 income categories. Responses were divided into income range quartiles to determine if information gathering and

purchasing decisions through education and ethnicity operate differently at different levels of household income.

Second, a household's age could explain cultural attributes, information acquisition strategies, and knowledge and adoption of energy efficient technology. Similar to household income, age influences association in different social groups with varying information gathering strategies and communication networks. Age is also associated with certain education levels. Last, in terms of Energy Star label awareness and purchase, age may play a role in energy efficiency awareness given that refrigerators first qualified for the Energy Star label in 1996 (Energy Star, 2014). Hence, younger respondents may be more aware of the label than older respondents who started to make purchasing decisions before refrigerators qualified for the label and before the Energy Star program started in 1992. To control for age, respondents were asked how old they were and their responses were recorded to the year except for householder's reporting to be 85 or older, which were recorded as 85 years old. Respondents' ages were divided into quintiles to observe the effects of education and ethnicity at different age ranges.

Last, I controlled for state appliance efficiency standards because it could explain the propensity for Energy Star appliance awareness and purchase, as well as cultural and educational attainment levels through state awareness initiatives or incentives. An indicator for whether the state in which the survey respondent lived had appliance efficiency standards not preempted by federal legislation was added to the regressions.

Table 1. Description of independent, dependent, and control variables

Variable name	Variable description	Minimum and maximum values	Center	Dispersion in Variation Ratios	Shape	No. of missing obs	Overall sample size
Energy Star refrigerator	Energy Star refrigerator purchase with label knowledge	0 = No, 1 = Yes	1 = Yes at 2,356	18%	1 mode	0	2,873
Hispanic or Latino ethnicity	Hispanic or Latino ethnicity	0 = No, 1 = Yes	0 = No at 2,406	16.25%	1 mode	0	2,873
No schooling	No schooling completed	0 = No, 1 = Yes	0 = No at 2,821	1.81%	1 mode	0	2,873
High school	K-grade 12 completed and/or high school diploma or GED	0 = No, 1 = Yes	0 = No at 1,884	34.42%	1 mode	0	2,873
College	Some college, no degree or Associate's degree	0 = No, 1 = Yes	0 = No at 1,977	31.19%	1 mode	0	2,873
Bachelor	Bachelor's degree	0 = No, 1 = Yes	0 = No at 2,310	19.6%	1 mode	0	2,873
Master	Master's, professional or doctorate degree	0 = No, 1 = Yes	0 = No at 2,500	12.98%	1 mode	0	2,873
Hispanic American & no schooling	Hispanic American with no schooling	0 = No, 1 = Yes	0 = No at 2,843	1.04%	1 mode	0	2,873
Hispanic American & high school	Hispanic American with K-12 and/or high school diploma or GED	0 = No, 1 = Yes	0 = No at 2,616	8.94%	1 mode	0	2,873
Hispanic American & college	Hispanic American with some college, no degree or Associate's degree	0 = No, 1 = Yes	0 = No at 2,756	4.07%	1 mode	0	2,873
Hispanic American & bachelor's	Hispanic American with bachelor's degree	0 = No, 1 = Yes	0 = No at 2,836	1.29%	1 mode	0	2,873
Hispanic American & master's	Hispanic American with Master's, professional or doctorate degree	0 = No, 1 = Yes	0 = No at 2,847	0.9%	1 mode	0	2,873
Household income	2009 gross household income	1 = <\$2,500- \$29,999 2 = \$30k- \$54,999 3 = \$55k- \$94,999 4 = \$95k-\$120k+	2 = \$30k-\$54,999 at 738	74.31%	Even distribution	0	2,873
Age	Age of householder	1 = 18-35 yrs of age 2 = 36-45 yrs of age 3 = 46-53 yrs of age 4 = 54-63 yrs of age 5 = 64-85+ yrs of age	2 = 36-45 yrs of age at 591	79.43%	Even distribution	0	2,873
State appliance efficiency awareness	State currently has appliance efficiency standards not preempted by federal law	0 = No, 1 = Yes	0 = No at 1,758	38.81%	1 mode	0	2,873

Source: U.S. Energy Information Agency. (2013) 2009 Residential Energy Consumption Survey [Dataset and codebook]. Retrieved from

<http://www.eia.gov/consumption/residential/data/2009/index.cfm?view=microdata>

Overall sample size= 2,873

Method of Analysis

I performed two regression analyses to determine the best model to explain energy efficient purchases. The first probit model (Regression 1) estimated the effects of education and Hispanic ethnicity on Energy Star refrigerator purchase controlling for income, age and regional energy efficiency appliance awareness. The second probit model (Regression 2) estimated the effects of education, Hispanic ethnicity and the interaction between education and ethnicity on Energy Star refrigerator purchase with the same controls as Regression 1.

Using maximum likelihood estimation, I estimated coefficient values for the independent variables, the corresponding standard errors, and overall statistical significance for education and ethnicity. The coefficient estimates showed whether the effect of the variables were positive or negative on the propensity to purchase; the standard errors were used to detect statistical significance for each estimate; and adjusted Wald tests were used to determine whether education overall and ethnicity were useful predictors of Energy Star refrigerator purchase.

In addition, I estimated average marginal effects of the key independent variables for several sets of covariate values in order to fully assess the effect of education and Hispanic identity on specific households. I identified the characteristics of first time and new homebuyers assuming these populations would be most likely to purchase refrigerators. According to information from the American Housing Survey, first time homebuyers in 2009 were on average 34 years old with a household income of \$67,342, while new home buyers were on average 42 years old with a household income of \$101,811 (Taylor, 2010). Hence, for post-estimation analyses, I selected respondents between 36 and 45 years of age with household income ranges between \$55,000 and \$94,999 and above \$95,000 to capture a range of potential consumer characteristics. I also selected householders with completed education from high school to a bachelor's degree since these were the most prominent levels of schooling completed for the subpopulation.

RESULTS

The results from the regression and post-estimation analyses suggested a limited, but significant effect of Hispanic identity on energy efficient purchasing. Both regressions yielded evidence to support the hypothesis that Hispanic ethnicity lowered the propensity for purchasing Energy Star refrigerators among U.S. households. Furthermore, post-estimation analyses suggested that Hispanic ethnicity was negatively associated with energy efficient purchases only for some households at varying education and income levels.

Regression 1 Results

Without the interaction terms in the model, householder identification with Hispanic ethnicity was negatively associated with Energy Star refrigerator purchase. The significance test for Hispanic identity suggested that ethnicity was useful predictor of purchase at the $p < 0.05$ level ($F = 4.76$, $d.f. = 243$, $p = 0.0301$). See Table 2. By contrast, householder education was positively associated with Energy Star refrigerator purchase. However, this association was not significant at the $p < 0.05$ level. Using an adjusted Wald test for all education levels not including “no schooling”, I also found that education was not a significant predictor of Energy Star refrigerator purchase ($F = 1.01$, $d.f. = 240$, $p = 0.405$). Coefficient estimates for control variables were positively associated with Energy Star refrigerator purchase and significant at $p < 0.01$ levels.

Table 2. Probit regressions of education & ethnicity on Energy Star refrigerator purchase

	Regression 1	Regression 2
constant	-0.104 (0.224)	-0.0263 (0.314)
high school	0.268 (0.211)	0.199 (0.311)
college	0.328 (0.203)	0.222 (0.299)
bachelors	0.356* (0.210)	0.261 (0.306)
masters	0.399* (0.224)	0.337 (0.307)
Hispanic ethnicity	-0.192** (0.881)	-0.335 (0.438)
Household income \$30k-\$54,999	0.388*** (0.091)	0.389*** (0.091)
Household income \$55k- \$94,999	0.621*** (0.096)	0.618*** (0.096)
Household income >\$95k	0.716*** (0.106)	0.717*** (0.107)
Householder 36-45 years old	0.369*** (0.091)	0.380*** (0.091)
Householder 46-53 years old	0.513*** (0.100)	0.523*** (0.100)
Householder 54-63 years old	0.340*** (0.099)	0.346*** (0.098)
Householder 64-85 years old	0.346*** (0.097)	0.350*** (0.097)
State energy efficient appliance standards in place	0.167*** (0.064)	0.168*** (0.064)
Hispanic*high school	-	0.0789 (0.455)
Hispanic*college	-	0.304 (0.477)
Hispanic*bachelors	-	0.268 (0.557)
Hispanic*masters	-	-0.152 (0.621)
F-test overall	11.82***	9.28***
N	2873	2873

Note: Energy Star refrigerator purchase tests are adjusted Wald tests.

Note: Standard errors in parenthesis.

*** Significant at $p < 0.01$

** Significant at $p < 0.05$

* Significant at $p < 0.1$

Regression 2 Results

When the interaction terms were added to the model, the coefficient estimates for education and Hispanic ethnicity decreased. Again, education estimates showed a positive association with Energy Star refrigerator purchase, and Hispanic identity estimates indicated a negative association with purchase. The interaction terms for education and ethnicity showed mixed results. Identifying as Hispanic American and having completed high school, some college, or a bachelor's degree was positively correlated with Energy Star refrigerator purchase. Nevertheless, identifying as Hispanic American and having completed a master's degree was negatively associated with purchase. None of the interaction terms were significant at the $p < 0.1$ level.

Adjusted Wald tests for education and ethnicity showed similar results as in Regression 1. The results suggested that there was no correlation between having completed some level of education and Energy Star refrigerator purchase ($F=0.95$, d.f.= 236, $p= 0.4766$). For Hispanic ethnicity, again, the test results suggested that Hispanic identity was a useful predictor of Energy Star refrigerator purchase at the $p < 0.1$ level ($F=1.93$, d.f.= 239, $p= 0.0906$). Finally, I tested the interaction terms to determine if they were useful predictors of Energy Star purchase. The results were not statistically significant suggesting that Regression 1 is a better fit for the data ($F=0.85$, d.f.= 240, $p= 0.4973$).

Notably, the standard errors for Hispanic ethnicity were much larger in Regression 2, along with the standard errors for all interaction term estimates probably due to small sample sizes. These errors suggest that the true coefficients for the population are anywhere within a wide interval making them more difficult to predict accurately with this regression model.

Post-Estimation: Average marginal effects for higher income households

The regression results suggested that Hispanic ethnicity may be a useful overall predictor of Energy Star refrigerator purchase, or more specifically, that it was associated with a lower propensity to purchase these energy efficient products. However, post-estimation analysis of the effect of Hispanic ethnicity on subpopulations with varying characteristics showed a more nuanced effect of cultural context on purchase. Table 3 shows the average marginal effects for households with similar characteristics as first time and new homebuyers.

The significant average marginal effects of Hispanic ethnicity on Energy Star refrigerator purchase ranged between -.0297 to -.0439 for Regression 1. They ranged between -0.043 to -0.059 for Regression 2. These effects were small but also suggest a lower propensity for Energy Star refrigerator purchase. In addition, the average marginal effects of Hispanic ethnicity were more negatively associated with Energy Star refrigerator purchase when householders had completed high school versus some college in Regression 1. This observation supports the part of my theory that asserts that higher education levels are associated with a higher propensity for Energy Star appliance purchase, though the overall effect remains negative for Hispanic respondents.

In Regression 1, the effect of identifying a Hispanic ethnicity was significantly associated with a lower propensity to purchase Energy Star refrigerators in cross sections of the sample having completed up to an associate's degree. By contrast, average marginal effects estimated in Regression 2 suggested that Hispanic ethnicity was a significant predictor of Energy Star refrigerator purchase only for householders that had completed schooling up to a high school diploma. These findings suggest that for a specific population of householders having completed up to high school with 2009 household incomes at or above \$55,000, Hispanic ethnicity had a significant and negative association with Energy Star refrigerator purchase.

Table 3. Average marginal effects of Hispanic ethnicity for select household characteristics in higher income quartiles

No.	Education Level Completed	Income Range	Age Range	Residing in state w/ energy efficiency appliance standards ?	Average marginal effect without the interaction term (Reg. 1)	Average marginal effect with the interaction term (Reg. 2)
1	High School	\$55,000-\$94,999	36-45 years	No	-.0439* (.022)	-.0593* (.030)
2	High School	\$55,000-\$94,999	36-45 years	Yes	-.0363* (.018)	-.0491* (.024)
3	High School	\$95,000<	36-45 years	No	-.0395* (.020)	-.0532* (.026)
4	High School	\$95,000<	36-45 years	Yes	-.0322* (.016)	-.0434* (.021)
5	Some college	\$55,000-\$94,999	36-45 years	No	-.0411* (.021)	-.0061 (.036)
6	Some college	\$55,000-\$94,999	36-45 years	Yes	-.0337* (.017)	-.0050 (.029)
7	Some college	\$95,000<	36-45 years	No	-.0368* (.019)	-.0054 (.032)
8	Some college	\$95,000<	36-45 years	Yes	-.0297* (.015)	-.0043 (.026)
9	Bachelors	\$55,000-\$94,999	36-45 years	No	-.0399 (.020)	-.0131 (.060)
10	Bachelors	\$55,000-\$94,999	36-45 years	Yes	-.0325 (.017)	-.0105 (.049)
11	Bachelors	\$95,000<	36-45 years	No	-.0356 (.018)	-.0116 (.053)
12	Bachelors	\$95,000<	36-45 years	Yes	-.0286 (.015)	-.0092 (.042)

Note: Standard errors in parenthesis.

*Significant at the p<0.05 level.

Post-Estimation: Average marginal effects for lower income households

I also conducted post-estimation analysis for analogous hypothetical households at lower income levels to determine if the effect of Hispanic ethnicity and varying education levels on purchasing propensity was consistent despite differences in household budget constraints. The effect of Hispanic ethnicity was similar for all head of households that completed education up to grade school, but differed when the head of household completed higher education levels and reported a lower household gross income.

The significant average marginal effects for Hispanic identity on Energy Star refrigerator purchase ranged from -.0429 to -.0697 in Regression 1. In Regression 2, the significant average marginal effects ranged from -.063 to -.0931. (See Table 4.) These effects were larger in lower income households than for higher income households suggesting that Hispanic consumers are less likely to purchase Energy Star refrigerators than non-Hispanic consumers at similar income levels, as well as Hispanic consumers at higher household incomes.

In Regression 1, Hispanic identity was a significant predictor of purchasing Energy Star refrigerators for all householders in the lowest income quartile (below \$2,500-\$29,999). For households in the second income quartile (\$30,000-\$54,999), Hispanic identity was a significant predictor of energy efficient refrigerator purchase only if the householder had completed some schooling between grade school to a bachelor's degree. These results suggest that Hispanic identity is a significant factor in purchasing Energy Star refrigerators not only for householders having completed high school but also consumers with a bachelor's degree when household income is below \$55,000.

In Regression 2, the average marginal effects of Hispanic identity for varying education levels and lower income quartiles were similar to those for households at higher income quartiles. Hispanic identity was a significant predictor of Energy Star refrigerator purchase only for households where the survey respondent completed at most a high school degree.

Table 4. Average marginal effects of Hispanic ethnicity for select household characteristics in lower income quartiles

No.	Education Level Completed	Income Range	Age Range	Residing in state w/ energy efficiency appliance standards ?	Average marginal effect without the interaction term (Reg. 1)	Average marginal effect with the interaction term (Reg. 2)
1	High School	< \$29,999	36-45 years	No	-.0697* (.032)	-.0931* (.043)
2	High School	< \$29,999	36-45 years	Yes	-.0639* (.029)	-.0855* (.039)
3	High School	\$30,000- \$54,999	36-45 years	No	-.0546* (.026)	-.0733* (.035)
4	High School	\$30,000- \$54,999	36-45 years	Yes	-.0469* (.022)	-.0630* (.030)
5	Some college	< \$29,999	36-45 years	No	-.0677* (.031)	-.0105 (.062)
6	Some college	< \$29,999	36-45 years	Yes	-.0615* (.028)	-.0094 (.056)
7	Some college	\$30,000- \$54,999	36-45 years	No	-.0518* (.025)	-.0078 (.046)
8	Some college	\$30,000- \$54,999	36-45 years	Yes	-.0441* (.217)	-.0066 (.039)
9	Bachelors	< \$29,999	36-45 years	No	-.0668* (.031)	-.0227 (.102)
10	Bachelors	< \$29,999	36-45 years	Yes	-.0604* (.028)	-.0203 (.092)
11	Bachelors	\$30,000- \$54,999	36-45 years	No	-.0506* (.025)	-.0168 (.076)
12	Bachelors	\$30,000- \$54,999	36-45 years	Yes	-.0429* (.021)	-.0140 (.064)

Note: Standard errors in parenthesis.

*Significant at the p<0.05 level.

DISCUSSION

The Energy Star program is one of the most successful programs in promoting energy efficiency among U.S. consumers. In 2000, Energy Star label awareness among U.S. households was about 40%. By 2009, U.S. household label recognition jumped to 77% (EPA Office of Air and Radiation, 2010). Though this increase in awareness is encouraging, label awareness and energy efficient purchases among different segments of the population are still unequal and result in unrealized energy savings.

Studying the effects of education and Hispanic ethnicity on Energy Star refrigerator purchasing decisions, the results of the regression models suggest that these effects are limited. While education was positively associated with purchase, education as an independent variable was not a useful predictor of purchase when controlling for income, age and state of residence in both regressions. Neither was the interaction term from Regression 2. These findings suggested that educational effects and interaction effects on individual purchasing decisions for Energy Star refrigerators were not suitable explanations for consumer behavior. Hence, my hypotheses regarding education and the interaction between education and Hispanic identity were incorrect in this study.

However, the evidence suggested that Hispanic ethnicity alone was negatively and significantly correlated with Energy Star refrigerator purchase in both regressions. Even when controlling for income, age and state of residence, identification with Hispanic descent was a useful predictor of purchase as stated in my hypothesis. If this is true for U.S. households, the cultural effects of Hispanic ethnicity could help explain lower purchasing propensities of Energy Star appliances among Hispanic consumers.

The post-estimation results further suggested that Hispanic ethnicity was important for predicting a lower propensity to purchase Energy Star refrigerators for a subpopulation of the sample: notably those between 36 and 45 years of age, across all income levels and having

completed schooling up to a high school diploma or equivalent. These findings have policy implications for energy efficient programs targeting current and future U.S. households.

With a growing proportion of the U.S. population identifying as Hispanic American, a cultural explanation of Energy Star adoption has policy implications for U.S. household energy use. A lower propensity to purchase in growing Hispanic communities, if sustained, would lead to lower Energy Star purchases and higher energy consumption and costs. My study suggests that the communication and decision-making strategies for Hispanic consumers lead to a lower propensity for energy efficient appliance purchase. It also suggests that previous Energy Star marketing was not as effective for Hispanic consumers as it was for non-Hispanic consumers in the U.S.

To address this challenge, the Environmental Protection Agency may consider adopting different informational campaigns to target Hispanic households that are likely to replace their refrigerators in the near future. This may include promoting the use of Spanish media for Energy Star label and product advertising by vendors, and other strategies proven to be successful in Hispanic consumer markets (Murray & Mills, 2011). To target future first time homebuyers, the EPA may also consider partnering with high schools to distribute information regarding energy efficient resources and the Energy Star program.

In addition, reinstating Energy Star appliance rebates could be a useful tool in persuading marginal households to purchase more energy efficient technology. The American Recovery and Reinvestment Act instituted rebates in 2009, offering them to every household rather than targeting those households that are less likely to purchase the appliances. The program closed in 2012 (U.S. Department of Energy, 2013).

While offering these benefits only to U.S. Hispanic consumers would not be feasible, another approach would be to target subpopulations where Hispanic consumers may be overrepresented such as in lower-income levels and rental arrangements. Tax credits could be used to induce

landlords to purchase Energy Star appliances for their renters to lower long-term energy use and costs (Murray & Mills, 2011; Mills & Schleich, 2012). These examples highlight the need to develop policies with voluntary consumer schemes with enough flexibility to address the differences in informational awareness and decision making of different subpopulations.

It is important to note, however, that these findings apply to a specific subpopulation of U.S. households and hence should be carefully generalized to larger contexts. My study included only U.S. households that owned at least one refrigerator, knew whether or not their refrigerator had an Energy Star label, and had replaced their refrigerator in the last five years. Educational and cultural effects of Hispanic identification may operate differently with varying characteristics. For example, the effects on purchasing washing machines or dishwashers could be different than that on purchasing refrigerators since those appliances may be cheaper to purchase, less of a necessity for the household, or more important in terms of specific convenience features.

Furthermore, there are some limitations with regards to measuring the cultural mechanism of Hispanic ethnicity. The effects of ethnicity on purchasing decisions may differ by country of descent due to diverse communication strategies. Also, householders that grew up in the U.S. versus a foreign country may have different perceptions of energy efficient labeling and may participate in different social settings that affect their purchasing decisions. This may be due to different levels of acculturation (Deshpande, Hoyer, & Donthu, 1986; Saegert, Hoover, & Hilger, 1985; Kara & Kara, 1996). Acculturation, or assimilation, refers to the process by which an individual from one country adopts the culture, values and behavior of individuals in another country. The more acculturated individuals become the more they adopt the attitudes and values of individuals in the host country (Kara & Kara, 1996). This process could have implications for this study. Nevertheless, the data for Hispanic descent still demonstrated an important difference between the purchasing behavior of Hispanic and non-Hispanic households. This difference should be studied further in broader contexts.

Future research in energy efficient purchasing behavior should also continue to explore characteristics of households, as well as more detailed analyses of cultural effects. How do other ethnic affiliations affect purchasing decisions? Does acculturation matter in predicting purchasing decisions? Is a head of household more likely to purchase an Energy Star refrigerator also more likely to purchase other Energy Star household appliances? What about electronics? U.S. consumers are a diverse population from different ethnicities to different income levels and age. In all, they compose an array of subpopulations with unique cultural contexts that affect purchasing decisions and energy consumption. Understanding these contexts and the extent to which they affect future consumption of existing and future energy-intensive technologies is an important research endeavor for energy and environmental policy.

CONCLUSION

I investigated the effects of education and Hispanic ethnicity on purchasing decisions for Energy Star refrigerators among U.S. households. Different variations on regression results and post estimation showed that Hispanic ethnicity predicts a lower propensity for Energy Star refrigerator purchase for U.S. households whom have replaced their refrigerator in the last 5 years and have completed some schooling up to the high school level. Similar to findings in other studies, the cultural context in which householders participate in seems to have an effect on energy efficient appliance purchasing choices, albeit small, and at least specifically for householders identifying Hispanic ethnicity. Further research is needed to support or negate this theory. If results continue to find associations between Hispanic ethnicity and lower Energy Star refrigerator purchasing propensity, policymakers can implement more targeted changes to address gaps in energy efficient technology adoption. In the long run, these efforts would generate considerable savings in energy, financial costs, and environmental protection.

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