What Factors Influence Consumers' Decisions to Purchase Energy Star Appliances?

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Abstract

This paper examines how differences in operating costs and market availability affect ownership of Energy Star dishwashers and clothes washers. I use logistic regressions and data from the 2009 Residential Energy Consumption Survey and the EPA's Energy Star program to quantify these effects. Results indicate that controlling for temporal changes is very important; after doing so I find that differences in availability of efficient appliances do not affect ownership patterns. Overall, the frequency of appliance use does not increase the household's responsiveness to electricity prices, which suggests that consumers do not fully value efficiency when choosing among appliances.

The average household in the United States uses two thirds of the electricity it consumes to power appliances.[1] This percentage has grown over the past decades despite dramatic efficiency improvements in appliances. This trend demands the attention of those working to reduce energy consumption in the residential sector and so, in 1992, the Environmental Protection Agency (EPA) launched the Energy Star program to address this concern. Energy Star is a voluntary participation program where qualifying appliances must meet a minimum efficiency standard for resource use. The program also requires that products remain competitive in all other attributes and that any changes in price be recoverable in energy savings within a reasonable payback period.[2] The Department of Energy (DOE) joined this program in 1996 and helped expand it from office equipment into large residential appliances including refrigerators, dishwashers, and clothes washers. Researchers estimated that the program saved 4.8 exajoules (EJ) of primary energy by 2006, and it is estimated that it will save 12.8 EJ by 2015 (Sanchez et al. 2008).[3]

Significant funding and effort have gone into supporting and promoting the Energy Star program. This paper seeks to understand what factors influence a household's decision to purchase Energy Star appliances. Specifically, I focus on how appliance operating cost, information, and access to efficient options affect consumers' demand for Energy Star clothes washers and dishwashers. As clothes washers and dishwashers become more common in US households, they contribute significantly to the growing percentage of energy spent on appliances. Understanding how consumers respond to efficiency improvements and market characteristics for these appliances is necessary to improve programs such as Energy Star that

[1] Appliances here include heating and cooling, refrigerators, other kitchen and recreational appliances and lighting.
[2] This is typically claimed to be 3-5 years by Energy Star. Products that do not have sufficiently short payback rates are sometimes also offered with rebates, which confounds these data slightly.
[3] An exajoule is equivalent to 10^{18} joules.

attempt to reduce this portion of energy consumption. If demand for efficiency is a function of the operating costs of the appliance, then we would expect that households facing higher electricity prices, for example, would have a higher demand for Energy Star products. In addition, if demand for efficiency is affected by characteristics of the market, such as the number of retailers with Energy Star products available, then we would expect households in regions where the products are more available to be more likely to own them.

The Energy Star program acts as a third party evaluator by labeling appliances to indicate whether they have attained a certain threshold level of efficiency. Banerjee and Solomon (2003) find such independent labels in general do not influence consumers reliably. However, Ward, et al. (2011) find that the Energy Star label in particular does influence consumers: consumers reported willingness to pay an average of $250-350 more for refrigerators that had been awarded an Energy Star label. Unfortunately, other studies on the willingness to pay for energy efficiency are not as encouraging (see Greening, et al. 1997). This paper will examine the potential effects of operating cost and market structure to influence consumers' decisions to purchase Energy Star dishwashers and clothes washers. What follows is a brief review of the Energy Star program and a summary of the literature on household appliance choice and energy consumption. Section two describes my data, and section three explains my theory and empirical approach. Section four provides summary statistics and section five details my analysis. Section six discusses the limitations of my research and potential directions for future studies and section seven concludes.

I. Literature Review

The following section is divided into two sections. The first section offers an introduction to the Energy Star program and an overview of how this program has attempted to address the market failures that characterize the appliance industry. The second section reviews papers that have studied the adoption of residential energy-efficient appliances and residential energy use.

I. a) Market Failures and the Energy Star Program

Economic theory suggests that consumers will invest in energy efficiency to the point where the marginal returns from this investment equal the marginal costs. However, the household appliance market does not operate ideally. Researchers have identified several market failures, which, they theorize, have produced the "energy paradox" of apparent underinvestment that this literature discusses in depth. Information failures, high transaction costs, market structure, and gold plating are identified as failures that characterize the appliance market (Blumstein 1980, Ruderman et al. 1987 and Niemeyer 2010).

Information is the most commonly identified failure in this market. Insufficient high-quality information can distort the market by inhibiting consumers' understanding of their potential marginal benefits and costs from an efficient appliance. For instance, if consumers do not have complete information on the reduced operating cost of the appliance because of its level of efficiency then they may overestimate the marginal cost of the purchase and thus underinvest. Alternatively, if information exists but is costly to obtain, this increases consumers' transaction cost by requiring substantial independent research to identify more efficient products. The market structure failure refers to the availability of products, which can restrict consumers' choices. In this circumstance consumers may still be investing at the appropriate level in terms of marginal benefits, but because they are not working with a complete choice set they may not have access to a preferred energy-efficient option. Finally, the fourth failure, gold plating, is a phenomenon where attributes are bundled: energy efficiency may be grouped with other costly features and not available separately. Prices of efficient appliances are then increased, which reduces consumers' investment in this feature. Under this condition, consumers may fully understand the marginal benefits of increased efficiency but be unwilling to pay the cost of the entire bundle necessary to acquire that one attribute.

Energy Star's mission is to reduce carbon emissions from energy consumption by altering the market for residential appliances.[4] To accomplish this goal the Energy Star program has taken steps to address the failures of market structure, information failures, and high transaction costs by:

1) Enticing manufacturers to produce efficient appliances so that they can participate in the program, thus increasing the supply of energy-efficient appliance options in the market.
2) Providing reliable, third-party evaluation of products' estimated savings from efficiency improvements. This helps to correct for the market's potential information failures about the degree of savings from efficiency.
3) Prominently displaying the certification label and cost savings tags to indicate products that have met the program's minimum standards. This reduces the transaction costs for consumers at the point of purchase by avoiding the need for intensive independent research on the differences between appliance models.

The Energy Star program has almost certainly introduced greater efficiency within households. For instance, the program demonstrably instigated efficiency gains for clothes washers by increasing standards to push for the horizontal axis design that was being used in

[4] http://www.energystar.gov/index.cfm?c=about.ab_index

Europe but that had been deemed “unmarketable” for the US consumer prior to Energy Star’s efforts (Paton 2005). Industry reports indicated that Americans had purchased more than three billion Energy Star appliances by 2009 (Annual Report, 2009). As for addressing the information failure and reducing transaction costs, Energy Star labeling has gained national recognition. The Consortium for Energy Efficiency (CEE) has been administering annual random sample surveys since 2000 to gauge consumer awareness of the Energy Star label. Findings from the CEE survey in 2010 indicate that 83 percent of respondents recognized the Energy Star label.[5] A nearly identical 84 percent of respondents had a general understanding of what the logo meant. This is strong evidence in support of the label’s ability to provide information on a national scale.

The Energy Star program plan does not specifically address the potential of gold-plating. Though it stipulates that prices must be comparable to similar models, it does not specify that the energy-efficient feature must exist across all price ranges of a manufacturer’s products. At least one researcher has already noted the existence of gold-plating in Energy Star products. Paton (2005) finds that, in the clothes washer industry, Energy Star requirements resulted in a two-tiered standard for energy efficiency.[6] The differentiated system created was a split in the industry so that efficient models capture “a significant market premium” on high-end appliances, but Energy Star products do not appear regularly at the lower end of the cost spectrum (Paton 2005).

I. b) Residential Adoption of Efficient Appliances

The seminal works on energy efficiency and demand for energy-consuming durables are Hausman (1979) and Dubin and McFadden (1984). These papers focus on implied consumer discount rates and short-run elasticities of demand. Hausman examines consumers’ choice of

[5] This was when individuals were aided with a visual; 72 percent of those surveyed knew of Energy Star unaided.
[6] This is attributed to the tax credits system, which was available for manufacturing firms on a per-unit-produced basis at a rate that reflected the tier of the product produced.

efficient air conditioners. Using data on air conditioner prices and energy efficiency, he measures consumers' willingness to trade higher up-front appliance cost for lower future operating expenses. Omitting consumer expectations about future prices or technological improvements, he finds that consumers are willing to invest in energy-efficient technologies, but only with very short payback periods. This produces high implied discount rates of about 20 percent, which vary inversely with income.

The greatest contribution of Hausman's paper is his model, which calculates the probability that a consumer will choose a specific appliance based on a derived indirect utility model. The empirical specification for my research is derived from this model and elaborated in section three. Dubin and McFadden (1984) build on Hausman's work by translating the engineering thermal load model to an economics-friendly formula, which allows the use of variables most often found in household survey data. Their model assumes concurrent decisions about appliance stock and intensity of use, which they note is only realistic if we can assume perfectly competitive rental markets for consumer durables (where "rental" prices are the annualized costs for the appliance).

Rapson (2011) relaxes Dubin and McFadden's restrictive assumption of appliance rental markets by employing a dynamic discrete choice model for air conditioner purchase, which incorporates intensity of use that varies with price of electricity and energy efficiency. His results indicate that demand for air conditioners increases with added energy efficiency. He reports elasticity of unit demand with respect to efficiency ranging from 0.7 to 1.0 for central air conditioners and from 0.2 to 0.3 for window/wall units. The relatively high elasticities Rapson reports indicate that consumers are generally forward looking in their purchases. In terms of operating cost, Rapson finds that increased electricity prices lower current energy consumption, but that they have a relatively weak long-term effect on demand for appliance units. Rapson's research is based on earlier years of the same data set I use (the Residential Energy Consumption Survey). Rapson, however, is limited by the complexity of his model and so cannot consider all relevant data. For instance, he relies on only a subsample of data that eliminates newly constructed homes and non-house owners, which potentially limits the responses he observes to changes in energy efficiency. In addition, his measure of efficiency is a two-year national average applied to all units purchased in that time frame. The Energy Star label available in more recent survey years offers an interesting alternative to his approach. Whereas Rapson must assume that individuals are aware of the average efficiency of the appliances they purchased and that they responded to this variation over time, I can identify the effect of a well-publicized and very visible label that uniformly marks a threshold of efficiency. The Energy Star label allows me to relax Rapson's implicit assumptions about consumer information.

Expanding the topic of energy-efficient choices beyond air conditioners, Ruderman, et al. (1987) applied this model to a variety of appliances, including several styles of furnaces and boilers as well as refrigerators and freezers. The first part of their paper estimates market elasticities and discount rates for efficient appliances. The second part estimates logistic regressions to examine what factors influence consumers' decisions to install efficient heating and cooling systems in new residences. They use data from the DOE when the department was in the process of debating energy efficiency standards that later became the Energy Star standards. Their paper examines the top energy-using appliances of the time, but this does not include dishwashers or clothes washers. Based on their very large estimated discount rates (ranging from 20 to 800 percent), Ruderman, et al. conclude that the appliance market does not operate efficiently. Though they discuss several potential market failures they do not have the opportunity to study the effects of a program designed to adjust market behavior like the Energy Star program.

Lyon (2010) is one of the few papers to look at clothes washer and dishwasher ownership specifically. He uses logistic regressions on a data set of appliance holding in Ireland to examine the household characteristics that influence appliance holding for all major residential appliances and the energy consumption of these households (controlling for appliance stock). Lyon presents a review of demographics for the population that owns various types of appliances, and the effect of these appliances on the households' energy use. However, this paper is very limited in its data and is not able to distinguish between efficient and standard appliances. As a result, Lyon does not address the question of which factors influence choices for energy-efficient versus standard models.

The discount rates discussed in this literature can be considered intuitively as approximating how consumers value the ratio of capital costs to expected operating costs. High discount rates imply that these ratios are top-heavy, with consumers valuing the initial capital price relatively more than the expected future operating price. The majority of the literature on discount rates confirms the findings of Hausman as well as Dubin and McFadden: consumers act on high discount rates, and thus implicitly place low weight on operating costs. The focus on heating and cooling within the broader literature makes sense because these appliances account for a significant portion of residential appliance energy use. However, the prevalence of other appliances such as clothes washers and dishwashers is increasing, which makes them more relevant subjects for study than they were previously.

My paper contributes to the body of work on consumer choices for energy-efficient durable goods by studying households' response to operating costs specifically for clothes washers and dishwashers. I examine the influences that specific changes in the appliance market structure introduced by the Energy Star program have on household ownership. As clothes washers and dishwashers become more common in US households they contribute significantly to the growing percentage of energy spent on appliances. Understanding how consumers respond to efficiency improvements and market characteristics for these appliances is necessary to improve programs such as Energy Star that attempt to reduce this portion of energy consumption.

II. Data

I use data from the 2009 Residential Energy Consumption Survey (RECS). The 2009 RECS, administered by the Energy Information Administration (EIA), includes responses from 12,083 households, with details on the households' appliance stock, how frequently they use their major appliances, and whether or not they are Energy Star certified. The survey also includes a categorical variable for the age of appliance, which allows me to look at differences among Energy Star appliances purchased less than two years ago, from two to four years ago, and from five to nine years ago. This data set does not include any details about the purchase price of the appliance. At the time of this analysis, the 2009 RECS data had been only partially released so I had only the portion of the survey that dealt with the household's energy use habits and demographics, but not their utility expenditure information, or price of electricity.

To insure confidentiality, RECS does not release the specific location for any households. The 2009 survey, however, identifies sixteen states where the responding population was sufficiently large. I limit my sample to households in these reporting states so that I can match RECS data with supplementary variables at the state level. I further limit my analysis to dishwashers and clothes washers, as these major appliances have the greatest variation in frequency of use and therefore enable me to model the effect of operating cost on demand.[7] After dropping individuals who responded “don’t know” to whether or not they own an Energy Star appliance, this leaves me with a sample population of 4,075 respondents holding clothes washers, and 2,835 respondents holding dishwashers.

The original data set provides a categorical variable with five levels for frequency of appliance use. However, the least frequent users and most frequent users are rare and limit the power of these dummy variables. I combine the lowest with the second lowest frequency and the highest with the second highest frequency variables to generate three levels for frequency of use for each appliance. These levels are categorized as: less than five times per week, five to nine times per week, more than ten times per week. This combined variable definition has the added benefit of increasing my observations in these categories across the age-of-appliance categories and across states.

I supplement these RECS data in two key ways. First, I add two measures of electricity price. The first is averaged state electricity prices during the period of years when the appliance was purchased (in 2009 dollars). I use this as the average price of energy facing consumers when they made their purchase decision. If consumers calculate the future discounted operating costs by assuming that electricity price will stay constant, then this variable will allow us to capture the effect of energy price on their decision-making. The second measure of electricity price is the state-average price in 2009, when the survey was conducted. I test the power of this variable for calculating operating cost, because, if consumers are forward-looking, then they might have responded to future expected operating costs at the point of purchase. This logic assumes that

[7] These appliances contrast with refrigerators, which operate continuously and therefore demonstrate far less variability in operating costs.

consumers were able to predict electricity prices relatively accurately when they purchased the appliance. In states that have had relatively stable electricity prices since 2002, this variable will be approximately equivalent to the state averaged price from the time of appliance purchase, and the models should present very similar results. The 2009 measure also has the advantage of only varying by state, which gives me a metric by which to examine the total variation across states that remains unaccounted for by differences in these prices.

Averaging prices in this way has the potential to obscure fluctuation in price that could influence consumers' behavior. For instance, some researchers have noted that consumers may delay large energy-using durable purchases under noisy energy price signals (Bushnell and Mansur 2005, Edlestein and Kilian 2009). If prices are relatively unstable over the period, or trending strongly upward or downward, then consumers may respond to this directionality or uncertainty when making a durable purchase. To address these possibilities I also include a measure of the standard deviation of energy prices over the span of years that are averaged for the given age bracket. Using this variable allows me to identify any differences in ownership trends associated with variation in energy prices instead of a given level of price.

The second key way I supplement the RECS data is by including two additional market characteristics for Energy Star products. As mentioned previously, the Energy Star program hopes to improve access to and information about efficient appliances. To serve this mission, the Energy Star program registers "partners" who have engaged in substantial efficiency improvements according to Energy Star standards, and organizations that sell or promote Energy Star appliances. The EIA maintains a database of these partners and of retailers who carry Energy Star appliances. I use this database to construct two variables that represent the number of Energy Star partners in each state per 100,000 inhabitants, as a measure for awareness or information availability; and the number of Energy Star retailers per 10,000 square miles in the state, as a measure of access to the appliances by residents of the state. The first variable assumes that the more registered partners in a state, the more likely a resident of that state is to have heard about Energy Star and to understand what the label means. The second variable assumes that consumer selection improves when there are a greater number of Energy Star retailers, thus allowing a household to choose an Energy Star product more readily.

III. Theory and Empirical Model

Appliances are energy-using durables, requiring energy inputs to produce a desired service in the household. They do not turn over rapidly, and major appliances have a very low saturation level, meaning a given household will be unlikely to own more than one of each major appliance. Consumers of energy-using durables maximize their utility in discrete purchase decisions as opposed to combinations and ratios of goods. The utility they gain from such a large purchase is dependent on the attributes of the appliance as well as on the particular consumer's characteristics. For example, a household with several children might prefer a clothes washer with the capacity to fit larger loads of laundry. The following theoretical derivation is consistent with Hausman as well as Dubin and McFadden but the version presented here is as developed by Train (1986).

Individuals vary in their characteristics and thus in how they value goods. Characteristics can also affect what set of goods individuals believe they have to choose among. This means the weight or value that two individuals place on similar appliances or on a similar selection of appliances also varies. A utility function for a given consumer n who considers a specific alternative of appliance model i can be defined as:

$$U_{in} = U(x_{in}, r_n) \text{ for all alternatives } i \text{ in a consumer-specific choice set } J_n \qquad (1)$$

where x_{in} is a vector that includes all characteristics of i as faced by consumer n, and r_n is a vector of all relevant characteristics of individual n that determines the value or weight the consumer places on the characteristics of alternative i. This function allows us to understand consumer choice by saying:

$$n \text{ will choose } i \text{ from } J_n \text{ iff } U(x_{in}, r_n) > U(x_{jn}, r_n) \text{ for all } j \text{ in } J_n \text{ where } j \neq i.$$

A researcher cannot observe all components of the x_{in} and r_n vectors for each individual. Similarly, the exact functional form of the utility function U cannot be known entirely. Thus function (1) needs to be adjusted to separate the observable characteristics from the unobservable:

$$V(z_{in}, s_n, ß) + e_{in} \qquad (2)$$

Here z_{in} represents the vector of observed characteristics of alternative i faced by individual n. These characteristics would include all observable features of the appliance, including size, style, cycle settings, etc., as well as energy efficiency. Similarly, s_n represents the observed components of the previously specified r_n, such as income, age, education, etc. ß is the vector of function parameters and e_{in} is the error term that will include all unobserved components of individual n's utility from alternative i. From Dubin and McFadden this utility function can be defined more explicitly as:

$$V_{in}=(i, y–r_{in}, p_{in}, z_{in}, s_n, ß) + e_{in} \qquad (3)$$

where y is the household's income, r_{in} is the annual cost of owning the appliance as derived below, and p_{in} is the cost of the appliance. r_{in} is a sum of appliance i's discounted capital cost and annual cost of operation and can be written as:

$$r_{in} = p_{elec}(EER*\mu) + p_{in}(\rho_{in})$$

where EER is the energy efficiency ratio of the appliance in required energy inputs (kwh) per cycle, μ is the use of the appliance on average per year (in number of cycles), and ρ_{in} is an exogenous discount factor equal to $r/(1+r)(1-(1+r)^{-q})$, where r is the discount rate and q is the expected life of the appliance. The expression $y–r_{in}$ then indicates that consumers derive utility from whatever income is left after paying to operate the appliance, implying that the lower the operating cost of the appliance the greater the utility for the consumer.

From equation 3 we can express the probability that an individual n will make a specific appliance choice i as: n will choose i if:

$$P_{in} = \text{Prob}(V_{in} + e_{in} > V_{jn} + e_{jn})$$

which can be rewritten as:

$$P_{in} = \text{Prob}(e_{jn} – e_{in} < V_{in} – V_{jn})$$

Note that the first difference is between two assumed random parameters, which by definition are unknown. We can then take their difference as represented by a random cumulative distribution.

I apply this theory to examine how consumers respond to changes in operating costs (EER) and to market structure (through the subscripts indicating individual differences in choices and preferences). My data are at the household level so I apply this theory as though the household were a single individual whose characteristics are composed of the householders' characteristics and the characteristics of the residence itself. For this analysis I define my dependent variable as a dummy, indicating the choice of an Energy Star appliance (dummy=1) or not. In order to address the problem of unboundedness presented with an OLS estimator (where predicted values can range above one and below zero meaninglessly) I use instead a logistic estimator. If I assume normally distributed errors in addition to the classical OLS assumptions, then a logit model is most appropriate as a maximum likelihood estimator.

My empirical estimation equation appears as follows:

$$\mathrm{ES_i} = \beta_1 P_{st} + \beta_2 \mu_{in} + \beta_3 (P_{st} * \mu_{in}) + \beta_4 M_s + \beta_1 r_n + [\beta_1 t_n \text{ OR } \beta_1 s] + e_i,$$

where $\mathrm{ES_i}$ indicates the discrete choice of an Energy Star appliance, P_{st} is the price of electricity that varies by state and by appliance age, μ_{in} is a vector of frequency of use that varies by appliance type and household, and $ß_3$ represents the coefficients on a vector of interaction terms between these first two variables. M_s represents the Energy Star market conditions that vary by state, r_n is the vector of household and residence characteristics as in Train's model. The square brackets indicate fixed effects for time period t and states, which I control for sequentially. e_i is the error term.

III. a) Implications and limitations of this approach

My focus on operating costs requires a brief discussion of my assumptions about the frequency of appliance use. In the short run, we would expect consumers to adjust to higher energy prices on the intensive margin with frequency of use, not on the extensive margin with a purchase of a new appliance. Thus we expect that frequency of appliance use would vary with both the price of electricity and the energy efficiency of the appliance. Consistent with this theory-driven prediction, the research on this topic finds that the majority of consumer responses to price of electricity does come on the intensive margin not on the extensive margin. That is, energy prices do not affect the discrete choice of whether or not to purchase an energy-efficient appliance (for example: Ruderman, et al. 1987, Rapson 2011). This adjustment of frequency of use not only induces conservation during times of high prices but can lead to increases in usage when efficient appliances reduce the marginal cost of additional usage. The latter possibility is called the rebound effect. However, as summarized by Greening, et al. (2000) and Sorrell, et al. (2009), evidence for a substantial rebound effect in major appliances is scarce.

Especially for large appliances, the frequency of use is found to be limited more by time constraints than input costs.[8] Major chores, such as washing laundry or dishes, require time inputs that can be much more substantial than the expense of energy inputs and so in these cases frequency of use is not expected to be as responsive to energy prices (Brencic and Young 2009). Davis (2008) finds some evidence to counter this argument in his paper on the rebound effect for clothes washers. Using data from a quasi-random government field study, he finds that households who were given energy-efficient washing machines increased clothes washing 5.6 percent on average. Even this rebound effect is relatively low, and most importantly these households were *given* these appliances, they were not determining the investment in energy efficiency for themselves. It is possible that, when making their own appliance choices, consumers would anticipate their frequency of appliance usage appropriately and thus be less subject to Davis' rebound effect.

[8] The idea of time constraints is that an individual has only so much time to allocate toward washing laundry or dishes and so even if the appliance becomes cheaper to use the individual will not change washing behavior, because of time constraints.

My data do not allow me to control for changes in frequency of use over time. However the necessary simplifying assumption that frequency of use is unaffected by energy prices may be more valid for these appliances than for the air conditioners and heaters studied in previous literature. A household's expected frequency of use for clothes washers and dishwashers may be determined exogenously to the energy inputs and is only endogenous to household characteristics that shape the household's demand function. Though there certainly is potential for a response to higher energy prices, for example running only full loads and thus reducing the total number of loads, I assume these effects are negligible. Consumers considering appliance choices then take into consideration what their expected usage will be and use this value to calculate the expected operating cost of the appliance. For decisions about energy efficiency, this assumption limits consumers' decisions to the extensive margin.

I am unable to use the standard discounted present value of operating cost that is traditionally used by this literature. Instead, I rely on frequency of use and energy cost as components of this value. Consumer responses, measured in this way, can still be meaningful. If consumers fail to respond to reduced operating costs then this is an indication that they are not incorporating the full utility benefits of energy efficiency in their appliance selection. Thus even this limited measure of consumer responsiveness can indicate important trends in consumer behavior.

In addition to considering operation cost, this paper examines the potential impact of changing Energy Star market characteristics on the consumer-specific choice set of J_n. As explained in section II, this attempts to capture the possibility that individuals may be influenced by variation in their access to Energy Star products or their level of understanding about what the Energy Star label means. For instance, the weight an individual n with characteristics s_n places on a bundle z_{in} that includes energy efficiency may increase when the individual becomes more informed about this attribute. I use a set of demographic controls to address the influence of s_n and how, in this case, the household's characteristics (not the individual's) affect the weight the household places on energy efficiency. Additional measures of market conditions allow me to address the potential influences of access and information on consumers' choices.

Though I focus on reduced operating costs, energy efficiency can potentially enter this utility function in two additional ways. As identified above, it can be an appliance attribute (component of the z_{in} vector) that is given value in its own right. Alternatively, energy efficiency can affect the price of the appliance. Technology improvements that allow for the increase in efficiency may be expensive, or energy efficiency may be bundled with other higher-end features, as previously discussed, so the capital cost of the appliance may affect demand for this attribute.

I cannot address z_{in} explicitly as my data do not allow me to distinguish between various styles and features of clothes washers and dishwashers. Instead, I capture energy efficiency in my dependent variable as a discrete choice between Energy Star or not. I also do not have data on the price of these appliances and thus cannot control this potential effect. The issues of bundling and increased technology cost are further confused by the system of rebates employed by the EIA in support of Energy Star products and by the appliance manufacturers themselves. These rebates are designed to keep Energy Star appliances at competitive prices and ideally eliminate any increase in cost from technology improvements that are not recoverable quickly through energy savings. If I can assume the rebate system has been effective then I may disregard technology development's potential effect on prices and thus appliance choice. The potential problem of bundling remains, however, and I have no way to address it with my data.

The limitations of omitting price and its effects on consumer choice are discussed further in the last section of this paper.

IV. Summary Statistics

Energy Star appliance sales have been growing in the US since the program was implemented in 1992. As shown in Figures 1 and 2, my data confirm this trend. These figures are normalized to 100 percent of purchases made in each appliance age bracket. They indicate that Energy Star clothes washers and dishwashers increased as a percentage of total appliance purchases from 2002-2009. Clothes washer purchases in 2008 and 2009 were 46 percent Energy Star, compared to purchases made between 2002 and 2005, when only 31 percent were Energy Star. Energy Star dishwasher purchases made a similar jump, going from 30 percent to 44 percent over the same years. Values displayed on these figures indicate the reported number of purchases in my data set. Over all age brackets, 67 percent of clothes washers and 65 percent of dishwashers are Energy Star.

As explained in the theory section, characteristics of consumers affect their purchase decisions. I use a vector of control variables that includes the household's demographics and the residence's characteristics. This vector includes: income (by quintile), education level, age and age-squared of the householder, the number of household members, whether the residence is rented or owned, type of residence (house, apartment, or mobile home), urban or rural location, and age of the house.[9]

[9] Age-squared is included as a control to account for potential variation in appliance purchasing and frequency of use habits over an individual's lifetime. As in most life-cycle models, younger and older individuals may display different behavior from middle-aged householders, and these effects would be more linearly correlated with a squared age term.

My usage of the household income variable required some manipulation. Income is a categorical variable in my data set. The original data set includes 24 levels of income, so it is potentially useable as a continuous variable. However, because the range is capped at $120,000 and not all jumps between categories represent an equal jump in income, the coefficient returned by the continuous variable would not be readily interpretable. As an alternative, I consolidate the reported income categories to form dummy variables for rough quintiles of the population in my sample. These values range from: less than $25,000 (25.5 percent of population), 25-$40,000 (18.1 percent), 40-$55,000 (16.2 percent), 55-$90,000 (19.3 percent), and more than $90,000 (20.98 percent). Defining income this way allows me to directly observe the effect of belonging to an income category on the probability Energy Star appliance ownership.

The population percentages of Energy Star dishwasher and clothes washer owners for each of these controls are presented in Table 1. With the exception of householder age and number of household members, all these controls are dummy variables, so most values reported in Table 1 are percentages. From these summary statistics we can see that households in higher income categories own a greater percentage of Energy Star appliances. 30 percent of Energy Star clothes washer owners and 40 percent of Energy Star dishwasher owners have incomes over $90,000, whereas only 14 percent and 9 percent of owners, respectively, make less than $20,000. From this table we also see that householders with higher levels of education are more likely to own Energy Star appliances. Residences that are owned, are houses, and are in urban areas are also all more likely to have Energy Star appliances.

Table 2 examines these variables and the frequency of appliance use between populations of Energy Star dishwasher and clothes washer owners and non-owners. Owners of Energy Star appliances face, on average, higher electricity prices, and a higher percentage of the owning population uses the appliance very frequently. For clothes washers this high frequency is still the smallest group, with 13 percent of Energy Star owners washing ten or more loads per week and a similar 11 percent of non-Energy Star owners washing that frequently. For dishwashers, frequency of use is much greater in general (as one would expect by nature of the appliance). 40 percent of Energy Star owners use their appliance more than ten times per week and only 31 percent of non-Energy Star owners use their appliance that frequently.

Table 3 presents the variation in electricity prices over time. Real values of state electricity prices are a remarkably constant 12 cents per kwh with standard deviations of about 3 cents. Within states these electricity prices are generally trending upward over time, with mean electricity prices increasing from 11.3 cents/kwh in the oldest category to 12.6 for the most recent appliance purchases. Across states, there is some variation in the degree of this change in prices. For instance, New Jersey has experienced substantial and consistent increases in real electricity prices through 2009, whereas Arizona has had hardly any change in real electricity prices since 2002.

Energy Star owners on average live in states with a higher number of retailers for their size. Figure 3 illustrates the variation across states for these two market attributes. These values vary usefully, where states with higher number of retailers per thousand square miles do not necessarily also have a greater number of partners per 100,000 residents and vice versa. Though this variable does not vary across time, I can exploit the variation across states. There is almost no difference between the means of Energy Star partners in the household's state across owning and non-owning populations. Energy Star owners have marginally more Energy Star partners in their state, but further analysis is necessary to tell if this difference is significant. The difference in Energy Star retailers is slightly larger, differing by about 0.4 retailers per 10,000 miles between owning and non-owning populations.

These summary statistics indicate trends in the data that are consistent with a consumer response to operating cost. Energy Star owners are both more likely to face high energy prices and to use their appliance more frequently. From data means alone, however, there is little evidence that populations of Energy star owners and non-owners vary in the availability or promotion of Energy Star products. Finally, evidence from Figures 1 and 2 and Table 3 seem to indicate substantial time trends, with both the purchase rate of Energy Star appliances and real electricity prices increasing over time. All of these relationships are explored further in the following analysis.

V. Analysis

This section employs logistic estimation to isolate the relative contributions of the variables discussed above to the likelihood of owning energy-efficient clothes washers and dishwashers. I run separate models for each appliance. The marginal effects of these models are presented in tables at the end of this paper and are discussed below. Complete tables of control variables for each of these models in included in the appendix. I conduct my estimation in three steps, where each step estimates a set of three models, using each of the different measures for the price of electricity. As described in the data section, these measures are: state-averaged electricity price when the appliance was purchased, the same measure again with a supplemental control for the standard deviation of prices over the averaged period, and the state-specific prices of electricity in 2009 when the survey was conducted. This insures that my results are robust to the specific definition of electricity prices.

The first step of my analysis is to understand how much of the variation in appliance ownership can be described by the control variable set. Building on the set of controls, I then study what additional variation in ownership can be attributed to differences in operating cost across households. My third step is to elaborate this model by controlling for additional market characteristics across states for Energy Star appliances. My next steps are a series of robustness checks. I run the first model set using fixed effects, first for age of appliance and then for state of residence. Finally, I run various robustness checks on the analysis by testing specific subsamples of my data to insure that the relationships I have identified hold true, and are not overly sensitive to sample populations.

V. a) Householder demographics and residence characteristics

Table 4 presents the marginal effects of the control variables on the probability of owning an Energy Star clothes washer or dishwasher. Compared to the lowest income quintile, all higher income quintiles are more likely to have Energy Star clothes washers. For dishwashers, only the highest two income brackets are significantly more likely than the lowest income bracket to have an Energy Star appliance. Higher levels of education significantly increase the likelihood that a household will have an Energy Star clothes washer but do not seem to increase the likelihood it will own an Energy Star dishwasher. Older householders and larger households are generally more likely to have Energy Star appliances. The type of house and ownership status also matter: compared to apartments, mobile homes are less likely and houses are more likely to have Energy Star appliances. Owners of their residence are also more likely to own Energy Star appliances. Finally, compared to newly constructed houses, older houses are less likely to have an Energy Star appliance. This is consistent with an increasing frequency of Energy Star purchases, since new houses have been furnished more recently and their appliances therefore had a greater chance of being Energy Star.

V. b) Operating Cost

I maintain the control set described above throughout the following analysis. To this model I now add a vector for operating costs. This vector includes a measure of electricity prices, the set of frequency of use variables, and a set of interaction terms between these two. As discussed in my theory section, this is not the classic discounted present value of operating cost. I do not have measures for appliance maintenance cost or purchase prices, which we would assume is discounted over the appliance's lifetime. Frequency of appliance use is also not a continuous variable in my data set. The lack of household-specific responses prevents me from estimating an average operating expense for each household. Maintenance cost data are rare and maintenance cost is often assumed to be low enough that the effect is inconsequential (e.g. Ruderman 1987), but the lack of appliance price is limiting. The implications of the missing price variable are discussed in more detail in the limitations section of this paper.

I focus on differences in responsiveness to "operating costs" across households by category of usage intensity. Reduced operating costs are one significant benefit of increased energy efficiency. Thus, if consumers fail to respond to reduced operating costs then this is an indication that they are not incorporating the full utility benefits of energy efficiency in their appliance selection. I run all models with respect to the highest frequency category, indicating more than ten uses per week. The interaction terms between electricity prices and frequency of use allow households that use their appliance relatively more or less to respond differentially to electricity prices.

The results of this model are reported in Table 5. All three measures for electricity price are significant for both clothes washers and dishwashers, and all measures are nearly identical in terms of model "hits." The measure for the standard deviation of electricity prices is very significant for both appliances, indicating that an increase of one standard deviation in measured variability of electricity prices would reduce the probability of those households having Energy Star appliances by more than 20 percent. This magnitude of response is beyond what can be expected from the literature, which may be an indication of correlation between the electricity price and its standard deviation.[10] However, the sign is consistent with the literature on consumer behavior under noisy price signals. Prior research finds that investments in energy-using durables are less likely or at least delayed under uncertain energy prices (Bushnell and Mansur 2005, Edelstein and Kilian 2009). Temporary price spikes are another potential explanation for the negative sign of this coefficient. If the standard deviation measure is capturing only short run price fluctuations then consumers may be less likely to respond with the purchase of an Energy Star appliance. Without panel data it is impossible to separate out long and short run response differences. These results leave the *true* effect of variations in electricity prices uncertain.

Using a clothes washer fewer than ten times a week does not significantly change the probability of having an Energy Star model (as indicated by the lack of significance on all frequency dummies). This is potentially explained by the fact that clothes washers are used relatively less frequently in general, so the lack of significance may be particular to the nature of the appliance. Frequency of use is more significant for dishwashers. In these models the lowest frequency of use is significant at the 10 percent level and negative, which indicates that households that rarely use this appliance are less likely (by about 20 percent) to have an Energy Star dishwasher, compared to households that use the appliance more than ten times per week.

[10] Statistical correlation of these variables is about 0.3.

Though this appears consistent with a consumer response to operating cost, the interaction terms in all these models are insignificant and essentially zero. This indicates that there is not a substantial difference in response to electricity price between households that use appliances relatively more or less. The lack of significance in these interaction terms suggest that consumers are not responding to differences in operating cost when choosing appliances.

Overall this model is an improvement from the controls only model (Table 4) as indicated with the log likelihood ratio test. Table 15 presents these log likelihood ratio tests for all models. Operating cost is presented in the first row and for all measures of price the chi squared values are significantly above the critical values so we reject the null of the controls only model. The goodness of fit for this model can be seen in the model's hits at the end of Table 5. With the addition of these variables this model is predicting over two-thirds of the observations correctly.

V. c) Market characteristics

Controlling only for demographics, another potential observable factor that might differentiate appliance choices across households is market characteristics. Individuals may not have the same access to Energy Star products or have the same level of understanding about what the Energy Star label means. To address this, I include the two variables for Energy Star partners and Energy Star retailers in the regression from Table 5. These results are presented in Table 6.

The added variables for Energy Star partners and retailers are not significant. Magnitudes of these effects are so low as to be essentially zero. Adding the market structure variables increases correct predictions for both clothes washers and dishwashers by only 2 hits, a negligible difference, and effects on all other marginal effects are minimal. Price remains a significant determinant of Energy Star ownership in these models, and frequency of use still matters for dishwashers, with nearly equal magnitudes in the marginal effects.

It is possible that there is simply not a fine enough level of detail in these market structure variables to capture the theoretical effect of information and availability. If I could vary these variables by county or census tract, instead of state, that would improve the relevance of these measures. The second potential problem with this variable is that it does not vary with age of appliance. These values were pulled from the current list of Energy Star partners (last updated in 2011), and thus do not accurately reflect the state of the market at the time when the households were making their purchases.

Under this second explanation, the variables should be most closely related to the most recently purchased appliances. To examine this possibility I run this same model again but this time only on a subsample of households that purchased appliances in the most recent period (2009 or 2008). These results are presented in Table 7. Though this model has much lower degrees of freedom, the magnitudes of the coefficients on market structure are more than doubled across all models. Interestingly, the negative effects remain for the number of Energy Star retailers on dishwasher purchases. The Energy Star partners coefficient is positive and significant for the restricted model, indicating that for more recent purchases more Energy Star partners per capita in the state increases the probability of a household in that state purchasing an Energy Star appliance by about 1.5 percent. This evidence is consistent with my explanation for the behavior of the market structure variables in Table 6. It suggests that the lack of significance for these variables most likely stems from their lack of variation with age of appliance. Thus these market characteristics may still be important sources of influence on consumers' purchase decisions, they simply do not have enough explanatory power to identify the effect in my models.

Due to this low power and their additional collinearity with state fixed effects, I leave them out of model estimation discussed below. Log likelihood ratio tests for this model confirm this. The chi-squared values for this model are very low thus I cannot reject the null (operating cost model) and I conclude that these variables add no additional explanatory power to my model.

V. d) Age fixed effects

As indicated by the hits and misses in Table 5 and Table 6, these models are already predicting at a fairly high level (69 percent correct for clothes washers and 73 percent correct for dishwashers from Table 5). However, there are several potential problems with them. Most importantly, they do not control for general changes that are occurring over time. Energy prices are generally increasing over time, as is Energy Star market share, and thus the significance we see in Tables 5 and 6 may be due to coincident growth patterns in the Energy Star market and not a true correlation between the two.[11] If these variables are simply moving together over the age-of-appliance categories then the magnitudes of the marginal effects discussed with Table 5 may be exaggerated. To address this issue I use fixed effects to control for the appliance's age bracket, omitting the dummy variable for newest purchases for comparison. These results are presented in Table 8.

Controlling for appliance age, the marginal effect of the price of electricity from the time of appliance purchase is generally about two-thirds of what it was in Table 5, but still significant. The marginal effect of the price of energy in 2009 is almost unchanged because it varies only by state. This supports the results from Table 5. Even controlling for appliance age, an increase in

[11] See the final "limitations" section of this paper for more details on Energy Star market share.

electricity prices of one cent increases the probability of owning an Energy Star appliance by about 2.5 percent for clothes washers and 1.4 percent for dishwashers. The change in magnitude of these coefficients indicates that about a portion of the effect from Table 5 is actually due to temporal changes in the market that are constant across all households.

Interestingly, frequency of use loses its significance when I control for age. This may indicate changes in features or the design of dishwashers over time that, in turn, affects the frequency of use. If, for instance, older appliances were smaller, then they might be used more frequently simply because they have a smaller capacity. Without being able to control for varying characteristics we cannot discern what is causing this effect. Even controlling for appliance age, all operating cost interaction terms remain insignificant which continues to suggest that consumers are not fully incorporating the benefits from reduced operating cost.

The overall fit of this model does appear slightly improved in terms of model hits as presented at the bottom of Table 8. Log likelihood ratio tests (Table 15) between this model and the operating cost model in Table 5 indicates that this model is a substantial improvement and I safely reject the null. This confirms the importance of controlling for temporal effects in this market.

V. e) State fixed effects

The second potential problem with the models presented in Tables 5 and 6 are that states themselves may have significantly different policies, incentives and energy programs that could affect the purchase of Energy Star appliances. The most obvious example of this is California, which is a typical outlier in energy studies. To examine the potential effect of California I rerun my models excluding all respondents from California to insure that my variables maintain their significance. This robustness test is reported in Table 9. Without California, the price of electricity is still significant. The magnitude of the marginal effects is reduced somewhat, especially for the electricity price measures from 2009. This may be indicative of California's relatively high energy prices and efficiency efforts. Frequency of use for dishwashers loses its significance, although the results remain negative and economically significant in the same direction as before. I conclude that keeping California in the model does not substantially distort my results. I continue to include these respondents in my models to maintain degrees of freedom and important variation.

California is not the only state with different policies. For instance, the recent round of stimulus money (2010) funded a variety of state-wide rebate programs that allocated over $17 million in Florida but only half a million dollars in each of the Carolinas. The products covered for each state also varied, with only 38 states offering dishwasher rebates and 48 offering clothes washer rebates (DOE 2011). To control for the possibility that it is policy differences across states that account for the variation in consumer choice, I run a second fixed effects model controlling for states. The marginal effects of this model are reported in Table 10. California is excluded as the reference state and dummy variables are included for all 15 other states reported by RECS. It is important to note that I cannot control for both age of appliance and state simultaneously, as these two variables represent all the variation that exists in my price of electricity variable. To eliminate both of these effects in one model I would need variation over time both within states and across states.

Careful analysis of the results in Table 10 indicates that states do not actually appear to explain any variation in ownership that is not already explained by price. For both appliances, in the models where electricity price is expressed as its 2009 price, no state dummy variables are significant, and this price measure is also not significant for clothes washers. The lack of significance on the state fixed effects in these models indicates that the price variation (in the 2009 electricity price measure) may explain the majority of the variation occurring between states. Conversely, this implies that the significance that remains on the price variables in the other two models is attributable to variation within states, over time. The large drop in these magnitudes (marginal effects of price are only about half of what they were in Table 5) indicate that a large portion of the previously identified effect of electricity price is due to systematic differences across states that are constant for all households. Again, I would need data that varied over time within and across states to allow me to separate these effects and identify the effect of electricity prices beyond constant temporal and state effects.

Under the first two measures of electricity price, the magnitudes of the coefficients on the state variables are very large, which indicates that ownership rates are quite different from California's ownership rate. For example, compared to California, clothes washers in Massachusetts are 96 percent less likely to be Energy Star whereas in Texas they are 47 percent more likely to be Energy Star. Again, California may be an outlier, so I run this model without California to examine the effect this subsample has on the marginal effects on ownership from living in a particular sate. Table 11 presents these results, with Illinois omitted as a reference state. I again get nearly complete significance on all state dummy variables for the models where electricity price is measured as the average from time of purchase. However, even while controlling for state, electricity price from the time of appliance purchase retains its significance, which indicates that households' responses are not entirely explained by factors that are consistent across all households in a state.

The overall fit of this model appears only slightly improved in terms of model hits, with negligible changes under some definitions of energy price. However, log likelihood ratio tests between this model and the operating cost model in Table 5 indicates that, for models that use energy prices from the time of appliance purchase, including state fixed effects is a substantial improvement. For the model that uses 2009 electricity prices however, this model is not an improvement and the chi-squared values are low enough that I cannot reject the null. This confirms that there is no significant variation in policy or incentives across states, instead differences in electricity prices accounts for the majority of the explanatory power.

V. f) Further Robustness Checks

The final set of robustness checks address concerns about rapidly increasing market share for Energy Star appliances. By 2009 Energy Star market share had reached more than 90 percent of all reported appliance shipments for some states (see Figures 4 and 5 for market share trends). Under this market condition my assumptions about market choice are no longer valid. In fact, the opposite problem may exist, where consumers have only Energy Star appliances to choose from. In order to prove my results robust against this possibility I rerun the models from Table 5 on a subsample of households, omitting all households that made their purchase in the newest age bracket (2008 or 2009). These results (presented in Table 12) are comparable to those in Table 5. Marginal effect of electricity prices falls slightly, but as I have eliminated one third of the variation in this variable I expect the decrease. Everything remains significant, and all operating cost interaction terms remain insignificant which continues to suggest that consumers are not fully incorporating the benefits for reduced operating cost. These results indicate that new appliance purchases are not significantly different in terms of responsiveness to electricity price. Including observations from households with recent appliance purchases does not appear to have distorted my results.

To confirm this I run the model again, but this time omitting only the states where there were no purchases of non-Energy Star appliances in the most recent time period. For clothes washers these states were New Jersey, Pennsylvania, and Illinois. For dishwashers this was only Wisconsin. In this model (Table 13) I get results nearly identical to those originally presented in Table 5, which confirms that the potential lack of variation of consumer choice in a few states did not substantially affect my results.

V. g) Summary Results

Table 14, included here, summarizes the changes in my key variables of operating cost across all these models for the electricity price measure at the time of appliance purchase. Overall, my analysis indicates that frequency of appliance use does not increase the household's responsiveness to electricity prices, which suggests that consumers do not fully value efficiency when choosing among appliances. This is indicated by the insignificance of the operating cost interaction terms, which remains even when controlling for age of the appliance and the household's state.

As Table 14 indicates, I find evidence that frequency of use does not affect appliance ownership patterns. Instead, it appears that frequency of use varies with age of appliance and older appliances are less likely to be Energy Star. Frequency of use for dishwashers loses its significance when I control for appliance age indicating changes in features or the design of dishwashers over time were the cause of the initial significance reported in the operating cost model.

My results leave the *true* effect of variations in electricity prices uncertain. In the fixed effects models, consumer's response to electricity prices is reduced by both eliminating

Table 14: Summary Results

	Clothes Washer			Dishwasher		
	Opp Cost	Age FE	State FE	Opp Cost	Age FE	State FE
Elec Price@Purchase	0.0329***	0.0249***	0.147***	0.0233***	0.0136**	0.156***
	(0.00807)	(0.00823)	(0.0132)	(0.00579)	(0.00593)	(0.0148)
StdDev Elec Price						
2009 Elec Price						
Freq1: <5/week	0.0968	0.144	0.117	-0.213*	-0.135	-0.183
	(0.107)	(0.108)	(0.108)	(0.111)	(0.113)	(0.114)
Freq2: 5-9/week	0.0254	0.0637	0.0292	-0.0907	-0.117	-0.0979
	(0.111)	(0.110)	(0.111)	(0.101)	(0.104)	(0.103)
Freq1*Elec Price	-0.0107	-0.0133	-0.0116	0.0131	0.00876	0.0111
	(0.00887)	(0.00900)	(0.00899)	(0.00876)	(0.00886)	(0.00894)
Fre2*Elec Price	-0.00133	-0.00421	-0.00124	0.00474	0.00751	0.00516
	(0.00936)	(0.00948)	(0.00947)	(0.00821)	(0.00837)	(0.00837)
Observations	4,075	4,075	4,075	2,835	2,835	2,835
Model hits	2806	2927	2840	2065	2099	2095
Log Likelihood	-2403.95	-2233.46	-2333.26	-1590.48	-1473.7	-1533.68

consistent temporal price in the market across households and systematic differences across states that are constant for all households. The drop in the marginal effects of electricity price on consumer decisions indicate that a portion of the effect of electricity price is due to these systematic differences across states and time and not truly from consumer appliance choices.

My analysis finds no evidence of effects of policy variation across states on household appliance choices. Using the 2009 electricity price measure suggests that differences in electricity prices explain the majority of the variation of appliance ownership occurring between states.

Finally, I find that differences in availability of efficient appliances do not affect ownership patterns. There is no indication in my analysis that households in states with a greater number of Energy Star retailers per square mile were any more or less likely to own Energy Star appliances. This is especially interesting considering the literature that has hypothesized that market structure and limited access to energy-efficient appliances was at least partially responsible for the sub optimum level of investment in energy efficiency. I find no evidence to support this hypothesis. In addition, I find only limited evidence that increased information (through Energy Star partners) increases the likelihood of owning an Energy Star appliance. This is also surprising considering the importance of this market failure in the discussion of energy efficiency in the literature (see section I for details).[12]

My results are robust to both sample population and measurement of electricity prices. Comparing the performance of my models indicates that all three measures of electricity price are identical. I compare the performance of the models as a whole to a naive estimator that would simply guess Energy Star every time and would estimate 67 percent correctly for clothes washers and 65 percent correctly for dishwashers. Building on my control variables, only fixing for age of appliance significantly increases the models' performance in terms of hits above what is already attained from the operating cost vector in Table 5. Age fixed effects add more predictive power than state fixed effects as states provide no additional explanation beyond electricity price variation.

VI. Limitations of my research and future direction for this topic

Though this research contributes in several ways to the study of residential responses to energy efficiency improvements in appliances, it is also limited by many factors. As with most research on this topic the quality and availability of data is the most common problem. Several trends that characterize the Energy Star appliance market also introduce potential limitations for

[12] This discussion is in reference to results from Table 6.

this research. The details of these limitations and their implications for my research are discussed below.

Appliance capital cost

My data do not allow me to control for the purchase price of appliances. Without being able to control for the potential of higher technology costs for Energy Star appliances, my findings are limited. For instance it may be that Energy Star products command a market premium so the apparent lack of consumer response to reduced operating costs simply comes from overinflated capital prices leading consumers to underinvest. Appliance prices are also necessary to place my findings confidently in the context of other papers on consumer discount rates. If, as my results indicate, consumers are not responding well to reduce operating costs from energy efficiency measures then this implies that they are applying discount rates above the market rate. Without examining appliance price trends, however, this magnitude cannot be estimated.

My data do allow me to control for subsidies on the purchase of appliances. The EIA stipulates that an Energy Star product must maintain a competitive price and subsidies are made available when products are considered to be above the market price and, importantly, the additional cost would not be recoverable in 3-5 years from energy savings. Including a variable for whether a subsidy was received or not could allow me to eliminate these price differentials, assuming subsidies were indeed paid to keep Energy Star product prices within the range of standard models' prices as the EIA claims. My initial analysis did include this variable. However, there was no variation in this dummy variable: every subsidy received was for an Energy Star product, making this variable highly endogenous. It added no extra significant explanation to my analysis so it was dropped in my final analysis.

Energy Star market share

Another variable I considered including as part of the market structure vector was Energy Star market share. The greater the percentage that Energy Star appliances have of the state's market the more likely a customer is to have information about what Energy Star is and to have access to Energy Star models at the time of their appliance purchase. The EPA has collected market share data through voluntary reporting since 2002. The reported values are recorded as the ratio of total shipments into that state comprised of Energy Star appliances. Because reporting is voluntary, the EPA warns against comparing these values across years, as the exact magnitudes may be unreliable.

Despite the potential reporting problems I tested the variable in my initial analysis. When this variable was included in my analysis, however, it was highly multicolinear with both price and age of appliance. This is a clear time trend problem: energy prices are trending upwards and, simultaneously, market share has been increasing. Compared to energy prices, however, market share has relatively low variation across states. When market share was modeled against just the age dummy variables the regression already had an R^2 of 0.86. Adding in price of energy explained 94 percent of the variation in this variable. Though theoretically interesting, market share did not provide enough additional variance to justify its use in my models and so it does not appear in my results. With more granular data about appliance age and more state identifiers this variable might add interesting variation to the analysis, and should be considered in future research.

Potential endogeneity of frequency of use

One of the major simplifying assumptions I make is that frequency of use does not change following the purchase of an energy-efficient appliance. With this analysis I cannot be certain about the direction or causality of frequency of use. To the extent that my assumptions hold, households that use their appliance more frequently pay a greater amount to operate the appliance and thus may be more aware of operating cost savings from energy efficiency. Without being able to control for frequency of use before the purchase, however, the coefficients I observe are also consistent with a potential rebound effect, where owners of efficient appliances operate their appliances more frequently because the marginal expense of doing so has fallen.

Panel data

As discussed above, without variation both within and across states over time I cannot be sure how truly responsive individuals are to electricity prices (and thus operating costs) in their choice of appliances. If I could control for both state and time trends I suspect that the significance of electricity prices reported here would be eliminated. As data improve on Energy Star appliance ownership the potential to exploit this variation also increases. A potential step in the immediate future is to mimic Rapson's (2011) approach of appending consecutive years of RECS surveys and using only the two most recent age brackets to create a larger data set with appliance purchases the ages of which are more narrowly defined. Currently only two years of RECS surveys (2005 and 2009) identify Energy Star products but future research will have many more surveys to exploit.

V. e) Future research

Building on the interesting potential of market share and subsidies, an important area for future research would be to exploit the variations in policy that occur across states in both subsidies and promotion for Energy Star. With several recent rounds of stimulus money allocated to Energy Star rebates, the results of this program are still to be seen. If significant variation in policies exists between states and over time within states then this type of analysis would add greatly to my limited discussion about the impacts of information and market structure by allowing us to identify which forms of funding and promotion are most effective.

VI. Conclusion

This analysis finds evidence that consumers do take into account some aspects of operating cost in their decisions to purchase appliances and yet they do not fully value efficiency. There appears to be some response to differences in electricity prices across states.[13] Householders who face higher energy prices are more likely to purchase Energy Star products. Controlling for temporal changes, my results indicate that increase in electricity prices of 1 cent/kwh increases the probability of Energy Star clothes washer ownership by 2.5 percent and the probability of Energy Star dishwasher ownership by 1.3 percent. Beyond variation in electricity prices, however, state variation does not appear to have any effect on ownership. Controlling for constant changes over time is shown to be very important for the evaluation of the Energy Star appliance market.

My analysis reveals that frequency of use varies with age of appliance. Once this effect is controlled for frequency of appliance use does not influence a household's appliance decision. Furthermore, frequency of use, does not affect how consumers respond to energy prices. This finding is inconsistent with economic theory that energy efficiency increases consumer utility through reduced operating costs, and suggests that consumers do not fully value efficiency when choosing among appliances. Frequency of appliance use may be more influenced by household characteristics such as number of children, age of householder, and time constraints on chores

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[13] State energy prices may also be endogenous to some degree with state energy policies affecting both electricity prices and incentives for energy efficiency such as investments in Energy Star appliances.

than the input costs of electricity. Overall, my findings are consistent with the literature, indicating relatively low responses to operating costs.

The ultimate effect of market structure is uncertain from my analysis. The partner and retailer variables I employ do not have enough power to clarify their effect. From this analysis, however, there is no indication that households in states with a greater number of Energy Star retailers per square mile were any more or less likely to own Energy Star appliances. This is inconsistent with the hypothesis that market structure and limited access to energy-efficient appliances are at least partially responsible for the sub-optimum level of investment in energy efficiency. In addition, I find only limited evidence that increased information (through Energy Star partners) increases the likelihood of owning an Energy Star appliance. This is also surprising considering the importance of this market failure in the discussion of energy efficiency in the literature. However there is some evidence that, with more detailed market characteristics that varied over time with appliance purchases, research could identify the effect of Energy Star promotion and availability to ownership rates.

Resources

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Figure 1

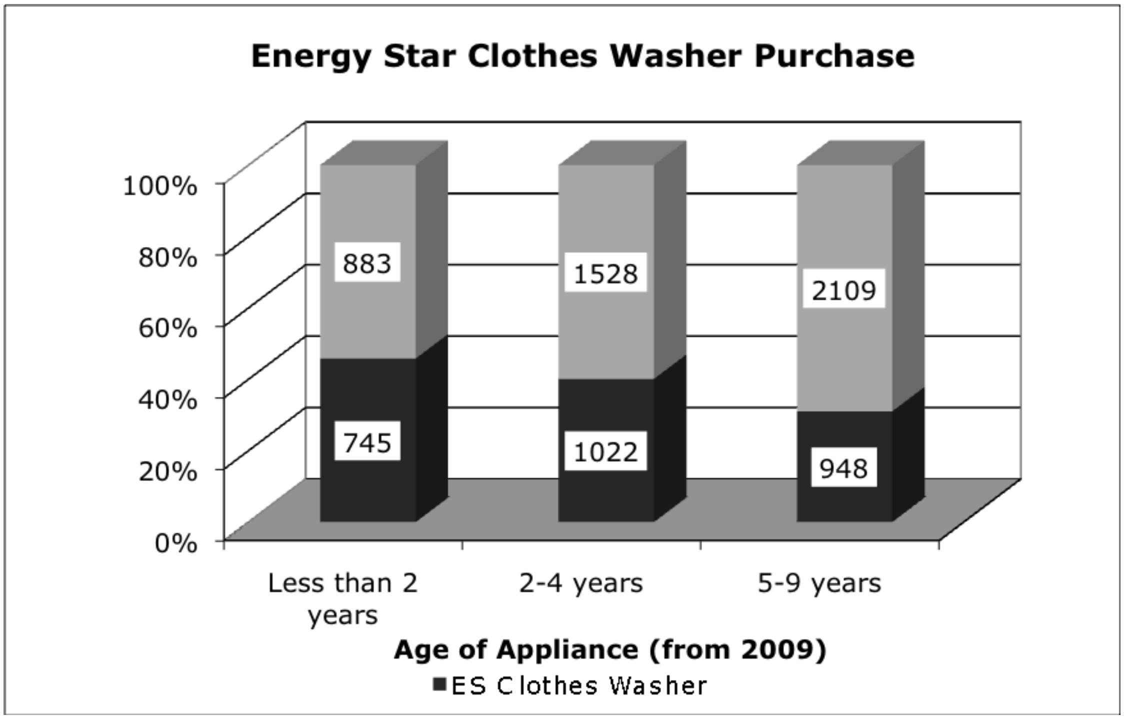

Figure 2

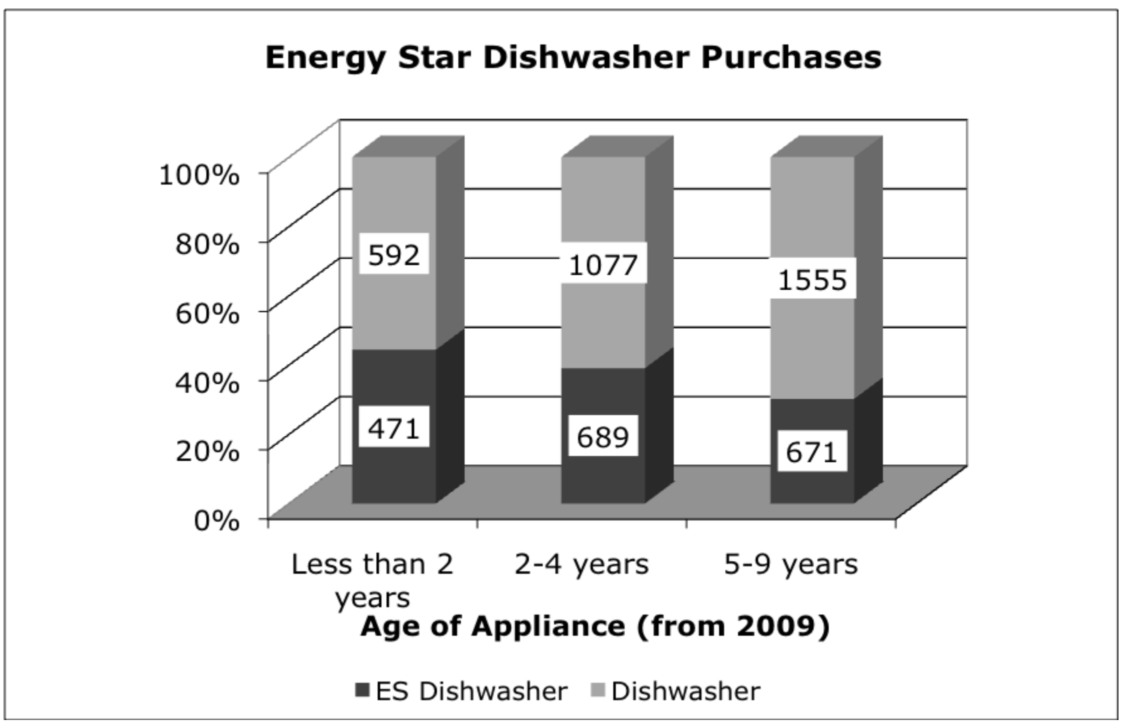

Figure 3

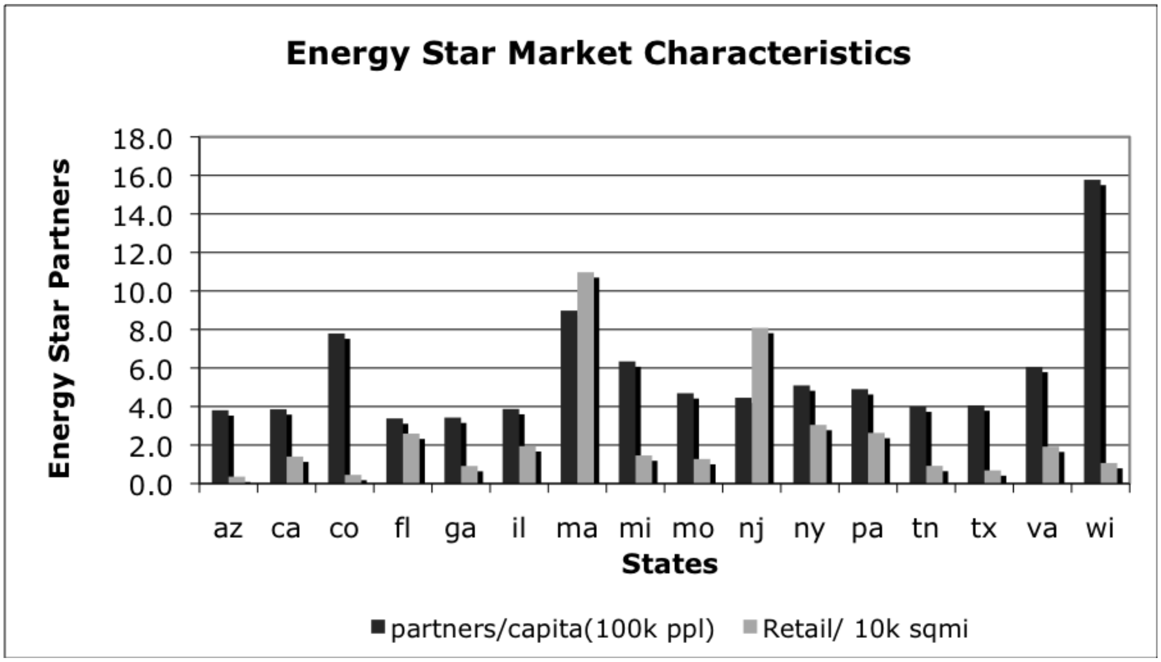
Energy Star Market Characteristics
Energy Star Partners
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
az
ca
co
fl
ga
il
ma
mi
mo
nj
ny
pa
tn
tx
va
wi
States
partners/capita(100k ppl)
Retail/ 10k sqmi

Figure 4

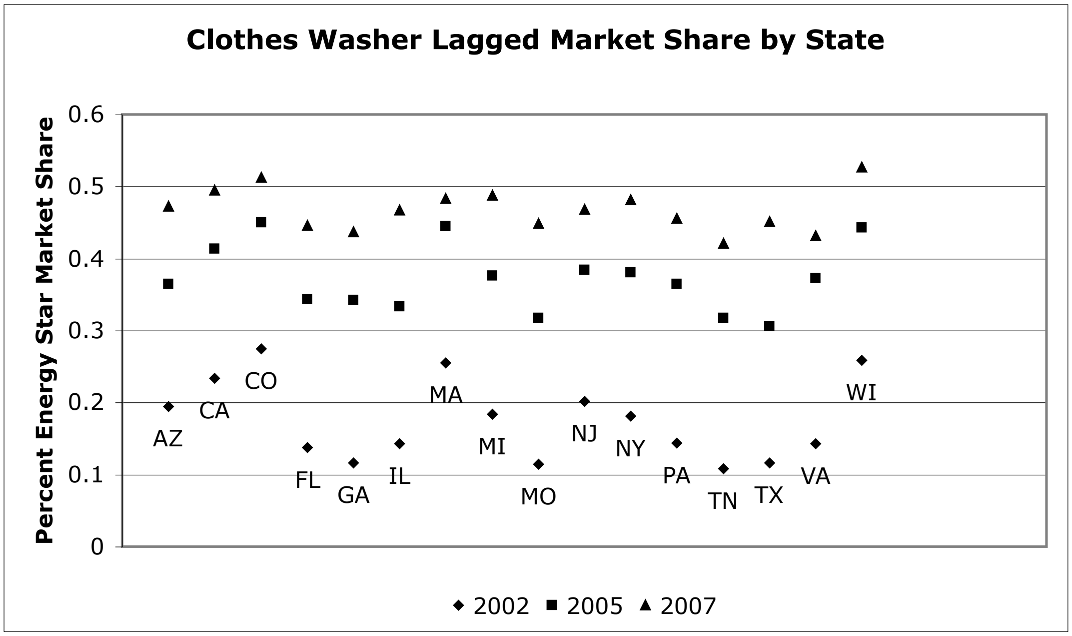

Figure 5

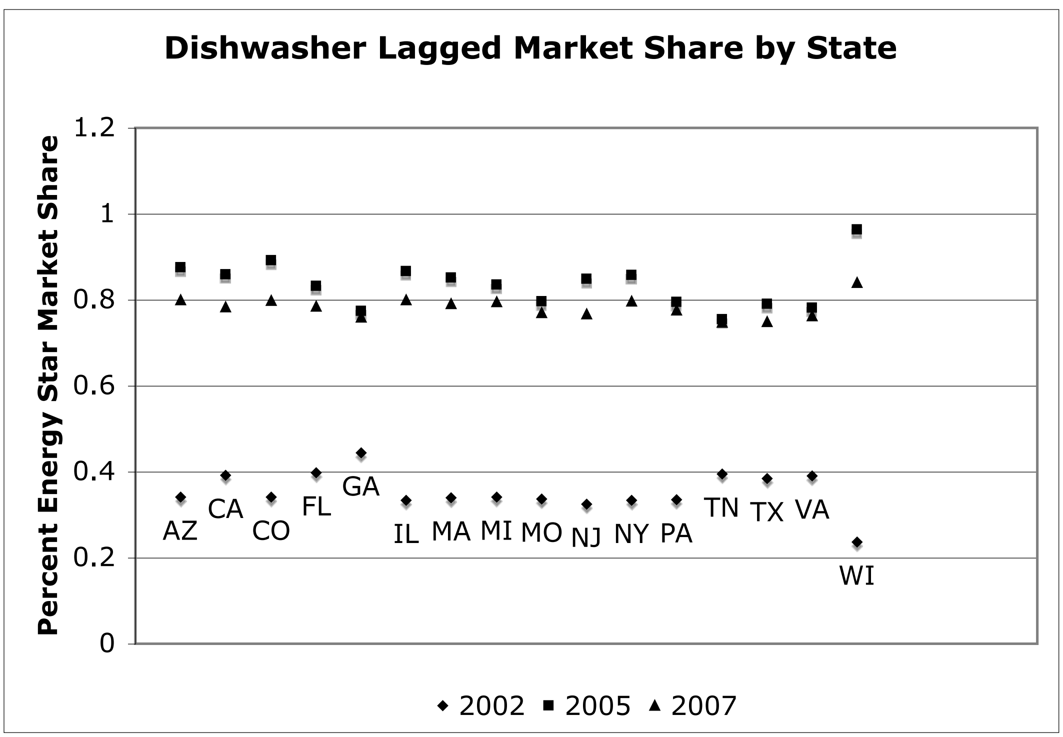

Table 1: Householder and Residence Summary Statistics

	Population Percentages for Energy Star Clothes Washers	Population Percentages for Energy Star Dishwashers
Income <25k	0.145	0.093
Income 25-40k	0.151	0.113
Income 40-55k	0.162	0.148
Income 55-90k	0.241	0.250
Income >90k	0.300	0.397
No High School	0.074	0.032
High School Degree	0.244	0.186
Some College	0.319	0.339
College Degree	0.232	0.266
Advanced Degree	0.131	0.177
Householder Age	49.457*	50.499*
# of House Members	2.987*	2.848*
Own Residence	0.819	0.877
Rent Residence	0.172	0.116
Apartment	0.109	0.108
Mobile Home	0.036	0.021
House	0.855	0.871
Rural Area	0.206	0.222
Urban Area	0.794	0.778
Built pre 1969	0.379	0.303
Built 1970-89	0.284	0.290
Built 1990-99	0.148	0.155
Built 2000-04	0.101	0.126
Built 2005-09	0.088	0.127

* Values are means from continuous variables not population percentages

Table 2: Operating Cost and Market Structure Variables Across Energy Star Owners and Non-Owners

	Mean ES Clothes Washer Owners	Mean ES Clothes Washer Non-Owners	Mean ES Dishwasher Owners	Mean ES Dishwasher Non-Owners
Elec Price@Purchase	12.266	11.440	12.144	11.268
2009 Elec Price	12.873	12.348	12.802	12.250
Freq1: <5/week	0.481	0.557	0.261	0.346
Freq2: 5-9/week	0.387	0.332	0.341	0.347
Freq3: > 10/week	0.132	0.111	0.398	0.308
ES Retailers	2.233	1.873	2.351	1.969
ES Partners	4.943	4.816	5.001	4.834

Table 3: Average Electricity Price from Appliance Purchase

	Obs	Mean	Std. Dev.
Energy Star Clothes Washers			
Purchased 2008-09	883	12.589	2.775
Purchased 2006-07	1528	12.480	2.977
Purchased 2002-05	2109	11.303	2.565
Energy Star Dishwashers			
Purchased 2008-09	592	12.596	2.813
Purchased 2006-07	1077	12.202	3.107
Purchased 2002-05	1555	11.239	2.577

Table 4: Marginal Effects from Control Variables

	ES Dishwasher	ES Clothes Washer
Income 25-40k	-0.00519	0.0485**
	(0.0362)	(0.0232)
Income 40-55k	0.0338	0.0604***
	(0.0343)	(0.0233)
Income 55-90k	0.0808**	0.116***
	(0.0319)	(0.0219)
Income>90k	0.146***	0.151***
	(0.0318)	(0.0225)
High School Degree	0.00836	0.0602**
	(0.0533)	(0.0271)
Some College	0.0403	0.0615**
	(0.0517)	(0.0277)
College Degree	0.0314	0.0774***
	(0.0534)	(0.0293)
Advanced Degree	0.0589	0.0586*
	(0.0536)	(0.0329)
Householder Age	0.00338***	0.00176***
	(0.000694)	(0.000543)
# of House Members	0.0124*	0.0232***
	(0.00751)	(0.00545)
Own Residence	0.236***	0.137***
	(0.0311)	(0.0225)
Mobile Home	-0.0343	-0.116**
	(0.0696)	(0.0464)
House	0.0716**	0.000367
	(0.0330)	(0.0249)
Rural Area	0.0915***	0.0701***
	(0.0249)	(0.0195)
Built pre 1969	-0.0467	-0.0103
	(0.0379)	(0.0312)
Built 1970-89	-0.149***	-0.0553*
	(0.0372)	(0.0319)
Built 1990-99	-0.0438	-0.0210
	(0.0419)	(0.0350)
Built 2000-04	-0.164***	-0.0454
	(0.0442)	(0.0386)
Observations	2,835	4,075
Hits	1431	2379

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Omitted dummies include: Income <25k, no high school, rent residence, apartment, urban area, built 2005-09

Table 5: Marginal Effects for Operating Cost Model on ES Clothes Washers and Dishwashers

	ES Clothes Washers			ES Dishwashers		
	(1)	(2)	(3)	(1)	(2)	(3)
Elec Price@Purchase	0.0329***	0.0375***		0.0233***	0.0311***	
	(0.00807)	(0.00824)		(0.00579)	(0.00605)	
StdDev Elec Price		-0.203***			-0.299***	
		(0.0363)			(0.0484)	
2009 Elec Price			0.0252***			0.0121**
			(0.00856)			(0.00609)
Freq1: <5/week	0.0968	0.112	0.109	-0.213*	-0.200*	-0.234*
	(0.107)	(0.108)	(0.121)	(0.111)	(0.113)	(0.126)
Freq2: 5-9/week	0.0254	0.0202	0.0330	-0.0907	-0.101	-0.153
	(0.111)	(0.112)	(0.124)	(0.101)	(0.103)	(0.115)
Freq1*Elec Price	-0.0107	-0.0118	-0.0107	0.0131	0.0122	0.0138
	(0.00887)	(0.00900)	(0.00946)	(0.00876)	(0.00892)	(0.00934)
Fre2*Elec Price	-0.00133	-0.000889	-0.00193	0.00474	0.00565	0.00942
	(0.00936)	(0.00950)	(0.00991)	(0.00821)	(0.00839)	(0.00869)
Observations	4,075	4,075	4,075	2,835	2,835	2,835
Model hits	2806	2825	2778	2065	2060	2062
Log Likelihood	-2403.95	-2388.45	-2428.47	-1590.48	-1571.14	-1608.85

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Omitted dummies include: Freq3:>10/week, income <25k, no high school, rent residence, apartment, urban area, built 2005-09

The complete set of controls for this model are included in the appendix

Table 6: Marginal Effects for Market Structure Model on ES Clothes Washers and Dishwashers

	ES Clothes Washers			ES Dishwashers		
	(1)	(2)	(3)	(1)	(2)	(3)
Elec Price@Purchase	0.0326***	0.0369***		0.0242***	0.0315***	
	(0.00818)	(0.00834)		(0.00606)	(0.00630)	
StdDev Elec Price		-0.202***			-0.299***	
		(0.0365)			(0.0485)	
2009 Elec Price			0.0235***			0.0117*
			(0.00880)			(0.00661)
Freq1: <5/week	0.0964	0.112	0.110	-0.211*	-0.200*	-0.234*
	(0.107)	(0.108)	(0.121)	(0.111)	(0.113)	(0.126)
Freq2: 5-9/week	0.0261	0.0208	0.0342	-0.0906	-0.101	-0.153
	(0.111)	(0.112)	(0.124)	(0.101)	(0.103)	(0.115)
Freq1*Elec Price	-0.0106	-0.0117	-0.0107	0.0130	0.0122	0.0138
	(0.00888)	(0.00901)	(0.00948)	(0.00876)	(0.00892)	(0.00934)
Fre2*Elec Price	-0.00138	-0.000923	-0.00198	0.00474	0.00564	0.00943
	(0.00937)	(0.00951)	(0.00994)	(0.00821)	(0.00839)	(0.00869)
ES Partners	0.00261	0.000898	0.00155	0.00207	0.000387	0.00106
	(0.00339)	(0.00341)	(0.00339)	(0.00447)	(0.00451)	(0.00448)
ES Retailers	0.000905	0.00193	0.00373	-0.00262	-0.00110	0.000818
	(0.00412)	(0.00409)	(0.00445)	(0.00496)	(0.00494)	(0.00536)
Observations	4,075	4,075	4,075	2,835	2,835	2,835
Model hits	2808	2823	2779	2067	2058	2064
Log Likelihood	-2403.57	-2388.26	-2427.87	-1590.29	-1571.11	-1608.79

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Omitted dummies include: Freq3:>10/week, income <25k, no high school, rent residence, apartment, urban area, built 2005-09

The complete set of controls for this model are included in the appendix

Table 7: Marginal Effects for Market Structure Model for Appliances Purchased in 2008-09

	ES Clothes Washers			ES Dishwashers		
	(1)	(2)	(3)	(1)	(2)	(3)
Elec Price@Purchase	0.0186	0.0179		-0.00573	-0.00526	
	(0.0118)	(0.0119)		(0.00693)	(0.00715)	
StdDev Elec Price		0.0316			-0.0243	
		(0.0874)			(0.0886)	
2009 Elec Price			0.0194			-0.00596
			(0.0120)			(0.00724)
Freq1: <5/week	0.216	0.211	0.211	-0.616*	-0.623*	-0.611*
	(0.163)	(0.163)	(0.168)	(0.350)	(0.349)	(0.366)
Freq2: 5-9/week	0.152	0.151	0.148	-0.168	-0.166	-0.201
	(0.142)	(0.142)	(0.147)	(0.205)	(0.204)	(0.233)
Freq1*Elec Price	-0.0212*	-0.0209*	-0.0206	0.0149	0.0151	0.0145
	(0.0126)	(0.0126)	(0.0128)	(0.00961)	(0.00967)	(0.00982)
Fre2*Elec Price	-0.0154	-0.0153	-0.0149	0.00738	0.00729	0.00870
	(0.0131)	(0.0131)	(0.0134)	(0.00865)	(0.00867)	(0.00901)
ES Partners	0.00496	0.00536	0.00518	0.0155**	0.0150**	0.0157**
	(0.00500)	(0.00513)	(0.00505)	(0.00699)	(0.00722)	(0.00708)
ES Retailers	0.00413	0.00385	0.00332	-0.00508	-0.00491	-0.00531
	(0.00593)	(0.00597)	(0.00592)	(0.00548)	(0.00551)	(0.00553)
Observations	850	850	850	547	547	547
Model hits	745	745	745	484	486	483
Log likelihood	-291.48	-291.42	-291.48	-154.22	-154.18	-154.3

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
Omitted dummies include: Freq3:>10/week, income <25k, no high school, rent residence, apartment, urban area, built 2005-09
The complete set of controls for this model are included in the appendix

Table 8: Marginal Effects for Age Fixed Effects Model on ES Clothes Washers and Dishwashers

	ES Clothes Washers			ES Dishwashers		
	(1)	(2)	(3)	(1)	(2)	(3)
Elec Price@Purchase	0.0249***	0.0241***		0.0136**	0.0154**	
	(0.00823)	(0.00831)		(0.00593)	(0.00617)	
StdDev Elec Price		0.0270			-0.0583	
		(0.0422)			(0.0557)	
2009 Elec Price			0.0282***			0.0126**
			(0.00883)			(0.00622)
Freq1: <5/week	0.144	0.143	0.162	-0.135	-0.137	-0.173
	(0.108)	(0.108)	(0.123)	(0.113)	(0.113)	(0.130)
Freq2: 5-9/week	0.0637	0.0646	0.0777	-0.117	-0.119	-0.187
	(0.110)	(0.109)	(0.124)	(0.104)	(0.105)	(0.119)
Freq1*Elec Price	-0.0133	-0.0132	-0.0139	0.00876	0.00895	0.0110
	(0.00900)	(0.00899)	(0.00969)	(0.00886)	(0.00888)	(0.00947)
Fre2*Elec Price	-0.00421	-0.00430	-0.00513	0.00751	0.00764	0.0123
	(0.00948)	(0.00947)	(0.0102)	(0.00837)	(0.00839)	(0.00889)
Purchased 2006-07	-0.199***	-0.195***	-0.202***	-0.182***	-0.190***	-0.185***
	(0.0276)	(0.0283)	(0.0276)	(0.0355)	(0.0363)	(0.0354)
Purchased 2002-05	-0.387***	-0.390***	-0.405***	-0.401***	-0.395***	-0.420***
	(0.0226)	(0.0229)	(0.0221)	(0.0283)	(0.0289)	(0.0277)
Observations	4,075	4,075	4,075	2,835	2,835	2,835
Hits	2927	2924	2933	2099	2094	2098
Log Likelihood	-2233.46	-2233.25	-2230.79	-1473.7	-1473.15	-1473.13

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Omitted dummies include: Freq3:>10/week, purchased 2008-09, income <25k, no high school, rent residence, apartment, urban area, built 2005-09

The complete set of controls for this model are included in the appendix

Table 9: Marginal Effects for Operating Cost Model Without California

	ES Clothes Washers			ES Dishwashers		
	(1)	(2)	(3)	(1)	(2)	(3)
Elec Price@Purchase	0.0376***	0.0412***		0.0254***	0.0317***	
	(0.00933)	(0.00951)		(0.00642)	(0.00666)	
StdDev Elec Price		-0.162***			-0.260***	
		(0.0395)			(0.0519)	
2009 Elec Price			0.0270***			0.0125*
			(0.00944)			(0.00652)
Freq1: <5/week	0.116	0.127	0.121	-0.203*	-0.198	-0.202
	(0.117)	(0.118)	(0.128)	(0.120)	(0.122)	(0.132)
Freq2: 5-9/week	0.0329	0.0251	0.0437	-0.122	-0.136	-0.177
	(0.122)	(0.124)	(0.132)	(0.110)	(0.112)	(0.121)
Freq1*Elec Price	-0.0129	-0.0136	-0.0122	0.0121	0.0120	0.0109
	(0.0103)	(0.0104)	(0.0104)	(0.00998)	(0.0102)	(0.0101)
Fre2*Elec Price	-0.00225	-0.00144	-0.00321	0.00800	0.00936	0.0118
	(0.0109)	(0.0111)	(0.0110)	(0.00930)	(0.00951)	(0.00943)
Observations	3,311	3,311	3,311	2,379	2,379	2,379
Hits	2275	2295	2246	1717	1725	1716
Log Likelihood	-1959.95	1951.59	-1985.11	-1335.62	-1323.04	-1353.9

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Omitted dummies include: Freq3:>10/week, income <25k, no high school, rent residence, apartment, urban area, built 2005-09

The complete set of controls for this model are included in the appendix

Table 10: Marginal Effects for State Fixed Effects Model

	ES Clothes Washers			ES Dishwashers		
	(1)	(2)	(3)	(1)	(2)	(3)
Elec Price@Purchase	0.147***	0.147***		0.156***	0.144***	
	(0.0132)	(0.0147)		(0.0148)	(0.0164)	
StdDev Elec Price		-0.00337			-0.129*	
		(0.0581)			(0.0755)	
2009 Elec Price			0.0290			0.00559
			(0.0188)			(0.0241)
Freq1: <5/week	0.117	0.117	0.107	-0.183	-0.179	-0.240*
	(0.108)	(0.108)	(0.122)	(0.114)	(0.114)	(0.127)
Freq2: 5-9/week	0.0292	0.0291	0.0304	-0.0979	-0.0990	-0.168
	(0.111)	(0.111)	(0.125)	(0.103)	(0.103)	(0.116)
Freq1*Elec Price	-0.0116	-0.0116	-0.0105	0.0111	0.0107	0.0142
	(0.00899)	(0.00899)	(0.00954)	(0.00894)	(0.00895)	(0.00942)
Fre2*Elec Price	-0.00124	-0.00124	-0.00175	0.00516	0.00532	0.0104
	(0.00947)	(0.00947)	(0.00997)	(0.00837)	(0.00838)	(0.00876)
Arizona	0.297***	0.297***	0.0165	0.335***	0.321***	0.0483
	(0.0127)	(0.0153)	(0.0754)	(0.0131)	(0.0184)	(0.0968)
Colorado	0.308***	0.307***	0.0591	0.335***	0.322***	-0.0184
	(0.0115)	(0.0130)	(0.0756)	(0.0145)	(0.0191)	(0.116)
Florida	0.297***	0.297***	0.00476	0.335***	0.311***	-0.0238
	(0.0195)	(0.0230)	(0.0412)	(0.0234)	(0.0304)	(0.0579)
Georgia	0.318***	0.317***	-0.0101	0.346***	0.326***	-0.0768
	(0.0136)	(0.0167)	(0.0803)	(0.0163)	(0.0240)	(0.117)
Illinois	0.305***	0.305***	0.0819	0.328***	0.322***	0.0565
	(0.0111)	(0.0116)	(0.0603)	(0.0129)	(0.0148)	(0.0871)
Massachusetts	-0.0609	-0.0601	0.0226	-0.150**	-0.120*	-0.00106
	(0.0503)	(0.0520)	(0.0598)	(0.0637)	(0.0652)	(0.0801)
Michigan	0.293***	0.293***	0.0288	0.314***	0.298***	-0.0519
	(0.0130)	(0.0146)	(0.0629)	(0.0160)	(0.0222)	(0.0922)
Missouri	0.366***	0.365***	0.0278	0.408***	0.391***	-0.0205
	(0.0133)	(0.0158)	(0.0966)	(0.0165)	(0.0214)	(0.143)
New Jersey	0.162***	0.161***	0.0120	0.174***	0.158***	0.0740
	(0.0406)	(0.0420)	(0.0699)	(0.0449)	(0.0485)	(0.0726)
New York	-0.364***	-0.363***	-0.000102	-0.394***	-0.372***	0.0343
	(0.0475)	(0.0494)	(0.0636)	(0.0560)	(0.0592)	(0.0822)
Pennsylvania	0.253***	0.252***	0.00973	0.283***	0.264***	-0.00841
	(0.0192)	(0.0217)	(0.0626)	(0.0211)	(0.0284)	(0.0854)
Texas	0.237***	0.236***	-0.00316	0.262***	0.258***	-0.0353
	(0.0223)	(0.0226)	(0.0411)	(0.0271)	(0.0278)	(0.0592)
Tennessee	0.322***	0.322***	0.0212	0.348***	0.337***	-0.0526
	(0.00993)	(0.0113)	(0.0914)	(0.0119)	(0.0154)	(0.138)
Virginia	0.321***	0.321***	0.0921	0.344***	0.332***	0.00941
	(0.0102)	(0.0115)	(0.0621)	(0.0130)	(0.0172)	(0.0995)
Wisconsin	0.266***	0.266***		0.299***	0.282***	
	(0.0173)	(0.0201)		(0.0183)	(0.0255)	
Observations	4,075	4,075	4,075	2,835	2,835	2,835
Hits	2840	2841	2787	2095	2087	2070
Log Likelihood	-2333.26	-2333.26	-2423.54	-1533.68	-1532.22	-1604.4

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1 The complete set of controls and table notes for this model are included in the appendix

Table 11: Marginal Effects for State Fixed Effects Model Without California

	ES Clothes Washers			ES Dishwashers		
	(1)	(2)	(3)	(1)	(2)	(3)
Elec Price@Purchase	0.147***	0.155***		0.153***	0.148***	
	(0.0141)	(0.0154)		(0.0153)	(0.0167)	
StdDev Elec Price		0.0833			-0.0584	
		(0.0657)			(0.0837)	
2009 Elec Price			-0.115			-0.0919
			(0.109)			(0.143)
Freq1: <5/week	0.121	0.121	0.118	-0.164	-0.163	-0.207
	(0.117)	(0.117)	(0.129)	(0.122)	(0.122)	(0.133)
Freq2: 5-9/week	0.0280	0.0305	0.0421	-0.123	-0.125	-0.191
	(0.122)	(0.122)	(0.132)	(0.111)	(0.111)	(0.121)
Freq1*Elec Price	-0.0125	-0.0125	-0.0120	0.00927	0.00915	0.0112
	(0.0103)	(0.0103)	(0.0105)	(0.0101)	(0.0101)	(0.0102)
Fre2*Elec Price	-0.00127	-0.00147	-0.00314	0.00785	0.00804	0.0127
	(0.0109)	(0.0109)	(0.0110)	(0.00942)	(0.00943)	(0.00950)
Arizona	-0.0690	-0.0349	-0.197	0.00385	-0.0177	-0.0886
	(0.0717)	(0.0739)	(0.149)	(0.0823)	(0.0904)	(0.182)
Colorado	-0.00735	0.0131	-0.237	-0.0372	-0.0495	-0.225
	(0.0655)	(0.0653)	(0.214)	(0.0821)	(0.0851)	(0.268)
Florida	-0.233***	-0.228***	0.0685	-0.237***	-0.241***	0.0230
	(0.0625)	(0.0627)	(0.0794)	(0.0766)	(0.0769)	(0.116)
Georgia	-0.0387	-0.00658	-0.304	-0.0417	-0.0639	-0.272
	(0.0618)	(0.0643)	(0.193)	(0.0778)	(0.0856)	(0.246)
Massachusetts	-0.631***	-0.651***	0.350***	-0.666***	-0.657***	0.308
	(0.0371)	(0.0352)	(0.0809)	(0.0303)	(0.0357)	(0.235)
Michigan	-0.0846	-0.0674	-0.0176	-0.127	-0.140	-0.0854
	(0.0754)	(0.0755)	(0.0584)	(0.0939)	(0.0960)	(0.0766)
Missouri	0.125***	0.153***	-0.480*	0.166***	0.148**	-0.370
	(0.0465)	(0.0478)	(0.284)	(0.0547)	(0.0636)	(0.428)
New Jersey	-0.468***	-0.476***	0.315***	-0.501***	-0.493***	0.303*
	(0.0726)	(0.0713)	(0.0722)	(0.0726)	(0.0754)	(0.174)
New York	-0.739***	-0.750***	0.397***	-0.743***	-0.738***	0.353
	(0.0250)	(0.0240)	(0.119)	(0.0251)	(0.0277)	(0.250)
Pennsylvania	-0.284***	-0.276***	-0.0262	-0.287***	-0.292***	-0.0339
	(0.0757)	(0.0763)	(0.0568)	(0.0911)	(0.0913)	(0.0733)
Texas	-0.372***	-0.401***	0.0635	-0.402***	-0.383***	0.0117
	(0.0609)	(0.0635)	(0.0812)	(0.0718)	(0.0787)	(0.119)
Tennessee	0.112**	0.143***	-0.388	0.144**	0.123*	-0.325
	(0.0524)	(0.0523)	(0.249)	(0.0627)	(0.0745)	(0.339)
Virginia	0.0780	0.102*	-0.0862	0.0496	0.0318	-0.121
	(0.0559)	(0.0555)	(0.135)	(0.0742)	(0.0809)	(0.171)
Wisconsin	-0.231***	-0.215***		-0.204**	-0.214**	
	(0.0766)	(0.0779)		(0.0991)	(0.1000)	
Observations	3,311	3,311	3,311	2,379	2,379	2,379
Hits	2309	2312	2248	1740	1746	1728
Log Likelihood	-1896.4	-1895.6	-1980.14	-12284.77	-1284.53	-1349.69

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1, Note that Wisconsin is dropped in addition for the models using 2009 electricity prices to avoid collinearity. The complete set of controls for this model are included in the appendix

Table 12: Marginal Effects for Operation Cost Model Without Appliances Purchased in 2008-09

	ES Clothes Washers			ES Dishwashers		
	(1)	(2)	(3)	(1)	(2)	(3)
Elec Price@Purchase	0.0307***	0.0359***		0.0220***	0.0308***	
	(0.00956)	(0.00975)		(0.00677)	(0.00708)	
StdDev Elec Price		-0.230***			-0.329***	
		(0.0403)			(0.0534)	
2009 Elec Price			0.0279***			0.0145**
			(0.0104)			(0.00712)
Freq1: <5/week	0.0742	0.0933	0.118	-0.214*	-0.197	-0.208
	(0.127)	(0.128)	(0.146)	(0.119)	(0.122)	(0.138)
Freq2: 5-9/week	0.0174	0.0102	0.0479	-0.0996	-0.121	-0.161
	(0.131)	(0.133)	(0.150)	(0.115)	(0.117)	(0.131)
Freq1*Elec Price	-0.00681	-0.00814	-0.00938	0.0163	0.0150	0.0147
	(0.0105)	(0.0106)	(0.0114)	(0.0100)	(0.0103)	(0.0107)
Fre2*Elec Price	0.00105	0.00166	-0.00146	0.00588	0.00746	0.0105
	(0.0110)	(0.0112)	(0.0119)	(0.00954)	(0.00977)	(0.0102)
Observations	3,225	3,225	3,225	2,288	2,288	2,288
Hits	2142	2147	2131	1599	1612	1589
Log Likelihood	-1994.84	-1978.42	-2008.72	-1347.31	-1327.87	-1358.51

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Omitted dummies include: Freq3:>10/week, income <25k, no high school, rent residence, apartment, urban area, built 2005-09

The complete set of controls for this model are included in the appendix

Table 13: Marginal Effects for Operation Cost Model Excluding States with no Variation in Model Purchases

	ES Clothes Washers			ES Dishwashers		
	(1)	(2)	(3)	(1)	(2)	(3)
Elec Price@Purchase	0.0325***	0.0383***		0.0220***	0.0295***	
	(0.00823)	(0.00843)		(0.00582)	(0.00609)	
StdDev Elec Price		-0.239***			-0.292***	
		(0.0382)			(0.0489)	
2009 Elec Price			0.0255***			0.0114*
			(0.00889)			(0.00613)
Freq1: <5/week	0.0927	0.111	0.103	-0.231**	-0.220*	-0.251**
	(0.110)	(0.111)	(0.125)	(0.111)	(0.113)	(0.126)
Freq2: 5-9/week	0.0206	0.0122	0.0374	-0.118	-0.128	-0.176
	(0.113)	(0.115)	(0.128)	(0.102)	(0.104)	(0.116)
Freq1*Elec Price	-0.0101	-0.0114	-0.0100	0.0138	0.0130	0.0144
	(0.00904)	(0.00920)	(0.00980)	(0.00878)	(0.00894)	(0.00936)
Fre2*Elec Price	-0.00102	-0.000327	-0.00237	0.00603	0.00690	0.0102
	(0.00952)	(0.00970)	(0.0103)	(0.00823)	(0.00841)	(0.00871)
Observations	3,765	3,765	3,765			
Hits	2583	2590	2558			
Log Likelihood	-2234.61	-2214.93	-2257.75			

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
Omitted dummies include: Freq3:>10/week, income <25k, no high school, rent residence, apartment, urban area, built 2005-09. Notes that for clothes washers New Jersey, Pennsylvania, and Illinois are excluded and for dishwashers Wisconsin is excluded.

The complete set of controls for this model are included in the appendix

Table 15: Likelihood Ratio Tests

	Clothes Washer			Dishwasher		
Price Measure	purchase	std dev	2009	purchase	std dev	2009
Operating cost	119.36***	150.36***	70.32***	80.78***	119.46***	44.04***
Market structure	0.76	0.38	1.20	0.38	0.06	0.12
Age fixed effects	340.98***	310.40***	395.36***	233.56***	195.98***	271.44***
State fixed effects	141.38***	110.38***	9.86	113.60***	77.84***	8.90

*** indicates significance at the 1% level. All chi-squared critical values are determined with respect to the operating cost model. Likelihood for the operating cost model is with respect to controls only model

Appendix

Table 5 Continued: Marginal Effects for Operating Cost Model on ES Clothes Washers and Dishwashers

	ES Clothes Washers			ES Dishwashers		
	(1)	(2)	(3)	(1)	(2)	(3)
Income 25-40k	0.0462**	0.0443*	0.0482**	-0.0166	-0.0179	-0.0129
	(0.0234)	(0.0234)	(0.0233)	(0.0373)	(0.0376)	(0.0369)
Income 40-55k	0.0485**	0.0474**	0.0491**	0.0142	0.0116	0.0177
	(0.0239)	(0.0240)	(0.0238)	(0.0356)	(0.0360)	(0.0353)
Income 55-90k	0.0897***	0.0874***	0.0943***	0.0437	0.0416	0.0520
	(0.0230)	(0.0231)	(0.0228)	(0.0339)	(0.0342)	(0.0335)
Income>90k	0.104***	0.104***	0.114***	0.0857**	0.0846**	0.100***
	(0.0246)	(0.0246)	(0.0242)	(0.0346)	(0.0348)	(0.0341)
High School Degree	0.0643**	0.0652**	0.0597**	-0.0145	-0.0161	-0.0124
	(0.0271)	(0.0271)	(0.0272)	(0.0549)	(0.0559)	(0.0545)
Some College	0.0665**	0.0680**	0.0608**	0.0214	0.0247	0.0219
	(0.0277)	(0.0278)	(0.0278)	(0.0528)	(0.0536)	(0.0525)
College Degree	0.0825***	0.0825***	0.0781***	0.00422	0.00699	0.00863
	(0.0291)	(0.0292)	(0.0293)	(0.0552)	(0.0559)	(0.0547)
Advanced Degree	0.0580*	0.0585*	0.0529	0.0247	0.0158	0.0311
	(0.0330)	(0.0330)	(0.0332)	(0.0566)	(0.0580)	(0.0559)
Householder Age	0.0160***	0.0163***	0.0160***	0.0171***	0.0177***	0.0169***
	(0.00283)	(0.00283)	(0.00282)	(0.00369)	(0.00370)	(0.00367)
Householder Age^2	-0.000142***	-0.000144***	-0.000141***	-0.000140***	-0.000145***	-0.000138***
	(2.72e-05)	(2.72e-05)	(2.71e-05)	(3.56e-05)	(3.58e-05)	(3.54e-05)
# of House Members	0.0114*	0.0117*	0.0140**	-0.00221	-0.00175	-0.000288
	(0.00602)	(0.00603)	(0.00598)	(0.00807)	(0.00813)	(0.00802)
Own Residence	0.140***	0.141***	0.136***	0.237***	0.236***	0.231***
	(0.0228)	(0.0229)	(0.0227)	(0.0318)	(0.0321)	(0.0315)
Mobile Home	-0.105**	-0.102**	-0.113**	-0.0216	-0.0207	-0.0284
	(0.0468)	(0.0468)	(0.0468)	(0.0694)	(0.0697)	(0.0696)
House	0.0187	0.0247	0.00881	0.0993***	0.104***	0.0879**
	(0.0259)	(0.0262)	(0.0256)	(0.0346)	(0.0350)	(0.0342)
Rural Area	0.0864***	0.0813***	0.0799***	0.0994***	0.0912***	0.0932***
	(0.0192)	(0.0193)	(0.0194)	(0.0248)	(0.0250)	(0.0250)
Built pre 1969	-0.0519	-0.0445	-0.0422	-0.0955**	-0.0873**	-0.0842**
	(0.0322)	(0.0321)	(0.0321)	(0.0396)	(0.0395)	(0.0394)
Built 1970-89	-0.0765**	-0.0692**	-0.0737**	-0.172***	-0.163***	-0.170***
	(0.0326)	(0.0325)	(0.0325)	(0.0379)	(0.0380)	(0.0378)
Built 1990-99	-0.0255	-0.0196	-0.0279	-0.0516	-0.0393	-0.0559
	(0.0355)	(0.0353)	(0.0355)	(0.0429)	(0.0425)	(0.0429)
Built 2000-04	-0.0429	-0.0322	-0.0477	-0.148***	-0.116***	-0.164***
	(0.0388)	(0.0383)	(0.0389)	(0.0447)	(0.0446)	(0.0446)
Observations	4,075	4,075	4,075	2,835	2,835	2,835
Model hits	2806	2825	2778	2065	2060	2062
Log Likelihood	-2403.95	-2388.45	-2428.47	-1590.48	-1571.14	-1608.85

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Omitted dummies include: Freq3:>10/week, income <25k, no high school, rent residence, apartment, urban area, built 2005-09

Table 6 Continued: Marginal Effects for Market Structure Model on ES Clothes Washers and Dishwashers

	ES Clothes Washers			ES Dishwashers		
	(1)	(2)	(3)	(1)	(2)	(3)
Income 25-40k	0.0456*	0.0440*	0.0476**	-0.0168	-0.0177	-0.0135
	(0.0234)	(0.0234)	(0.0233)	(0.0373)	(0.0376)	(0.0370)
Income 40-55k	0.0477**	0.0470**	0.0483**	0.0145	0.0119	0.0171
	(0.0239)	(0.0240)	(0.0239)	(0.0357)	(0.0360)	(0.0354)
Income 55-90k	0.0887***	0.0869***	0.0936***	0.0432	0.0416	0.0515
	(0.0230)	(0.0231)	(0.0228)	(0.0340)	(0.0342)	(0.0336)
Income>90k	0.103***	0.104***	0.113***	0.0854**	0.0847**	0.0997***
	(0.0246)	(0.0246)	(0.0242)	(0.0347)	(0.0349)	(0.0341)
High School Degree	0.0642**	0.0652**	0.0598**	-0.0139	-0.0161	-0.0118
	(0.0271)	(0.0271)	(0.0272)	(0.0549)	(0.0559)	(0.0545)
Some College	0.0662**	0.0679**	0.0606**	0.0216	0.0246	0.0224
	(0.0277)	(0.0278)	(0.0278)	(0.0529)	(0.0536)	(0.0526)
College Degree	0.0819***	0.0822***	0.0776***	0.00439	0.00683	0.00925
	(0.0292)	(0.0292)	(0.0293)	(0.0552)	(0.0559)	(0.0547)
Advanced Degree	0.0572*	0.0579*	0.0519	0.0251	0.0159	0.0312
	(0.0330)	(0.0330)	(0.0333)	(0.0566)	(0.0580)	(0.0559)
Householder Age	0.0160***	0.0162***	0.0160***	0.0171***	0.0177***	0.0169***
	(0.00283)	(0.00283)	(0.00282)	(0.00369)	(0.00371)	(0.00367)
Householder Age^2	-0.000142***	-0.000144***	-0.000141***	-0.000140***	-0.000145***	-0.000137***
	(2.72e-05)	(2.72e-05)	(2.71e-05)	(3.56e-05)	(3.58e-05)	(3.54e-05)
# of House Members	0.0117*	0.0120**	0.0145**	-0.00197	-0.00168	-0.000220
	(0.00603)	(0.00604)	(0.00600)	(0.00808)	(0.00814)	(0.00803)
Own Residence	0.140***	0.140***	0.135***	0.237***	0.237***	0.231***
	(0.0228)	(0.0229)	(0.0227)	(0.0319)	(0.0322)	(0.0316)
Mobile Home	-0.103**	-0.100**	-0.111**	-0.0229	-0.0215	-0.0275
	(0.0468)	(0.0468)	(0.0467)	(0.0695)	(0.0699)	(0.0696)
House	0.0198	0.0258	0.0103	0.0985***	0.104***	0.0886***
	(0.0260)	(0.0263)	(0.0256)	(0.0347)	(0.0351)	(0.0343)
Rural Area	0.0857***	0.0810***	0.0790***	0.0990***	0.0912***	0.0928***
	(0.0192)	(0.0193)	(0.0195)	(0.0248)	(0.0251)	(0.0250)
Built pre 1969	-0.0547*	-0.0462	-0.0440	-0.0957**	-0.0869**	-0.0853**
	(0.0324)	(0.0323)	(0.0323)	(0.0398)	(0.0397)	(0.0396)
Built 1970-89	-0.0777**	-0.0695**	-0.0739**	-0.173***	-0.163***	-0.171***
	(0.0327)	(0.0325)	(0.0326)	(0.0380)	(0.0380)	(0.0379)
Built 1990-99	-0.0260	-0.0197	-0.0278	-0.0519	-0.0393	-0.0561
	(0.0356)	(0.0353)	(0.0355)	(0.0429)	(0.0425)	(0.0429)
Built 2000-04	-0.0430	-0.0322	-0.0471	-0.147***	-0.116***	-0.164***
	(0.0388)	(0.0383)	(0.0389)	(0.0447)	(0.0446)	(0.0446)
Observations	4,075	4,075	4,075	2,835	2,835	2,835
Model hits	2808	2823	2779	2067	2058	2064
Log Likelihood	-2403.57	-2388.26	-2427.87	-1590.29	-1571.11	-1608.79

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Omitted dummies include: Freq3:>10/week, income <25k, no high school, rent residence, apartment, urban area, built 2005-09

Table 7 Continued: Marginal Effects for Market Structure Model for Appliances Purchased in 2008-09

	ES Clothes Washers			ES Dishwashers		
	(1)	(2)	(3)	(1)	(2)	(3)
Income 25-40k	0.0407	0.0404	0.0406	-0.0113	-0.0106	-0.0113
	(0.0249)	(0.0250)	(0.0250)	(0.0352)	(0.0351)	(0.0352)
Income 40-55k	0.0134	0.0134	0.0128	0.0114	0.0115	0.0120
	(0.0292)	(0.0292)	(0.0294)	(0.0295)	(0.0294)	(0.0293)
Income 55-90k	0.0189	0.0187	0.0181	0.0167	0.0171	0.0166
	(0.0290)	(0.0290)	(0.0291)	(0.0285)	(0.0284)	(0.0285)
Income>90k	0.0820***	0.0816***	0.0811***	0.0741**	0.0750**	0.0741**
	(0.0274)	(0.0274)	(0.0275)	(0.0314)	(0.0316)	(0.0315)
High School Degree	0.00929	0.00889	0.00904	0.0431	0.0435	0.0427
	(0.0354)	(0.0355)	(0.0354)	(0.0342)	(0.0341)	(0.0343)
Some College	0.0146	0.0143	0.0148	0.0392	0.0396	0.0385
	(0.0348)	(0.0348)	(0.0348)	(0.0444)	(0.0445)	(0.0445)
College Degree	-0.0109	-0.0120	-0.0109	0.0657*	0.0661*	0.0648*
	(0.0413)	(0.0417)	(0.0413)	(0.0381)	(0.0381)	(0.0382)
Advanced Degree	-0.0220	-0.0227	-0.0216	0.00464	0.00493	0.00417
	(0.0531)	(0.0533)	(0.0529)	(0.0536)	(0.0535)	(0.0538)
Householder Age	0.00186	0.00193	0.00173	0.00235	0.00234	0.00235
	(0.00381)	(0.00381)	(0.00381)	(0.00357)	(0.00357)	(0.00358)
Householder Age^2	-1.12e-05	-1.19e-05	-1.01e-05	-1.83e-05	-1.82e-05	-1.85e-05
	(3.78e-05)	(3.78e-05)	(3.78e-05)	(3.45e-05)	(3.44e-05)	(3.45e-05)
# of House Members	0.00793	0.00784	0.00761	0.00897	0.00897	0.00872
	(0.00745)	(0.00745)	(0.00746)	(0.00947)	(0.00946)	(0.00945)
Own Residence	0.0463	0.0469	0.0466	0.229***	0.229***	0.229***
	(0.0330)	(0.0331)	(0.0331)	(0.0676)	(0.0675)	(0.0675)
Mobile Home	-0.0922	-0.0967	-0.0912	0.0335	0.0336	0.0347
	(0.0789)	(0.0813)	(0.0785)	(0.0458)	(0.0457)	(0.0445)
House	0.0317	0.0304	0.0328	0.0248	0.0249	0.0250
	(0.0375)	(0.0374)	(0.0376)	(0.0367)	(0.0367)	(0.0367)
Rural Area	0.0569***	0.0567***	0.0575***	-0.00344	-0.00345	-0.00346
	(0.0216)	(0.0216)	(0.0216)	(0.0327)	(0.0327)	(0.0327)
Built pre 1969	0.00546	0.00610	0.00439	-0.0175	-0.0178	-0.0181
	(0.0403)	(0.0403)	(0.0405)	(0.0420)	(0.0420)	(0.0422)
Built 1970-89	0.0462	0.0465	0.0459	-0.0285	-0.0285	-0.0299
	(0.0354)	(0.0354)	(0.0355)	(0.0440)	(0.0439)	(0.0444)
Built 1990-99	0.00539	0.00606	0.00564	-0.0412	-0.0410	-0.0422
	(0.0425)	(0.0423)	(0.0424)	(0.0569)	(0.0567)	(0.0573)
Built 2000-04	0.0204	0.0217	0.0211	-0.00168	-0.00318	-0.00185
	(0.0431)	(0.0427)	(0.0428)	(0.0612)	(0.0624)	(0.0613)
Observations	850	850	850	547	547	547
Model hits	745	745	745	484	486	483
Log likelihood	-291.48	-291.42	-291.48	-154.22	-154.18	-154.30

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Omitted dummies include: Freq3:>10/week, income <25k, no high school, rent residence, apartment, urban area, built 2005-09

Table 8 Continued: Marginal Effects for Age Fixed Effects Model on ES Clothes Washers and Dishwashers

	ES Clothes Washers			ES Dishwashers		
	(1)	(2)	(3)	(1)	(2)	(3)
Income 25-40k	0.0347	0.0349	0.0355	-0.0135	-0.0132	-0.0141
	(0.0238)	(0.0238)	(0.0238)	(0.0381)	(0.0381)	(0.0381)
Income 40-55k	0.0396	0.0397	0.0397	0.0206	0.0207	0.0199
	(0.0243)	(0.0243)	(0.0243)	(0.0360)	(0.0360)	(0.0360)
Income 55-90k	0.0815***	0.0818***	0.0811***	0.0483	0.0486	0.0483
	(0.0231)	(0.0231)	(0.0232)	(0.0342)	(0.0342)	(0.0342)
Income>90k	0.0930***	0.0929***	0.0917***	0.0889**	0.0889**	0.0895**
	(0.0248)	(0.0248)	(0.0249)	(0.0348)	(0.0348)	(0.0348)
High School Degree	0.0728***	0.0729***	0.0710***	-0.0116	-0.0124	-0.0135
	(0.0270)	(0.0270)	(0.0271)	(0.0563)	(0.0564)	(0.0563)
Some College	0.0724***	0.0723***	0.0709**	0.0164	0.0167	0.0149
	(0.0279)	(0.0279)	(0.0279)	(0.0542)	(0.0543)	(0.0542)
College Degree	0.0887***	0.0889***	0.0874***	0.00383	0.00369	0.00202
	(0.0289)	(0.0289)	(0.0290)	(0.0565)	(0.0566)	(0.0566)
Advanced Degree	0.0715**	0.0717**	0.0695**	0.0167	0.0145	0.0144
	(0.0321)	(0.0321)	(0.0322)	(0.0584)	(0.0587)	(0.0585)
Householder Age	0.0174***	0.0173***	0.0171***	0.0202***	0.0203***	0.0201***
	(0.00287)	(0.00287)	(0.00287)	(0.00378)	(0.00378)	(0.00378)
Householder Age^2	-0.000151***	-0.000150***	-0.000149***	-0.000162***	-0.000163***	-0.000161***
	(2.75e-05)	(2.75e-05)	(2.75e-05)	(3.64e-05)	(3.64e-05)	(3.64e-05)
# of House Members	0.0102*	0.0101*	0.0101*	0.00279	0.00278	0.00247
	(0.00605)	(0.00605)	(0.00605)	(0.00821)	(0.00821)	(0.00820)
Own Residence	0.142***	0.142***	0.140***	0.248***	0.247***	0.244***
	(0.0235)	(0.0235)	(0.0235)	(0.0334)	(0.0334)	(0.0334)
Mobile Home	-0.114**	-0.115**	-0.112**	-0.0256	-0.0253	-0.0243
	(0.0486)	(0.0487)	(0.0486)	(0.0717)	(0.0716)	(0.0715)
House	0.0199	0.0194	0.0230	0.0845**	0.0855**	0.0866**
	(0.0262)	(0.0262)	(0.0263)	(0.0356)	(0.0357)	(0.0357)
Rural Area	0.0796***	0.0803***	0.0816***	0.0960***	0.0943***	0.0956***
	(0.0193)	(0.0193)	(0.0193)	(0.0249)	(0.0250)	(0.0250)
Built pre 1969	-0.0128	-0.0125	-0.0157	-0.0436	-0.0453	-0.0452
	(0.0319)	(0.0319)	(0.0320)	(0.0396)	(0.0397)	(0.0397)
Built 1970-89	-0.0488	-0.0488	-0.0492	-0.135***	-0.136***	-0.136***
	(0.0324)	(0.0324)	(0.0324)	(0.0388)	(0.0388)	(0.0388)
Built 1990-99	-0.00570	-0.00566	-0.00575	-0.0143	-0.0147	-0.0156
	(0.0348)	(0.0348)	(0.0349)	(0.0423)	(0.0423)	(0.0424)
Built 2000-04	0.00776	0.00770	0.00684	-0.0208	-0.0207	-0.0218
	(0.0366)	(0.0366)	(0.0367)	(0.0429)	(0.0429)	(0.0430)
Observations	4,075	4,075	4,075	2,835	2,835	2,835
Hits	2927	2924	2933	2099	2094	2098
Log Likelihood	-2233.46	-2233.25	-2230.79	-1473.70	-1473.15	-1473.13

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Omitted dummies include: Freq3:>10/week, purchased 2008-09, income <25k, no high school, rent residence, apartment, urban area, built 2005-09

Table 9 Continued: Marginal Effects for Operating Cost Model Without California

	ES Clothes Washers			ES Dishwashers		
	(1)	(2)	(3)	(1)	(2)	(3)
Income 25-40k	0.0621**	0.0609**	0.0647**	-0.00601	-0.00694	-0.000247
	(0.0255)	(0.0255)	(0.0254)	(0.0398)	(0.0401)	(0.0394)
Income 40-55k	0.0588**	0.0580**	0.0591**	0.0256	0.0235	0.0323
	(0.0262)	(0.0263)	(0.0262)	(0.0379)	(0.0382)	(0.0375)
Income 55-90k	0.107***	0.105***	0.112***	0.0780**	0.0771**	0.0863**
	(0.0253)	(0.0254)	(0.0251)	(0.0360)	(0.0362)	(0.0356)
Income>90k	0.111***	0.112***	0.123***	0.112***	0.113***	0.126***
	(0.0275)	(0.0274)	(0.0270)	(0.0372)	(0.0373)	(0.0366)
High School Degree	0.0634**	0.0631**	0.0597*	0.00513	0.00316	0.00799
	(0.0314)	(0.0314)	(0.0315)	(0.0579)	(0.0588)	(0.0576)
Some College	0.0487	0.0492	0.0436	0.0306	0.0338	0.0308
	(0.0325)	(0.0325)	(0.0325)	(0.0566)	(0.0573)	(0.0564)
College Degree	0.0491	0.0479	0.0453	0.0126	0.0155	0.0168
	(0.0349)	(0.0350)	(0.0350)	(0.0592)	(0.0599)	(0.0589)
Advanced Degree	0.0433	0.0422	0.0392	0.0212	0.0123	0.0301
	(0.0386)	(0.0387)	(0.0388)	(0.0614)	(0.0627)	(0.0606)
Householder Age	0.0156***	0.0159***	0.0157***	0.0170***	0.0175***	0.0169***
	(0.00318)	(0.00318)	(0.00317)	(0.00405)	(0.00407)	(0.00403)
Householder Age^2	-0.000137***	-0.000139***	-0.000138***	-0.000139***	-0.000142***	-0.000138***
	(3.06e-05)	(3.07e-05)	(3.06e-05)	(3.92e-05)	(3.94e-05)	(3.90e-05)
# of House Members	0.0101	0.0106	0.0125*	-0.00446	-0.00409	-0.00224
	(0.00708)	(0.00709)	(0.00703)	(0.00893)	(0.00898)	(0.00887)
Own Residence	0.133***	0.133***	0.132***	0.188***	0.188***	0.188***
	(0.0263)	(0.0263)	(0.0261)	(0.0360)	(0.0362)	(0.0355)
Mobile Home	-0.0878*	-0.0856*	-0.103**	0.0143	0.0163	0.00253
	(0.0512)	(0.0512)	(0.0513)	(0.0708)	(0.0708)	(0.0717)
House	0.0269	0.0329	0.00968	0.139***	0.142***	0.120***
	(0.0300)	(0.0302)	(0.0293)	(0.0395)	(0.0398)	(0.0389)
Rural Area	0.0903***	0.0866***	0.0859***	0.104***	0.0977***	0.0987***
	(0.0205)	(0.0205)	(0.0207)	(0.0262)	(0.0264)	(0.0265)
Built pre 1969	-0.0491	-0.0435	-0.0363	-0.0880**	-0.0808*	-0.0744*
	(0.0350)	(0.0349)	(0.0349)	(0.0424)	(0.0423)	(0.0422)
Built 1970-89	-0.0806**	-0.0745**	-0.0791**	-0.173***	-0.165***	-0.174***
	(0.0352)	(0.0351)	(0.0351)	(0.0405)	(0.0405)	(0.0404)
Built 1990-99	-0.0259	-0.0205	-0.0296	-0.0559	-0.0436	-0.0634
	(0.0382)	(0.0380)	(0.0383)	(0.0457)	(0.0453)	(0.0458)
Built 2000-04	-0.0370	-0.0284	-0.0415	-0.139***	-0.112**	-0.157***
	(0.0412)	(0.0408)	(0.0413)	(0.0469)	(0.0468)	(0.0469)
Observations	3,311	3,311	3,311	2,379	2,379	2,379
Hits	2275	2295	2246	1717	1725	1716
Log Likelihood	-1959.95	--1951.59	-1985.11	-1335.62	-1323.04	-1353.90

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Omitted dummies include: Freq3:>10/week, income <25k, no high school, rent residence, apartment, urban area, built 2005-09

Table 10 Continued: Marginal Effects for State Fixed Effects Model

	ES Clothes Washers			ES Dishwashers		
	(1)	(2)	(3)	(1)	(2)	(3)
Income 25-40k	0.0343	0.0344	0.0466**	-0.0237	-0.0247	-0.0154
	(0.0239)	(0.0239)	(0.0234)	(0.0382)	(0.0383)	(0.0373)
Income 40-55k	0.0384	0.0384	0.0463*	0.00654	0.00480	0.0149
	(0.0244)	(0.0244)	(0.0241)	(0.0365)	(0.0366)	(0.0358)
Income 55-90k	0.0806***	0.0805***	0.0901***	0.0372	0.0370	0.0466
	(0.0234)	(0.0234)	(0.0231)	(0.0345)	(0.0345)	(0.0340)
Income>90k	0.0932***	0.0933***	0.108***	0.0782**	0.0771**	0.0913***
	(0.0250)	(0.0250)	(0.0246)	(0.0352)	(0.0353)	(0.0348)
High School Degree	0.0734***	0.0734***	0.0594**	-0.00679	-0.00665	-0.0136
	(0.0270)	(0.0270)	(0.0273)	(0.0557)	(0.0559)	(0.0549)
Some College	0.0737***	0.0737***	0.0601**	0.0305	0.0309	0.0213
	(0.0278)	(0.0278)	(0.0279)	(0.0536)	(0.0538)	(0.0529)
College Degree	0.0874***	0.0874***	0.0774***	0.0127	0.0137	0.00883
	(0.0291)	(0.0291)	(0.0294)	(0.0558)	(0.0560)	(0.0550)
Advanced Degree	0.0673**	0.0673**	0.0520	0.0278	0.0270	0.0326
	(0.0326)	(0.0326)	(0.0334)	(0.0573)	(0.0576)	(0.0561)
Householder Age	0.0165***	0.0165***	0.0158***	0.0193***	0.0192***	0.0171***
	(0.00285)	(0.00285)	(0.00282)	(0.00373)	(0.00373)	(0.00368)
Householder Age^2	-0.000144***	-0.000144***	-0.000139***	-0.000157***	-0.000156***	-0.000140***
	(2.73e-05)	(2.73e-05)	(2.72e-05)	(3.61e-05)	(3.61e-05)	(3.56e-05)
# of House Members	0.0128**	0.0128**	0.0147**	-4.17e-05	-0.000196	-0.000431
	(0.00605)	(0.00606)	(0.00602)	(0.00822)	(0.00823)	(0.00805)
Own Residence	0.144***	0.144***	0.135***	0.236***	0.236***	0.232***
	(0.0232)	(0.0232)	(0.0228)	(0.0328)	(0.0329)	(0.0318)
Mobile Home	-0.109**	-0.109**	-0.117**	-0.0141	-0.0135	-0.0273
	(0.0480)	(0.0480)	(0.0473)	(0.0697)	(0.0697)	(0.0699)
House	0.0243	0.0243	0.0111	0.0975***	0.0999***	0.0887**
	(0.0264)	(0.0264)	(0.0258)	(0.0356)	(0.0357)	(0.0345)
Rural Area	0.0795***	0.0796***	0.0792***	0.0970***	0.0962***	0.0932***
	(0.0195)	(0.0195)	(0.0195)	(0.0250)	(0.0250)	(0.0252)
Built pre 1969	-0.0319	-0.0318	-0.0486	-0.0652	-0.0632	-0.0915**
	(0.0327)	(0.0327)	(0.0328)	(0.0406)	(0.0405)	(0.0405)
Built 1970-89	-0.0617*	-0.0616*	-0.0763**	-0.154***	-0.152***	-0.175***
	(0.0327)	(0.0327)	(0.0327)	(0.0386)	(0.0386)	(0.0381)
Built 1990-99	-0.0122	-0.0122	-0.0298	-0.0309	-0.0279	-0.0598
	(0.0352)	(0.0352)	(0.0357)	(0.0427)	(0.0426)	(0.0431)
Built 2000-04	-0.0157	-0.0156	-0.0459	-0.0880**	-0.0836*	-0.166***
	(0.0378)	(0.0378)	(0.0389)	(0.0446)	(0.0445)	(0.0448)
Observations	4,075	4,075	4,075	2,835	2,835	2,835
Hits	2840	2841	2787	2095	2087	2070
Log Likelihood	-2333.26	-2333.26	-2423.54	-1533.68	-1532.22	-1604.40

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Omitted dummies include: Freq3:>10/week, California, income <25k, no high school, rent residence, apartment, urban area, built 2005-09

Note that Wisconsin is dropped in addition for the models using 2009 electricity prices to avoid collinearity

Table 11 Continued: Marginal Effects for State Fixed Effects Model Without California

	ES Clothes Washers			ES Dishwashers		
	(1)	(2)	(3)	(1)	(2)	(3)
Income 25-40k	0.0495*	0.0490*	0.0628**	-0.0119	-0.0124	-0.00288
	(0.0261)	(0.0261)	(0.0256)	(0.0409)	(0.0410)	(0.0399)
Income 40-55k	0.0462*	0.0464*	0.0557**	0.0194	0.0185	0.0295
	(0.0269)	(0.0269)	(0.0265)	(0.0389)	(0.0390)	(0.0380)
Income 55-90k	0.0966***	0.0969***	0.107***	0.0726**	0.0727**	0.0805**
	(0.0258)	(0.0258)	(0.0255)	(0.0366)	(0.0366)	(0.0362)
Income>90k	0.0971***	0.0963***	0.114***	0.103***	0.103***	0.116***
	(0.0283)	(0.0283)	(0.0276)	(0.0380)	(0.0380)	(0.0374)
High School Degree	0.0754**	0.0750**	0.0599*	0.0141	0.0142	0.00659
	(0.0314)	(0.0313)	(0.0316)	(0.0588)	(0.0589)	(0.0581)
Some College	0.0585*	0.0580*	0.0431	0.0406	0.0410	0.0297
	(0.0327)	(0.0327)	(0.0327)	(0.0575)	(0.0576)	(0.0568)
College Degree	0.0549	0.0538	0.0443	0.0221	0.0228	0.0165
	(0.0351)	(0.0351)	(0.0352)	(0.0600)	(0.0601)	(0.0592)
Advanced Degree	0.0549	0.0536	0.0385	0.0254	0.0251	0.0316
	(0.0383)	(0.0384)	(0.0391)	(0.0623)	(0.0624)	(0.0608)
Householder Age	0.0164***	0.0164***	0.0155***	0.0197***	0.0196***	0.0172***
	(0.00321)	(0.00321)	(0.00318)	(0.00412)	(0.00413)	(0.00404)
Householder Age^2	-0.000140***	-0.000141***	-0.000136***	-0.000161***	-0.000160***	-0.000142***
	(3.09e-05)	(3.09e-05)	(3.07e-05)	(3.99e-05)	(4.00e-05)	(3.92e-05)
# of House Members	0.0107	0.0108	0.0132*	-0.00205	-0.00213	-0.00246
	(0.00714)	(0.00714)	(0.00706)	(0.00911)	(0.00911)	(0.00890)
Own Residence	0.142***	0.143***	0.131***	0.191***	0.192***	0.189***
	(0.0269)	(0.0269)	(0.0263)	(0.0371)	(0.0371)	(0.0358)
Mobile Home	-0.100*	-0.102*	-0.108**	0.0209	0.0215	0.00360
	(0.0529)	(0.0529)	(0.0521)	(0.0709)	(0.0709)	(0.0720)
House	0.0267	0.0256	0.0115	0.131***	0.131***	0.121***
	(0.0303)	(0.0303)	(0.0295)	(0.0407)	(0.0407)	(0.0392)
Rural Area	0.0864***	0.0859***	0.0855***	0.104***	0.104***	0.0990***
	(0.0206)	(0.0206)	(0.0208)	(0.0264)	(0.0264)	(0.0266)
Built pre 1969	-0.0264	-0.0281	-0.0436	-0.0542	-0.0531	-0.0821*
	(0.0357)	(0.0358)	(0.0357)	(0.0437)	(0.0437)	(0.0436)
Built 1970-89	-0.0674*	-0.0688*	-0.0826**	-0.158***	-0.157***	-0.179***
	(0.0354)	(0.0355)	(0.0354)	(0.0413)	(0.0413)	(0.0407)
Built 1990-99	-0.0124	-0.0137	-0.0319	-0.0357	-0.0338	-0.0682
	(0.0379)	(0.0380)	(0.0384)	(0.0457)	(0.0457)	(0.0461)
Built 2000-04	-0.00761	-0.00810	-0.0394	-0.0797*	-0.0777*	-0.159***
	(0.0401)	(0.0402)	(0.0414)	(0.0468)	(0.0468)	(0.0470)
Observations	3,311	3,311	3,311	2,379	2,379	2,379
Hits	2309	2312	2248	1740	1746	1728
Log Likelihood	-1896.40	-1895.60	-1980.14	-12284.77	-1284.53	-1349.69

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1, Note that Wisconsin is dropped in addition for the models using 2009 electricity prices to avoid collinearity

Omitted dummies include: Freq3:>10/week, Illinois, income <25k, no high school, rent residence, apartment, urban area, built 2005-09

Table 12 Continued: Marginal Effects for Operation Cost Model Without Appliances Purchased in 2008-09

	ES Clothes Washers			ES Dishwashers		
	(1)	(2)	(3)	(1)	(2)	(3)
Income 25-40k	0.0341	0.0312	0.0360	0.00240	-0.000852	0.00568
	(0.0286)	(0.0288)	(0.0285)	(0.0432)	(0.0437)	(0.0428)
Income 40-55k	0.0480*	0.0463	0.0475	0.0282	0.0248	0.0313
	(0.0290)	(0.0292)	(0.0290)	(0.0417)	(0.0423)	(0.0414)
Income 55-90k	0.0980***	0.0949***	0.101***	0.0601	0.0571	0.0678*
	(0.0279)	(0.0281)	(0.0277)	(0.0400)	(0.0405)	(0.0396)
Income>90k	0.0877***	0.0885***	0.0963***	0.0903**	0.0872**	0.103**
	(0.0304)	(0.0305)	(0.0300)	(0.0409)	(0.0414)	(0.0404)
High School Degree	0.0795**	0.0809**	0.0740**	-0.0361	-0.0390	-0.0345
	(0.0327)	(0.0328)	(0.0327)	(0.0631)	(0.0644)	(0.0627)
Some College	0.0803**	0.0825**	0.0739**	0.00242	0.00551	0.00282
	(0.0335)	(0.0336)	(0.0334)	(0.0611)	(0.0623)	(0.0607)
College Degree	0.108***	0.107***	0.103***	-0.0268	-0.0266	-0.0231
	(0.0350)	(0.0352)	(0.0350)	(0.0640)	(0.0652)	(0.0636)
Advanced Degree	0.0824**	0.0825**	0.0759*	0.0200	0.00651	0.0250
	(0.0391)	(0.0393)	(0.0393)	(0.0659)	(0.0677)	(0.0653)
Householder Age	0.0207***	0.0213***	0.0204***	0.0226***	0.0237***	0.0222***
	(0.00339)	(0.00340)	(0.00338)	(0.00436)	(0.00440)	(0.00434)
Householder Age^2	-0.000181***	-0.000187***	-0.000178***	-0.000184***	-0.000193***	-0.000180***
	(3.23e-05)	(3.25e-05)	(3.22e-05)	(4.19e-05)	(4.23e-05)	(4.17e-05)
# of House Members	0.0123*	0.0126*	0.0147**	-0.000504	-0.000284	0.00107
	(0.00719)	(0.00723)	(0.00714)	(0.00914)	(0.00926)	(0.00908)
Own Residence	0.157***	0.159***	0.151***	0.222***	0.221***	0.216***
	(0.0260)	(0.0261)	(0.0259)	(0.0354)	(0.0358)	(0.0353)
Mobile Home	-0.120**	-0.120**	-0.123**	-0.0482	-0.0469	-0.0521
	(0.0536)	(0.0537)	(0.0533)	(0.0796)	(0.0802)	(0.0794)
House	0.00234	0.00894	-0.00328	0.0740*	0.0803**	0.0669*
	(0.0302)	(0.0305)	(0.0300)	(0.0393)	(0.0398)	(0.0390)
Rural Area	0.0836***	0.0758***	0.0787***	0.113***	0.102***	0.107***
	(0.0236)	(0.0238)	(0.0237)	(0.0292)	(0.0296)	(0.0294)
Built pre 1969	-0.0623*	-0.0516	-0.0573	-0.125***	-0.114**	-0.120***
	(0.0375)	(0.0375)	(0.0375)	(0.0444)	(0.0446)	(0.0445)
Built 1970-89	-0.113***	-0.102***	-0.112***	-0.213***	-0.201***	-0.213***
	(0.0377)	(0.0378)	(0.0377)	(0.0416)	(0.0419)	(0.0415)
Built 1990-99	-0.0360	-0.0274	-0.0388	-0.0707	-0.0556	-0.0759
	(0.0415)	(0.0413)	(0.0414)	(0.0485)	(0.0486)	(0.0484)
Built 2000-04	-0.0491	-0.0319	-0.0548	-0.149***	-0.108**	-0.164***
	(0.0444)	(0.0441)	(0.0445)	(0.0473)	(0.0480)	(0.0470)
Observations	3,225	3,225	3,225	2,288	2,288	2,288
Hits	2142	2147	2131	1599	1612	1589
Log Likelihood	-1994.84	-1978.42	-2008.72	-1347.31	-1327.87	-1358.51

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Omitted dummies include: Freq3:>10/week, income <25k, no high school, rent residence, apartment, urban area, built 2005-09

Table 13 Continued: Marginal Effects for Operation Cost Model Excluding States with no Variation in Model Purchases

	ES Clothes Washers			ES Dishwashers		
	(1)	(2)	(3)	(1)	(2)	(3)
Income 25-40k	0.0361	0.0344	0.0382	-0.00709	-0.00732	-0.00294
	(0.0247)	(0.0248)	(0.0246)	(0.0373)	(0.0375)	(0.0369)
Income 40-55k	0.0435*	0.0437*	0.0439*	0.0178	0.0158	0.0214
	(0.0251)	(0.0251)	(0.0250)	(0.0357)	(0.0360)	(0.0355)
Income 55-90k	0.0836***	0.0821***	0.0883***	0.0442	0.0433	0.0525
	(0.0242)	(0.0243)	(0.0241)	(0.0342)	(0.0344)	(0.0338)
Income>90k	0.0999***	0.102***	0.111***	0.0929***	0.0921***	0.107***
	(0.0258)	(0.0258)	(0.0254)	(0.0347)	(0.0349)	(0.0342)
High School Degree	0.0698**	0.0707**	0.0660**	-0.00230	-0.00376	-0.000659
	(0.0280)	(0.0281)	(0.0281)	(0.0550)	(0.0558)	(0.0546)
Some College	0.0780***	0.0790***	0.0726**	0.0330	0.0365	0.0331
	(0.0286)	(0.0286)	(0.0286)	(0.0531)	(0.0538)	(0.0529)
College Degree	0.0875***	0.0876***	0.0829***	0.0165	0.0195	0.0206
	(0.0302)	(0.0303)	(0.0303)	(0.0554)	(0.0560)	(0.0550)
Advanced Degree	0.0701**	0.0700**	0.0647*	0.0396	0.0308	0.0456
	(0.0338)	(0.0339)	(0.0341)	(0.0564)	(0.0577)	(0.0558)
Householder Age	0.0158***	0.0160***	0.0158***	0.0164***	0.0170***	0.0162***
	(0.00294)	(0.00295)	(0.00293)	(0.00373)	(0.00374)	(0.00371)
Householder Age^2	-0.000138***	-0.000140***	-0.000137***	-0.000133***	-0.000138***	-0.000130***
	(2.84e-05)	(2.85e-05)	(2.83e-05)	(3.60e-05)	(3.62e-05)	(3.59e-05)
# of House Members	0.0128**	0.0130**	0.0154**	-0.00292	-0.00235	-0.00115
	(0.00624)	(0.00626)	(0.00621)	(0.00813)	(0.00819)	(0.00808)
Own Residence	0.135***	0.133***	0.131***	0.235***	0.235***	0.230***
	(0.0235)	(0.0235)	(0.0233)	(0.0320)	(0.0323)	(0.0318)
Mobile Home	-0.101**	-0.0946**	-0.112**	-0.00574	-0.00599	-0.0113
	(0.0479)	(0.0479)	(0.0479)	(0.0695)	(0.0699)	(0.0698)
House	0.0183	0.0277	0.00816	0.0938***	0.0984***	0.0831**
	(0.0269)	(0.0273)	(0.0266)	(0.0348)	(0.0352)	(0.0344)
Rural Area	0.0911***	0.0848***	0.0844***	0.0991***	0.0909***	0.0932***
	(0.0200)	(0.0202)	(0.0202)	(0.0253)	(0.0255)	(0.0255)
Built pre 1969	-0.0548	-0.0469	-0.0438	-0.0894**	-0.0814**	-0.0783**
	(0.0335)	(0.0334)	(0.0334)	(0.0399)	(0.0398)	(0.0398)
Built 1970-89	-0.0696**	-0.0604*	-0.0663**	-0.167***	-0.158***	-0.166***
	(0.0335)	(0.0334)	(0.0334)	(0.0382)	(0.0382)	(0.0381)
Built 1990-99	-0.0235	-0.0169	-0.0255	-0.0447	-0.0327	-0.0490
	(0.0366)	(0.0364)	(0.0366)	(0.0430)	(0.0426)	(0.0430)
Built 2000-04	-0.0347	-0.0221	-0.0385	-0.148***	-0.116***	-0.164***
	(0.0397)	(0.0392)	(0.0398)	(0.0450)	(0.0449)	(0.0449)
Observations	3,765	3,765	3,765	2,759	2,759	2,759
Hits	2583	2590	2558	2004	2000	2004
Log Likelihood	-2234.61	-2214.93	-2257.75	-1551.26	-1533.29	-1568.41

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Omitted dummies include: Freq3:>10/week, income <25k, no high school, rent residence, apartment, urban area, built 2005-09.

Notes that for clothes washers New Jersey, Pennsylvania, and Illinois are excluded and for dishwashers Wisconsin is excluded