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Utility Rebates for ENERGY STAR Appliances: Are They Effective? *

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Abstract

We estimate the impact of utility cash rebates on the market share of ENERGY STAR appliances by exploiting the variation in timing and size of rebates across US states. We find that a dollar increase in the (population) weighted utility rebate raises the share of ENERGY STAR qualified clothes washers by 0.4%, but does not affect dishwasher and refrigerator shares. Using information on energy saved by an ENERGY STAR appliance and assuming a redemption rate of 40%, the cost per tonne of carbon saved is about $140 for the clothes washers rebate program. The corresponding cost of a megawatt hour saved (about $28) is lower than the estimated cost of building and operating an additional power plant and the average on-peak spot price. We conclude that ENERGY STAR clothes washers rebate program is, on average, a cost-effective way for utilities to reduce electricity demand.

Keywords: Eco-labelling; Energy efficiency; Appliances; Utility rebates; Carbon saving; Energy saving.

JEL Classification Codes: C13, C33, L68, L94, Q4.

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"Efficiency is the steak. Renewables are the sizzle." – Carl Pope, former executive director of the Sierra Club[1]

1 Introduction

It is now widely accepted that anthropogenic greenhouse gas (GHG) emissions are the main cause of climate change. The energy sector accounts for approximately 65% of our output of GHGs (International Energy Agency, 2009) and thus reducing emissions in this sector is a crucial element of GHG reduction. To reduce GHGs increasing energy efficiency is considered a "low-hanging fruit" because of its low marginal cost. The World Energy Outlook 2009, published by the International Energy Agency (IEA), highlights the huge potential of CO_2 reductions from increased energy efficiency. In this paper we analyze a policy in the US that uses financial incentives to encourage the adoption of energy efficient household appliances.

Federal and local governments and utility companies across the US and Canada promote the adoption of energy efficient appliances identified by a voluntary eco-labelling program, the ENERGY STAR label, by offering financial incentives. These incentives are usually in the form of cash rebates.[2] The ENERGY STAR label is designed to promote the use of energy-efficient products and reduce the emissions of greenhouse gases by reducing energy consumption. The adoption of energy efficient appliances has public (reduced GHG emissions, other criteria air pollutants) and private (savings in utility bills) benefits.[3] In this paper we ask two questions. First, what is the sales impact of these rebates? Second, is it cost effective for a utility company to offer rebates to its consumers for buying ENERGY STAR appliances?

To study the impact of rebates on the sales of energy efficient ENERGY STAR appliances we use quarterly sales data on the percentage of ENERGY STAR labelled appliances (clothes washers, dishwashers, and refrigerators) for all 50 US states. We combine this with a detailed utility-level and state-level dataset on rebate programs between 2001 and 2006. Our aim is to identify the impact of rebates on sales of ENERGY STAR appliances by correlating differences in the market share of ENERGY STAR appliance sales with variation in rebate values across and within appliances and across and within US states over time.

[1] Wald (2007)

[2] Some US states have also offered sales tax holidays on energy efficient appliances. For example, Connecticut, Delaware, Florida, Georgia, Missouri,North Carolina, South Carolina, Texas, Vermont, Virginia and West Virginia. However, in the majority of the cases these sales tax holidays are offered only over an extremely short period of time, e.g. a weekend.

[3] According to calculations made by D&R International Ltd. the lifetime cost for clothes washers, using the product database from 2007, was $1,883 for a standard model and $1,726 for an ENERGY STAR model. While the median purchase price for a standard model ($573) was much lower than an ENERGY STAR model ($966) the average energy costs for the former were much higher at $1,310 than the latter ($760).

The panel nature of our dataset allows us to ensure that we do not attribute state-level differences, or national-level common time effects to the rebate variable. Our results indicate that, on average, an increase of the (population) weighted utility rebate by $1 increases the market share of ENERGY STAR clothes washers by 0.4%. We also find that the utility rebates have no statistically significant impact on the sales of ENERGY STAR-qualified dishwashers and refrigerators.

We then use the above estimates to evaluate the cost of a tonne of carbon emissions saved as well as the cost of a megawatt hour saved. The former cost calculation will enable us to compare the cost with that of the social opportunity cost of carbon while the latter cost will be informative in comparing with the cost of constructing and operating a power plant or the average price of additional electricity bought in the spot market. Both costs depend on the assumption for redemption rates of mail-in rebates, which are the main avenue for these rebates. The cost, per tonne of carbon saved, ranges from $140 to $352 depending on a redemption rate of 40% and 100% respectively. We also calculate the cost of a megawatt hour saved from having the rebate programs in place by comparing it with the estimated cost of building and operating a power plant as well as the cost of on-peak spot prices. The cost of a megawatt hour saved ranges from around $28 to $71 when we use redemption rates of 40% and 100% respectively. The lower estimate of $28 per MWh saved is much lower than the cost of constructing and operating the cheapest power plant.[4] Average on-peak prices of $60 are also higher than the cost of rebate programs which means that buying electricity when demand exceeds supply is more expensive than reducing electricity demand through increased efficiency.

There has been, to the best of our knowledge, no previous research on evaluating the impact of utility rebates to promote the sale of ENERGY STAR appliances. Earlier work in marketing focuses more on the effects of sales promotions in the nondurable goods sector rather than the durable goods sector. Thompson and Noordewier (1992) investigate the effects of sales promotions on automobile sales of the Big Three automobile manufacturers in the US (General Motors, Ford and Chrysler) and find that major year-end promotions using low-rate financing and cash rebates to stimulate sales were effective in 1985 and 1986 but not in 1987. There has also been recent work on the impact of financial incentives on the sales of electric hybrid vehicles (see, for example, Gallagher and Muehlegger (2011), Sallee (2011), and Chandra et al. (2010)). All the authors find that incentives uniformly increase the market share of hybrid vehicles. Bennear et al. (2011) look at the impact of high efficiency toilet (HET) programs and find that incentives increase their uptake.

[4] The levelized cost of electricity for a coal-fired power plant, according to Du and Parsons (2009), is the lowest at $62 per MWh.

The utility rebate programs we study in this paper are a part of demand-side management (DSM) initiatives undertaken by utility companies. DSM refers to the "planning, implementation, and monitoring of utility activities designed to encourage consumers to modify patterns of electricity usage, including the timing and level of electricity demand" (Energy Information Administration, 2009). They were initiated in the late 1970s primarily due to rising gas and oil prices.[5] The Energy Information Administration (2009) reports that the total actual peak load reduction achieved in 2007 through DSM was 30,276 MW with 58% being attributed to energy efficiency while the total DSM cost was $2.5 billion. There is a sizeable literature on the impact of DSM programs. Gillingham et al. (2006) provide a review of, among other energy efficiency policies, DSM activities and also report the range of negawatt costs calculated in the existing literature to be between $8 and $229 per MWh saved.[6,7] A recent paper by Arimura et al. (2012) finds that DSM expenditures over the last couple of decades have cost utilities around $50 per MWh saved.

Our focus in this paper is on a specific component of DSM, namely, the utility rebate programs promoting the purchase of energy efficient household appliances. Very few studies have looked at the cost-effectiveness of such rebate programs in the residential sector. Revelt and Train (1998) estimate the impact of rebates and loans on the choice of efficiency of refrigerators by residential customers of Southern California Edison (SCE) using stated preference data. They predict that the rebate program leads 8.5% customers to switch from a standard-efficiency refrigerator to a high-efficiency one. They also find that loan programs have a greater impact with 22.6% of buyers switching from standard to high efficiency.[8] In a survey of the literature on the various kinds of DSM programs Nadel (1992) shows that the cost incurred by a utility in rebate programs ranges from low to moderate[9] and is generally between $14 to $50 per MWh. Nadel (1990) reports the cost to utilities for rebate programs in the commercial and industrial sectors to be $20-30 per MWh.

The rest of the paper is organized as follows. In the next section, we provide a brief overview of the ENERGY STAR program and discuss the rebate programs offered by utility companies. We provide a description of the data and its sources and limitations in section 3. A brief theoretical model and the empirical strategy to estimate the model are laid out in section 4. The econometric results are discussed

[5]See Eto (1996), Nadel and Geller (1996) and Nadel (2000) for a history of utility DSM programs in the US.

[6]"Negawatt" is a term coined by Amory Lovins of the Rocky Mountain Institute to refer to a watt of electricity that does not have to be produced due to an energy saving process in place.

[7]We, hereon, convert all figures originally reported in kilowatt hours to megawatt hours for consistency. 1 megawatt hour (MWh) = 1,000 kilowatt hours (kWh).

[8]See Train and Atherton (1995) for a similar paper.

[9]This is based on rebate programs for the commercial, industrial and residential sectors.

in section 5. The penultimate section uses the results from our regression model to calculate the energy saving and cost of the rebate programs while the final section has concluding remarks.

2 ENERGY STAR Program and Utility Rebates

The ENERGY STAR program was introduced in 1992 by the United States Environmental Protection Agency (EPA) as a voluntary labelling program designed to promote the use of energy-efficient products and thus help to reduce the emissions of greenhouse gases. Research on the ENERGY STAR program has focused almost exclusively on the energy, dollar and carbon savings or the overall success of the ENERGY STAR program. Howarth et al. (2000) find that the Green Lights and ENERGY STAR Office Products programs have very little effect on the demand for energy, but improvements in energy efficiency lead to one-to-one reductions in energy use. In terms of calculating savings estimates, Webber et al. (2000) conclude that 740 petajoules of energy has been saved[10] and 13 million metric tons of carbon avoided due to the ENERGY STAR program. In a more recent study, Sanchez et al. (2008) estimate that ENERGY STAR-labelled products have saved 4.8EJ of primary energy and avoided 82Tg C equivalent.[11]

In this paper, we focus on the ENERGY STAR program for clothes washers, dishwashers and refrigerators. The market share of ENERGY STAR qualified clothes washers has increased from 10% in 2001 to almost 38% in 2006. ENERGY STAR qualified dishwashers have captured a little more than 92% of the market in 2006 as compared to around 10% in 2001 (Figure 1). Figure 1 shows the high penetration of ENERGY STAR qualified dishwashers when compared to clothes washers and refrigerators.

In 1998, ENERGY STAR qualified clothes washers in the northwestern part of the United States were promoted through rebates and incentives offered by the Northwest Energy Efficiency Alliance. Supplemental rebates and financing was offered by a number of utilities in Washington, Oregon, Montana and Idaho (Energy Star Sales Report, 1999). Similarly, most utility companies in California and several utility companies in New England (through the Northeast Energy Efficiency Partnerships, Inc.) and Wisconsin also supported the sale of ENERGY STAR appliances (Energy Star Sales Report, 1999). The same regions experienced a much larger penetration of ENERGY STAR qualified clothes washers than other regions.

While the savings to consumers, in terms of lower utility bills, are quite obvious there are a number

[10] 1 petajoule = 10^{15} Joules. 740 petajoules is equivalent to 205.5×10^6 MWh. 1 MWh = 3.6×10^9 Joules.

[11] 1EJ (Exajoule)=10^{18} Joules. 4.8EJ is equivalent to 1.3×10^9 MWh. 1Tg (Teragram) = 10^{12} grams

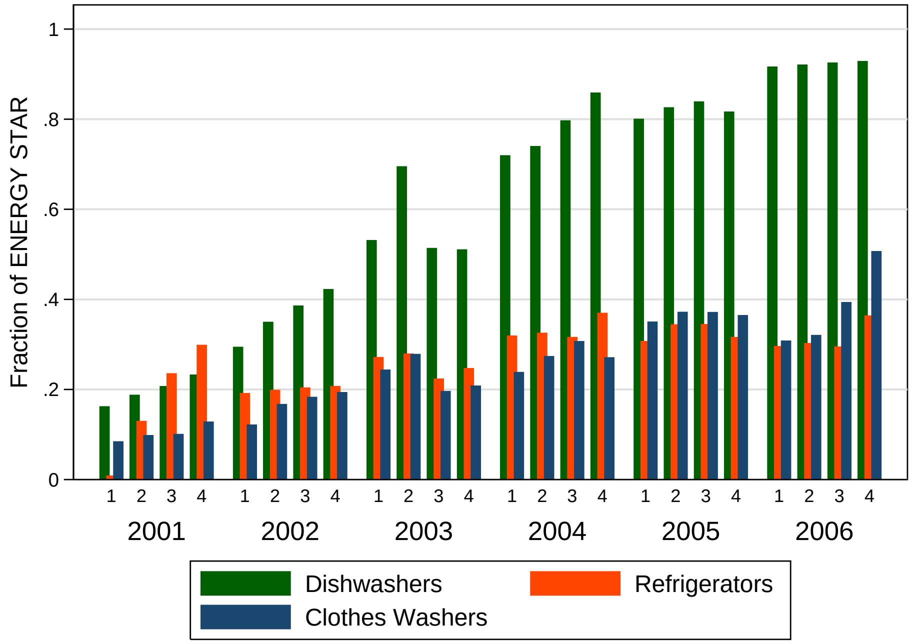

Figure 1: Share of ENERGY STAR qualified Dishwashers, Clothes Washers and Refrigerators by year and quarter in the US (Source: ENERGY STAR)

of reasons why utilities would want to promote the use of ENERGY STAR products.[12] The literature on DSM argues that promoting energy efficiency costs less than building new power plants. There are also environmental reasons. Utility companies need to follow a number of environmental regulations. There are emissions control strategies in place and saving energy on the margin will allow the more polluting plants to be removed from producing electricity. Reducing electricity demand also reduces the need to upgrade the transmission and distribution network. Lastly, reducing peak demand combined with reducing energy demand can lead to grid reliability.

3 Data Description

We use data from two sources. The sales data of ENERGY STAR-qualified appliances are from the US Department of Energy (2008a). Information about the utility rebates on ENERGY STAR products is from D&R International Ltd.

[12]Benefits to consumers can be seen by comparing the average energy use of an ENERGY STAR and a non-ENERGY STAR qualified appliance. See Table 5 for information on the energy used by an average ENERGY STAR versus an average non-ENERGY STAR clothes washer and Table 7 for dishwashers and refrigerators.

Table 1: Number of Utility Rebates for ENERGY STAR Appliances (2001–2006)

State	Clothes Washers	Dishwashers	Refrigerators
California	28	23	36
Colorado	8	1	2
Connecticut	6	0	3
Iowa	12	11	13
Idaho	12	8	5
Illinois	2	0	0
Massachusetts	21	2	0
Minnesota	19	6	7
Missouri	1	0	0
Montana	7	6	6
New Hampshire	8	0	0
Nevada	10	3	8
New York	2	0	0
Oregon	51	35	30
Rhode Island	3	0	0
South Dakota	2	0	0
Texas	0	0	1
Utah	0	0	1
Washington	60	26	21
Wisconsin	2	2	3
Wyoming	1	1	1
Total	255	124	137

Note: Numbers indicate total number of utility rebates offered.

3.1 ENERGY STAR Sales

The ENERGY STAR website has data on sales of the four major appliances, *viz.* clothes washers, dishwashers, air conditioners and refrigerators.[13] The data are disaggregated by the type of major appliance in each US state by quarter from 2001 to 2006. We exclude air conditioners from our analysis due to missing sales data for a number of time periods. Sales of appliances are categorized into ENERGY STAR and non-ENERGY STAR units. The appliance manufacturers report the sale of ENERGY STAR units to the US EPA every year. For obtaining sales figures of non-ENERGY STAR units the EPA uses the difference of the sales figures of total ENERGY STAR units sold and the total US sales obtained from industry reports.

3.2 Utility Rebates

Financial incentives are in the form of rebates that vary in amount as well as form across utility companies and across different appliances. Information on utility rebates and incentives between 2001 and 2006 has been provided by D&R International Ltd. This includes details of the incentive type, the program

[13] http://www.energystar.gov/index.cfm?c=manuf_res.pt_appliances, accessed 24 July, 2008.

Table 2: Types of Financial incentives Offered by Utility Companies (2001–2006)

Type of Dollar Incentive/Rebate	Frequency	Percent
Instant Rebate (at point of sale)	14	2.56
Instant Rebate (as credit on bill)	15	2.74
Mail-in Rebate	517	94.69

name, the amount of rebate offered, a summary of the rebate with the period of time the rebate is offered and the appliances or products to which the rebate applies. Table 1 provides details on the number of utility companies providing rebates to its customers from 2001 to 2006 for various appliances. Rebates are concentrated mostly in the northwestern states and California as well as in the northeastern states. We have considered only mail-in and instant rebates that constitute 91% of the total incentives on offer. Our dataset has a total of 602 financial incentives out of which 546 are mail-in and instant rebates. Of these, 95% are mail-in and 5% are instant rebates. Table 2 provides a detailed breakdown of the various types of financial incentives offered by utility companies.

3.2.1 Weighted Utility Rebates

Rebates provided by utility companies are local in nature and, usually, do not apply to the entire state. That leads to an aggregation problem when we are trying to estimate the effectiveness of rebates on the sales of ENERGY STAR units for the state as a whole. Consider a situation where we have rebates in two states with a similar population, and preferences. The rebates are assumed, for the sake of simplicity, to be of equal value. However, the extent of the rebates differs with one state having it in, say, just one county served by a utility company and the other state having it in more counties. This should not lead to the same effect on the state-wide sales share of ENERGY STAR appliances. In this situation we would expect the latter of the two states to have a bigger impact on the sales share. To rectify this we assign weights to the rebates. The weights that we use are the share of the residential customers served by the utility company providing the rebate to the total number of residential customers in a state. The number of customers served by each utility company are from Energy Information Administration (2006) of the US Department of Energy. Using weighted rebates means that utilities serving a larger customer base will have higher weights assigned to their rebates.[14] To describe the above more succinctly, let us assume

[14]Our preferred specifications use weighted rebates. However, in table 17 in the Appendix, we also report results from using a simple average of utility rebate offered. These results suffer from measurement error due to the issue of aggregation described above. We also analyze the impact of utility rebates after controlling for state-level sales tax rebates on ENERGY STAR appliances. Unlike the utility rebates, which typically last for an year or more, most state-level sales tax rebates typically last for a few days during a year. These results are not reported in the text and can be requested from the authors. We find that

the following scenario. Suppose that n_1 customers are served by utility 1, and are offered a rebate of, say, X dollars and there are only two utilities serving the state, say utility 1 and utility 2. Furthermore, suppose that n_2 is the number of customers served by utility 2 but are offered no rebates. In this case, we calculate the average weighted rebate in the state as $[n_1/(n_1+n_2)] * X$.

4 Model and Empirical Strategy

4.1 Model

We build a simple model to illustrate an individual's choice to buy an ENERGY STAR appliance. Consider individual i deriving utility u_{ijst} from services provided by appliance $j \in \{CW, DW, RF\}$, where CW stands for clothes washers, DW for dishwashers, and RF for refrigerators, in state s, during period t. This utility is approximated linearly as:

$$u_{ijst} = \alpha_{ij} - \beta_i c_{ijst}. \tag{1}$$

where α_{ij} is a constant individual specific utility from appliance j's services, β_i is individual specific marginal utility of income, and c_{ijst} is individual i's cost of owning appliance j, in state s at time t. Thus utility is comprised of benefits from services provided by the appliance, and a disutility associated with the expenses of owning the appliance. Assuming a lifespan T_j for appliance j, the lifetime utility from ownership is:

$$U_{ijst} = A_{ij} - \beta_i \sum_{\tau=0}^{\tau=T_j} \frac{1}{(1+\rho)^\tau} c_{ijs(t+\tau)} \tag{2}$$

where $A = \alpha_j \sum_{\tau=0}^{\tau=T_j} \frac{1}{(1+\rho)^\tau}$ is an appliance specific lifetime benefit from consuming appliance $j \in \{CW, DW, RF\}$, and ρ is a discount factor that is assumed to be constant across all individuals.

We assume equivalence in services provided by ENERGY STAR and non-ENERGY STAR appliances. In other words, α_{ij} does not change on choosing ENERGY STAR appliances. However, the cost of

the results of regressions controlling for the sales tax rebate are essentially the same as those reported in this paper. Coefficients on the sales tax rebates are not significant. This is because these rebates are in place only for a few days, typically a weekend, and since we are using quarterly sales data it is hard to identify their impact.

ownership (c_{ijst}) differs. The cost of owning an appliance is

$$c_{ijs(t+\tau)} = \begin{cases} P^j_{s(t+\tau)} - R^j_{s(t+\tau)} + P^E_{s(t+\tau)} E_{ijs(t+\tau)} & , \tau = 0 \\ P^E_{s(t+\tau)} E_{ijs(t+\tau)} & , \forall \tau = 1, 2, \ldots, T_j \end{cases} \tag{3}$$

where $P^j_{s(t+\tau)}$ is a state- and time-specific price for appliance j, $R^j_{s(t+\tau)}$ is an appliance- and time-specific rebate offered in state s (if any), $P^E_{s(t+\tau)}$ is a state-specific price for electricity, and $E_{ijs(t+\tau)}$ is individual and time specific electricity usage for appliance j in state s. Equation (3) states that in the first period of ownership ($\tau = 0$), the individual pays for ownership, earns a rebate (if any is offered in that state), and pays for operation of the appliance. In all subsequent periods, the individual only pays the cost for operating the appliance. Thus, utility from lifetime ownership is:

$$U_{ijst} = A_{ij} - \beta_i \left(P^j_{st} - R^j_{st} \right) - \beta_i \sum_{\tau=0}^{\tau=T_j} \frac{1}{(1+\rho)^\tau} \left(P^E_{s(t+\tau)} E_{ijs(t+\tau)} \right). \tag{4}$$

An individual purchases an ENERGY STAR appliance if and only if the utility from owning an ENERGY STAR appliance (ENERGY STAR is denoted by adding superscript $*$) is at least as high as from owning a standard appliance. If a state offers an ENERGY-STAR appliance (j) rebate an individual chooses to buy the ENERGY STAR version if and only if:

$$R^{j*}_{st} \geq \underbrace{\left(P^{j*}_{st} - P^j_{st} \right)}_{\text{I}} - \sum_{\tau=0}^{\tau=T_j} \frac{1}{(1+\rho)^\tau} \underbrace{\left[P^E_{s(t+\tau)} \left(E_{ijs(t+\tau)} - E^*_{ijs(t+\tau)} \right) \right]}_{\text{II}}. \tag{5}$$

We expect expression I to be positive, i.e., manufacturers price equivalent ENERGY STAR appliances higher than non-ENERGY STAR ones. Given that ENERGY STAR appliances have a higher energy efficiency than equivalent alternatives, we expect expression II to also be positive. In other words, lifetime electricity consumption from an ENERGY STAR appliances is lower than its alternative. If the discounted value of energy saved by buying the ENERGY STAR appliance is greater than its price difference, the right hand side of equation (5) is negative and the rebate problem is trivial – irrespective of the rebate offered (all rebates have to be greater than zero) the customer will always choose an ENERGY STAR appliance. In other words, the rebate does not generate additional sales. Rebates induce additional sales only if the right hand side of equation (5) is positive, and the rebate is higher than this additional outlay for purchasing an ENERGY STAR appliance for the consumer.

Assume that all states have the same distribution of consumers by electricity usage. Intuitively, this implies that, given constant electricity prices, a similar share of consumers buy ENERGY STAR appliances in the absence of a rebate. As long as there is a proportion of consumers for whom the right hand side of equation (5) is positive, this also implies that if a state offers a rebate, a higher proportion of consumers in that state will purchase ENERGY STAR appliances than states with no rebate. Similarly, equation (5) also implies that if a state has a higher electricity price, the share of consumers purchasing ENERGY STAR appliances will be higher than other states (as the right hand side of equation (5) will be smaller).

This model yields the following empirical predictions:

Prediction 1: An increase in the ENERGY STAR appliance rebate R_{st}^{j*} raises the share of consumers purchasing ENERGY STAR appliance j relative to all other states.

Prediction 2: An increase in the price of electricity $P_{s(t+\tau)}^{E}$ in a state raises the share of consumers purchasing ENERGY STAR appliance j relative to all other states.

In the next section we describe how we test Prediction 1 above.

4.2 Empirical Strategy

Assuming that consumers are similarly distributed across states in terms of energy usage by appliance, and building on the intuition provided by equation (5), our preferred reduced form state-level empirical specification is:

$$\begin{aligned}\text{log(ENERGY STAR share)}_{jst} = \alpha_{st} + \sum_{j=1}^{3} \beta_{1j} \text{Appliance dummy}_{jt} \\ + \sum_{j=1}^{3} \beta_{2j} \text{Appliance dummy}_{jst} \text{*Utility Rebate}_{jst} + \varepsilon_{jst}, \end{aligned} \tag{6}$$

where $j \in \{CW, DW, RF\}$ is the index for the appliance type, s is the US state index, and t is the year-quarter time index. Unobserved state-time specific heterogeneity is captured by the α_{st} terms, and appliance specific heterogeneity is captured by the "Appliance dummy$_{jt}$" terms. Finally, ε_{jst} is a standard i.i.d. error term. Equation (5) above indicates that besides rebates, a difference in prices across ENERGY STAR and non-ENERGY STAR appliances, electricity prices, and a difference in energy consumption between ENERGY STAR and non-ENERGY STAR appliances influence the proportion of adoption. These components are either state invariant (electricity prices), or appliance invariant (relative energy efficiency, and price differentials). Therefore, we include state-time fixed effects, α_{st}, to capture state-time invariant electricity prices and other relevant unobserved variables. We also include appliance-time fixed effects to capture price and energy efficiency differentials in ENERGY STAR and non-ENERGY STAR appliance categories over time (the underlying assumption is that models and pricing vary nationwide).

The β_{2j} coefficients on the right-hand side are our variables of interest since they indicate the average effect of the rebate offered for a particular appliance on its market share. This specification enables us to estimate the impact of incentives provided by utility companies as well as control for various other factors that may affect the share of ENERGY STAR appliances.[15] A positive estimate for all three β_{2c} coefficients would imply that the rebates are having a favourable impact and that the utility companies are being successful in encouraging people to switch to more energy-efficient technologies. We use a fixed effects panel data regression model. In other words, we assume that the α_{st} terms are fixed effects in the regression.[16]

4.2.1 Identification

We use the variations in the timing and size of rebates across states and over time to estimate the impact of the utility rebates on the sales of ENERGY STAR labelled clothes washers, dishwashers and refrigerators. In addition, there are several states that did not provide any such incentives to its customers. Furthermore, we also use the difference in accessibility to the rebates, given by the fraction of population covered by the rebates, to estimate the impact of the rebates.

We provide summary statistics of the rebate amounts for the various appliances in Table 3. The table also indicates the variation that exists in the rebate amounts by reporting the between-states variation and the within-states variation. The corresponding values are also reported for the fraction of population covered by the rebates. We also present some graphs to provide a visual representation of the variation that is present in the weighted rebate amounts as well as the fraction of population covered by the rebates. Figure 2 shows the variation in weighted rebate amounts for three states, California (CA), Oregon

[15] Note that even though the individual coefficients on the impact of the rebate can differ, our regression pools all three appliances together. This is because we believe that the same underlying utility function determines the choice between an ENERGY STAR and a non-ENERGY STAR appliance.

[16] Depending on the assumptions we make about the correlation of the α_{st} terms with the other explanatory variables in equation (6) we have either a fixed effects model or a random effects model. In the fixed effects model the individual effects are assumed to be correlated with the explanatory variables while in the random effects model this correlation is assumed, by definition, to be zero.

Table 3: Summary Statistics

Variable	Mean	SD	Min.	Max.	Obs.
Clothes Washers					
Clothes Washers Share	0.274	0.138	0.026	0.842	1200
Log of Clothes Washers Share	-1.460	0.626	-3.663	-0.173	1200
Avg. Rebate† (*overall*)	68.654	27.384	25	200	247
(*between*)		18.658			
(*within*)		18.707			
Avg. Weighted Rebate† (*overall*)	22.469	23.576	0.161	100.161	247
(*between*)		23.076			
(*within*)		14.921			
Fraction of Population covered by Rebate† (*overall*)	0.402	0.397	0.003	1	247
(*between*)		0.388			
(*within*)		0.191			
Dishwashers					
Dishwashers Share	0.607	0.286	0.056	0.993	1199
Log of Dishwashers Share	-0.664	0.641	-2.875	-0.008	1199
Avg. Rebate† (*overall*)	34.348	12.974	10	58.182	161
(*between*)		11.937			
(*within*)		4.311			
Avg. Weighted Rebate† (*overall*)	4.587	6.991	0.024	30	161
(*between*)		6.526			
(*within*)		4.666			
Fraction of Population covered by Rebate† (*overall*)	0.158	0.231	0	1	161
(*between*)		0.247			
(*within*)		0.149			
Refrigerators					
Refrigerators Share	0.273	0.108	0	0.595	1200
Log of Refrigerators Share	-1.473	0.838	-6.847	-0.520	1199
Avg. Rebate† (*overall*)	49.062	25.004	15	112.5	188
(*between*)		23.801			
(*within*)		9.212			
Avg. Weighted Rebate† (*overall*)	12.718	19.225	0.024	100	188
(*between*)		26.046			
(*within*)		12.343			
Fraction of Population covered by Rebate† (*overall*)	0.295	0.399	0	1	188
(*between*)		0.394			
(*within*)		0.236			

†: Conditional on non-zero rebate values.
(*overall*) refers to the summary statistics of the overall variation.
(*between*) refers to the between-states variation.
(*within*) refers to the within-state variation.

(OR) and Wisconsin (WI), while Figure 3 shows the extent of rebate coverage in those same three states. Each figure has three separate graphs for the three different appliances that we consider, *viz.* clothes washers, dishwashers and refrigerators. The graphs show a great deal of variability in the weighted rebate amounts as well as the rebate coverage. A more complete list of rebates, average and weighted, by state are listed in Tables 8 to 16 in Appendix A.1. The tables suggest that there is enough variation in the rebate (weighted and simple average) amounts and its coverage to obtain reliable estimates in our analysis.

The last column in table 3, **Obs.**, indicates the number of data points in our dataset with positive rebate values. For example, there are 247 state-quarter rebates for clothes washers. Since our panel has 50 US states that we track over four quarters for a period of six years between 2001 and 2006 there are 1200 observations for clothes washers. Of those 1200 observations, 247 data points have positive rebates. The table shows us that the number of positive utility rebates available for clothes washers far exceeds that for dishwashers and refrigerators. If we consider the average rebate amount and the average weighted rebate amount we see that clothes washers get a much higher rebate amount when compared to dishwashers and refrigerators. The number of rebates as well as the average amount of a rebate is lowest for dishwashers.

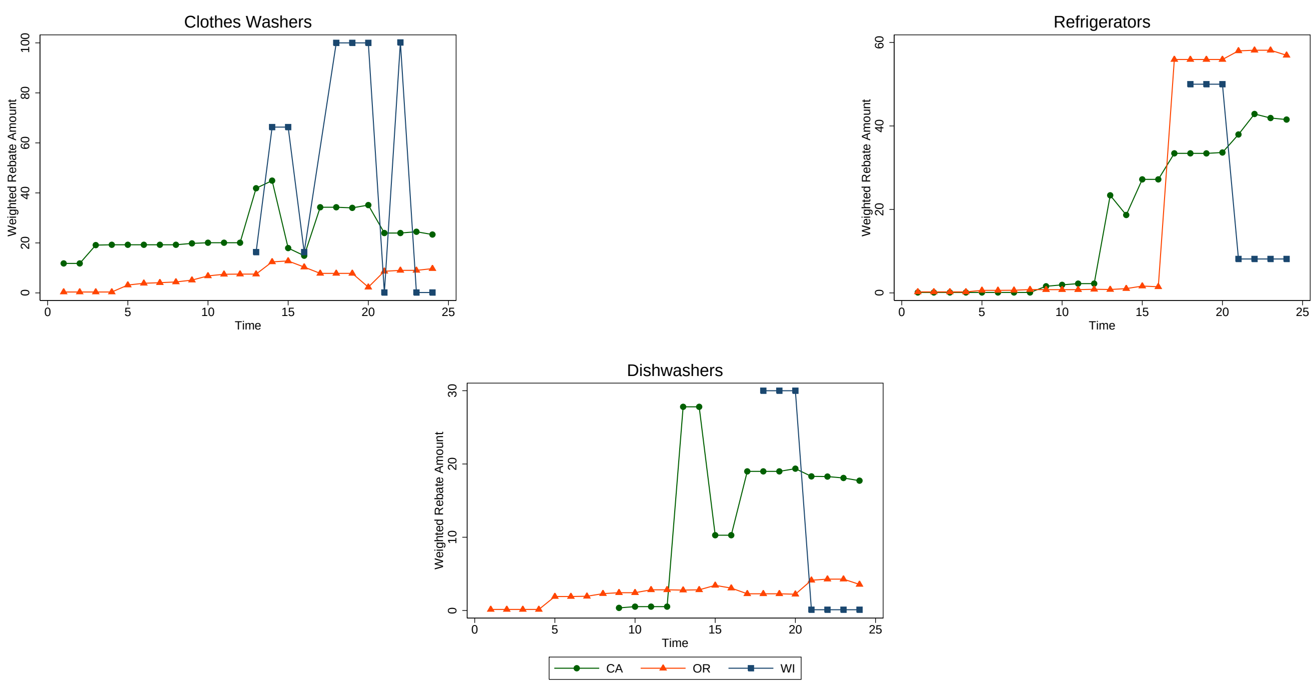

Figure 2: Variation in (Weighted) Rebate Amount

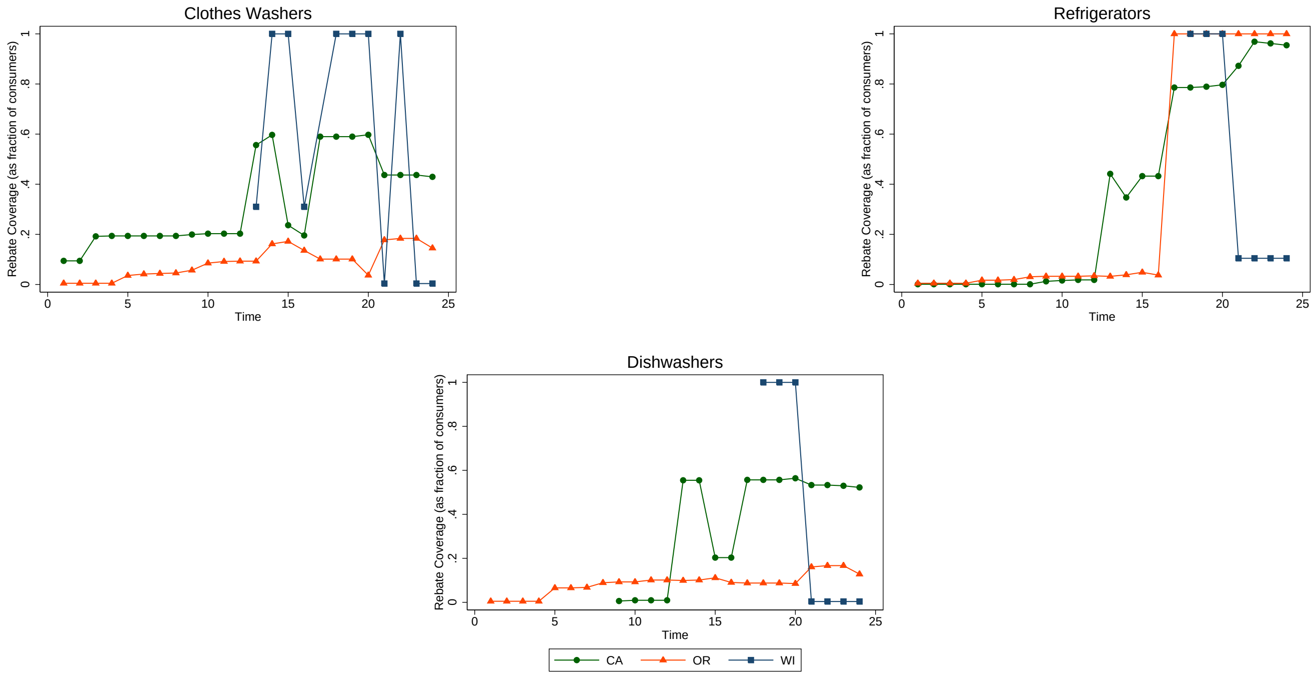

Figure 3: Variation in Fraction of Eligible Consumers

5 Results

We now present the results of the specifications and describe the methods used to estimate the coefficients. The dependent variable in all the specifications is the logarithm of the share of ENERGY STAR appliances.

It is often customary while reporting panel regression results to report the results from the pooled OLS specification. In the interest of preserving space we have excluded the pooled OLS results in the paper. This is because an F-test of the null hypothesis that the constant terms are equal across all the states is not accepted. In other words, there are significant state-level effects which implies that pooled OLS would be inappropriate. In the main text of this paper we only present results from fixed effects specifications with our preferred weighted average rebate variable (see Table 4).[17] The alternative random effects estimation methods with the unweighted rebate amount and weighted rebate amount assumes exogeneity of all the regressors with the random individual effects.[18] This is a strong assumption that may not be realistic in our case. We use a test for overidentifying restrictions to test for fixed versus

[17]The fixed effects specification with the simple average rebate variable is in Table 17 of Appendix A.1. Qualititatively, the results present similarly signed coefficients. However, coefficient magnitudes and standard errors differ significantly.

[18]Random effects models are better suited to estimating models that have time-invariant independent variables. They are also more efficient than fixed effects models.

Table 4: FE Models for (Log) Share of Individual ENERGY STAR Appliances

	FE1	FE2	FE3	FE4
CW*Wt. Avg. Rebate Amount	1.181^a	1.156^a	0.236^a	0.395^a
	(0.161)	(0.165)	(0.077)	(0.132)
DW*Wt. Avg. Rebate Amount	2.678^a	2.617^a	-1.124^b	-0.604
	(0.450)	(0.456)	(0.429)	(0.417)
RF*Wt. Avg. Rebate Amount	1.171^a	1.030^a	0.012	0.282^c
	(0.269)	(0.272)	(0.113)	(0.150)
State Fixed Effects	Yes	Yes	Yes	
Year-Quarter-State Fixed Effects				Yes
Appliance Fixed Effects	Yes			
Quarter-Appliance Fixed Effects		Yes		
Year-Quarter-Appliance Fixed Effects			Yes	Yes
Observations	3,598	3,598	3,598	3,598
Adjusted R^2	0.270	0.321	0.920	0.902

Clustered standard errors in parentheses
^{a}, ^{b}, ^{c}: Significant at the 1%, 5% and 10% levels respectively
Utility rebate amounts re-scaled
CW: Clothes Washers, RF: Refrigerators, DW: Dishwashers

random effects and find that the hypothesis of the regressors being orthogonal to the state-level fixed effect is rejected.[19] For this reason the fixed effects specification is our preferred specification.

The columns FE1, FE2, FE3 and FE4 in Table 4 estimate equation (6) using various specifications. All the regressions have clustered, by state, standard errors to correct for any possible serial correlation. In specification FE1 we do not have any controls for time but have state fixed effects to control for unobserved state-level heterogeneity. Since we are using market shares of all three household appliances, *viz.* clothes washers, dishwashers and refrigerators, we have appliance dummies to control for the type of appliance. In FE2 we introduce fixed effects for quarters, by appliance that allow seasonal variation in appliance replacement patterns, in addition to state fixed effects. FE3 is a more comprehensive specification with fixed effects for each of our time periods and states by appliance. This assumes state level preferences for ENERGY STAR adoption to be similar across appliances, but allows national preferences to fully vary across appliance and time. The appliance market is nationwide with the same models available in all states. Furthermore, technical developments (in energy efficiency and otherwise), and design trends, occur in different appliance categories at different times. FE3 will be able to account for such variation. FE4 is our most comprehensive specification. It is similar to FE3 in that nationwide preferences are allowed to vary across appliances and time. However, additionally, we also have state-specific time

[19]We use the `xtoverid` command (Schaffer and Stillman, 2006) in STATA.

effects that allow adoption trends in ENERGY STAR appliance to vary across all periods of time. As discussed earlier, we believe that the unobservable components of appliance adoption (from equation 5) are either state, or appliance invariant. As this specification includes state-by-time and appliance-by-time fixed effects, it captures this unobserved heterogeneity more completely than our other specifications.

Our coefficients of interest are the ones for the appliance type interacted with the average rebate amount. The baseline is the case where there are no rebates. A positive coefficient for the interaction of appliance type with average rebate amount would indicate a favourable effect on the ENERGY STAR sales share of the appliance due to the rebate. We find that while utility rebates for clothes washers induce a positive and significant impact on sales shares, this is not true for dishwashers and refrigerators. The impact, while positive and significant for dishwashers in FE1 and FE2, becomes negative and insignificant in FE3 (significant at 5%) and FE4. The impact of rebates is also not significant for refrigerators in specification FE3 and FE4. The results of the various specifications indicate that the effect of rebates is not as robust for dishwashers and refrigerators as it is for clothes washers.

We choose the FE4 specification over FE1, FE2 and FE3 because it is the most comprehensive specification and accounts for unobserved state- and time-level heterogeneity as well as controlling for appliance-specific time effects.[20] Results from our preferred specification, FE4 from Table 4, indicate that a $1 increase in utility rebates will lead to a 0.4% increase in the share of ENERGY STAR clothes washers. However the effect does not appear to be statistically significant for dishwashers while the effect for refrigerators is statistically significant only at the 10% level.[21]

We should note, however, that the average weighted clothes washer rebate is around $15. Therefore, a $15 increase in rebates leads to a 6% increase in the share of sales of ENERGY STAR clothes washers. We can conclude that the rebate programs have had a positive and significant effect on clothes washers but the impact on dishwashers and refrigerators does not appear to be very significant.

The impacts of dishwasher rebates and refrigerator rebates are significant in most of our specifications. However the sign is not consistent over all our specifications which is the reason why we have not considered dishwashers and refrigerators in the implications for policy. There are a couple of reasons

[20]While the weighted rebate variable is superior to the simple average we perform some robustness checks to ensure that we are able to identify the impact of the rebates on the share of ENERGY STAR appliances sold. We do this by estimating our models excluding states that have a very low coverage of rebates. This is described in section A.3.2 while the results are presented in table 22, both in Appendix A. We also expect all the coefficients for the respective appliance rebates to be positive but find that the coefficient for dishwasher rebates is insignificant while that for refrigerators is positive and significant but only at the 10% level in our preferred specification FE4 in table 4. We further analyse this by performing power calculations that are described in section A.5 in Appendix A. These robustness checks lead us to believe that our preferred specification is appropriate.

[21]The rebate amounts have been scaled down by 100 to ensure that the results are easier to read.

why we believe that rebates for dishwashers and refrigerators appear to be not effective. Firstly, the efficiency standard for dishwashers has not been changed very frequently to allow for changes in efficiency of the dishwashers in the market. As a result, a huge percentage of dishwashers in the market were ENERGY STAR-rated and therefore, rebates may not have had an impact. Secondly, the frequency and average amount of rebates for both dishwashers and refrigerators were lower than rebates for clothes washers. The rebates may not have persuaded the marginal consumer to make the switch from a non-ENERGY STAR-rated machine to an ENERGY STAR-rated one. However, these are merely hypotheses and it may prove to be a future area of research to isolate the causes, if any, of a difference in the effects of rebates for different appliances.

6 Policy Implications

We use estimates from our preferred specification, FE4 from Table 4, to examine the effect of utility rebates. Since the coefficient for clothes washers rebates is robust over specifications FE1 to FE4 we only consider clothes washers and exclude dishwashers and refrigerators for calculating the cost of the rebate programs. We assume that clothes washers are replaced at the end of their expected lifetime.[22] We first perform a counterfactual exercise in which we assume that none of the states have a utility rebate in place, i.e. $\beta_{2,CW} = 0$ in equation (6). This gives us the market share of ENERGY STAR clothes washers if no utility rebate had been offered, say $\tilde{y}$. Since the estimated coefficient of the effect of the utility rebate variable is positive, the market share for ENERGY STAR clothes washers will be lower than the fitted values using the original estimating equation, say $\hat{y}$. We use the ratio of these fitted values, $\frac{\tilde{y}}{\hat{y}}$ and multiply it with the actual market share to obtain the counterfactual market share if there had been no rebate. The difference between the counterfactual and the actual market shares is the effect of the utility rebates.

Note that we have used the share of ENERGY STAR appliances in our regressions. But to carry out the counterfactual exercise we need unit sales. We have yearly but not quarterly unit sales figures of clothes washers in every US state from 2001 to 2006. However, we *do* have the quarterly unit sales figures for the overall US. Therefore, to get an approximate value of the quarterly unit sales in each US state we use those sales figures to get an approximate value of the quarterly unit sales. This will account for the seasonality in sales that may exist. So, for example, the yearly unit sales in California in 2001

[22] One possibility is that clothes washers are replaced before the end of their lifetime but we discount that possibility in the following counterfactual exercise.

were 766,500. The first quarter unit sales overall in the US were approximately 26% of the annual unit sales in 2001. We therefore assume the first quarter unit sales in California (in 2001) to be 26% of 766,500.

We use these imputed values to obtain the increase in the units of ENERGY STAR clothes washers sold in each state, i, in time t given by

$$\text{IUS}_{it} = \text{AUS}_{it} - \text{CUS}_{it} \qquad \text{where } \text{CUS}_{it} = \frac{\tilde{y}}{\hat{y}} * \text{AMS}_{it} \tag{7}$$

where IUS_{it} is the increase in units sold of ENERGY STAR clothes washers, AUS_{it} is the actual imputed units sold, AMS_{it} is the actual market share and CUS_{it} is the counterfactual imputed units sold.

The total carbon saving, TCS_{it}, is

$$\text{TCS}_{it} = \text{IUS}_{it} * \Delta\text{Energy Use} * \text{Average Life} * \text{Carbon Emissions Factor} \tag{8}$$

where ΔEnergy Use is the difference in the energy use between an average ENERGY STAR and an average non-ENERGY STAR clothes washer. The "Average Life" is the average lifetime of a clothes washers which is typically 11 years (US Department of Energy, 2008b). Annual estimates of the average energy used by ENERGY STAR and non-ENERGY STAR clothes washers have been obtained from D&R International, Ltd. and are listed in Table 5. The figures indicate the average energy consumed in a year under normal usage. To transform the energy saved into the amount of carbon equivalent saved we use the carbon emissions factor obtained by Sanchez et al. (2008) from the Cadmus Group. The carbon emissions factor is assumed to be 0.203 kg C/kWh.[23] Therefore, total energy saving is in terms of kg carbon equivalent forgone. We find that the energy saved leads to an equivalent carbon saving of around 55 thousand tons.

The total rebate outlay, Total Rebate_{it}, in state i in time t is given by

$$\text{Total Rebate}_{it} = \text{Utility Rebate}_{it} * \text{AUS}_{it} \tag{9}$$

where Utility Rebate_{it} is the average weighted rebate amount. This assumes that redemption rate for rebates is 100%. However, according to Spencer (2002), the redemption rate of mail-in rebates for typically high-value products having a high rebate value is around 40%.[24] After accounting for instant rebates we

[23] This means that to produce 1 kWh of electricity, 0.203 kg of carbon equivalent, on average, is produced.

[24] According to personal interviews conducted by Silk and Janiszewski (2008), promotion managers said that "redemption rates tend to be "very low" when the reward is below $10, that rebates of $10 to $20 on a $100 software product range between 10% and 30%, and that redemption rates on consumer electronics average approximately 40%".

Table 5: Average Energy Use of Clothes Washers (in kWh/year)

Year	non-ENERGY STAR	ENERGY STAR
2001	854	290
2002	829	297
2003	829	297
2004	615	254
2005	529	243
2006	531	234

Source: D&R International Ltd.

calculate the cost of carbon emissions forgone using both redemption rates to get a range of the cost. A 100% redemption rate on mail-in rebates leads to a rebate spending of \$19.2 million while assuming a 40% redemption rate reduces that figure to \$7.7 million.

The cost of carbon emissions forgone, Total Cost, is

$$\text{Total Cost} = \frac{\sum_{i,t} \text{Total Rebate}_{it}}{\sum_{i,t} \text{Total Carbon Saving}_{it}} \tag{10}$$

Using the figures for the rebate outlay this translates to a cost of \$352 for every tonne of carbon emissions forgone when the redemption rate is 100% while the cost falls to \$140 with the lower redemption rate of 40%. If we compare the cost of reducing a tonne of carbon to the social cost of carbon as estimated by Nordhaus (2007), which is \$17 per tonne, we find that utility companies end up paying much higher for greenhouse gas reductions. However, our lower estimate of \$140 per tonne compares favourably with the larger estimate of the social cost of carbon (\$350 per tonne) obtained by Stern (2007).[25]

There may be concerns of a “rebound effect”. This could happen when the purchase of a high-efficiency clothes washers lowers the cost of use (per load of clothes in this instance) encouraging a higher use of energy reducing the overall energy saved. Davis (2008) uses household-level data from a field trial to show that the gains from the energy saving are not offset by higher usage. The field trial in Bern, Kansas (population approximately 200) was conducted to estimate the energy and water savings of h-axis clothes washers by replacing the more inefficient v-axis washers of the participating households

[25]Reducing energy use through rebates to energy efficient appliances generates more than carbon savings. A lowered production of energy also reduces other criteria air pollutants, and a host of other toxic and non-toxic pollutants associated with the fossil fuel supply chain. Including the benefits of reducing these other externalities would give us the true social value of these rebates. A complete analysis of the social benefits of the rebate program is outside the scope of this paper.

(Tomlinson and Rizy, 1998).[26] Davis (2008) estimates a demand function for clothes washing and finds the price elasticity of utilization to be very low at -0.06. Following this result we assume that the rebound effect is not significant in terms of estimating the energy saving.[27]

As mentioned before, one of the reasons why utilities have demand side management programs, like rebates, in place is to reduce peak demand. For utility companies in a state with very little electricity supply, like California, the cost of buying peak power when demand exceeds supply is very high. The other option is to start peaking plants that are usually natural gas and are very expensive to start up and run. Assuming a redemption rate of 40% the cost, per megawatt hour, of the utility rebate programs comes to around \$28 while it is \$71 for a 100% redemption rate. These are obtained by multiplying the cost per tonne (\$140 for a 40% redemption rate and \$352 for a 100% redemption rate) with the carbon emissions factor (0.203 kg C/kWh). The lower estimate cost compares very favourably to the average on-peak spot prices for electricity. The mean of average on-peak prices from 2003 to 2006 is \$60 which is considerably higher than the cost of the rebate programs. The mean of the minimum average on-peak spot prices over the four years, \$48, is also slightly higher than the cost of the rebate programs (We list on-peak and off peak prices at different US regional markets in Table 23 in Appendix A). We can, therefore, conclude that the rebate program for clothes washers has been successful for utility providers that are looking to reduce the demand for electricity by providing incentives to consumers for switching to more energy-efficient models.

Since utilities are also concerned about the costs involved to build and operate additional power plants we can compare the costs of the rebate programs to that of building one. Du and Parsons (2009) have calculated the cost of electric generation for the three major types of power plants, *viz.* coal-fired, gas-fired and nuclear. Their calculations, in Table 6, are an updated version of the figures published in Deutch et al. (2003). Du and Parsons (2009) find that the cost of constructing and operating a nuclear power plant is highest, at \$84 per MWh. Coal and gas-fired power plants are more cost-effective at \$62 and \$65 per MWh. However, if the social cost of carbon is considered to be \$25 per tonne of CO_2 emitted then the costs rise substantially to \$83 and \$74 for coal- and gas-fired plants respectively. Having utility rebate programs in place are, therefore, a cost-effective alternative to building and running additional

[26] Front-loading clothes washers are referred to in industry terminology as h-axis (horizontal axis) clothes washers while top-loading clothes washers are referred to as v-axis (vertical axis) clothes washers. While there exist top-loading h-axis clothes washers they are rare.

[27] We focus on a within appliance rebound effect. Consider the possibility that installing an energy efficient appliance lowers energy use and pulls the household into a lower energy tariff bracket. In this case, overall household energy use (due to this lower price for energy for all use) can rebound more than that in the individual appliance alone. We thank an anonymous referee for alerting us to this possibility.

Table 6: Costs of Electric Generation Alternatives ($/MWh)

Type	Base Case	with Carbon Charge $25/tCO_2$	with same cost of capital
Nuclear	84		66
Coal	62	83	
Gas	65	74	

Source: Du and Parsons (2009), original values are in cents/kWh.

power plants.

7 Conclusion

In this paper we have looked at the effectiveness of rebates provided by utility companies on the sales of ENERGY STAR appliances by utilizing the variation in timing and size of the utility rebates across US states. The results indicate that these programs have had a positive and significant impact on the market share of energy efficient clothes washers but not on refrigerators and dishwashers. We find that an increase in a dollar value of rebate leads to a 0.4% increase in the share of ENERGY STAR-qualified clothes washers. Since the average (weighted) rebate for a clothes washer is around $15 this translates to a 6% increase in the share of energy-efficient clothes washers. Measuring the impact of these rebates in terms of the cost of carbon emissions forgone we find that utility rebates lead to a reduction of 55 thousand tons of carbon equivalent. Using the amount spent by utility on providing rebates we find that, over the lifetime of a clothes washer, this leads to a cost of $140 for each tonne of carbon equivalent emissions forgone. The cost-effectiveness of clothes washer rebate programs, per megawatt hour, is $28. These results suggest that utilities are better-off providing incentives to their customers instead of having additional power plants that are costlier to build and operate. This figure is consistent with the cost-effectiveness of DSM initiatives that, according to various authors, range from $8.9 to $253.7 per MWh.

An important feature of this paper is the use of utility-level rebate programs that have been aggregated up to the state level. This allows us to capture the effect of these DSM programs on the market share of energy-efficient ENERGY STAR appliances. There have been relatively few papers that have performed an *ex post* analysis of specific DSM programs. Our objective was to take one particular aspect of DSM, financial incentives in the form of rebates, and analyze its cost-effectiveness. We believe that the study of other DSM components should form an agenda for future research. There are many supporters and a few opponents of DSM and it is therefore important to resolve the argument about the benefits or costs of DSM.

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A Appendix

A.1 Tables

Table 7: Average Energy Use of Dishwashers & Refrigerators (in kWh/year)

	Dishwashers		Refrigerators	
Year	non-ENERGY STAR	ENERGY STAR	non-ENERGY STAR	ENERGY STAR
2001	700	555	540	450
2002	700	555	558	502
2003	574	455	558	502
2004	439	336	520	442
2005	413	341	520	442
2006	448	341	525	457

Source: D&R International Ltd.

A.1.1 Variation in Rebate Amounts and Rebate Coverage

The following tables provide a comprehensive overview of the variation in the rebates for states that had at least one rebate program in place between 2001 and 2006. The rebates are in terms of simple averages (Tables 8, 10 and 12) and weighted averages (Tables 9, 11 and 13) for each appliance, *viz.* clothes washers, dishwashers and refrigerators. The variation in terms of coverage is provided in Tables 14, 15 and 16 for clothes washers, dishwashers and refrigerators, respectively. All the tables indicate that there is a great deal of variation in both rebate amounts and rebate coverage within states over time. We have repeated our preferred specification from Table 4 without states that have a very low coverage of rebates. The states excluded are Iowa, Idaho, Minnesota, Missouri, Montana, South Dakota and Wyoming. These states have a rebate coverage of less than 10% of their population (see Tables 14, 15 and 16. We also exclude Montana. Montana's coverage is higher than 10% for certain quarters in 2006, however its coverage is signicantly lower than 10% for all other quarters and years. Just to be sure about this exclusion, we also run these specifications with Montana included and find that it does not make a difference. The results, which can be obtained from the authors, show that the coefficient for the clothes washers rebate amount remains positive and stable over all three specifications and are very close to the estimates that we obtain in Table 4.

Table 8: **Simple Average of Clothes Washer Rebate Values**

	2001				2002				2003				2004				2005				2006			
State	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
CA	125	125	100	91.7	91.7	91.7	91.7	91.7	93.8	90	90	90	79.2	78.6	95	100	87.5	87.5	66.7	78.6	79.8	79.8	80.9	74
CO	0	0	0	0	0	0	0	0	0	0	50	50	50	50	50	50	50	50	50	50	58.3	56.3	56.3	58.3
CT	0	0	0	0	0	0	0	0	25	25	25	25	0	0	0	0	50	50	50	50	35	35	0	0
DE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	75	75
IA	0	0	0	0	0	0	0	0	0	0	0	0	75	75	75	75	0	0	0	0	60.9	60.9	60.9	60.9
ID	0	0	0	0	100	100	100	75	75	66.7	66.7	66.7	66.7	66.7	66.7	100	200	200	200	200	81.3	81.3	81.3	81.3
IL	0	0	0	0	0	0	0	0	0	0	0	0	0	87.5	87.5	0	0	0	0	0	0	0	0	0
MA	0	0	0	0	0	0	0	0	50	50	50	50	50	50	50	50	50	49.3	50	50	71.9	100	100	100
MN	0	0	0	0	0	0	0	0	0	0	0	0	93.8	82.1	82.1	93.8	50	75	50	50	53	50.8	53	53
MO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	50	50	50	50	50	50	50
MT	0	0	0	0	0	0	0	0	0	0	75	0	0	0	75	75	75	75	75	75	69	69	69	74
NH	0	0	0	0	0	50	50	50	50	50	50	50	0	50	50	0	50	50	50	50	50	50	0	0
NV	0	0	0	0	0	0	0	0	0	100	100	50	0	50	50	0	0	50	50	50	0	40	40	40
NY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	50	50	50	30	30	30	30
OR	75	75	75	75	96.3	102	101.7	108.6	93.5	85.4	90	90	90	82.8	81.3	84.7	73.5	73.5	73.5	58.3	65.6	65	65	65.3
RI	0	0	0	0	0	0	0	0	0	0	0	0	50	50	50	50	35	35	35	35	25	25	25	25
SD	0	0	0	0	0	0	0	0	0	0	0	0	0	62.5	62.5	0	0	0	0	0	0	0	0	0
VT	0	0	0	0	0	0	0	0	0	0	0	0	50	50	50	50	50	50	50	50	0	50	50	50
WA	0	0	106.7	106.7	106.7	104.5	101.9	101.8	97.5	90.5	91.8	89.7	90.1	84.1	84.1	91.2	82.4	82.4	82.4	82.4	77	77.3	74.3	74.3
WI	0	0	0	0	0	0	0	0	0	0	0	0	100	75	75	100	0	100	100	100	37.5	58.3	37.5	37.5
WY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60	60	60	60

Table 9: **Weighted Average of Clothes Washer Rebate Values**

	2001				2002				2003				2004				2005				2006			
State	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
CA	11.8	11.8	19.1	19.3	19.3	19.3	19.3	19.3	19.8	20.1	20.1	20.1	41.9	44.9	17.9	14.9	34.3	34.3	34	35.1	24	24	24.5	23.3
CO	0	0	0	0	0	0	0	0	0	0	1.4	1.4	1.4	2.2	3.2	2.4	2.4	3.2	3.2	2.4	9.1	10	10	9.1
CT	0	0	0	0	0	0	0	0	23.4	23.4	23.4	23.4	0	0	0	0	46.7	46.7	46.7	46.7	6.9	6.9	0	0
DE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	75	75
IA	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0.6	0.6	0.6	0	0	0	0	4.1	4.1	4.1	4.1
ID	0	0	0	0	3.1	3.1	3.1	4.1	4.1	4.7	4.7	4.7	4.7	7.7	7.7	5.4	0.6	0.6	0.6	0.6	2.6	2.6	2.6	2.6
IL	0	0	0	0	0	0	0	0	0	0	0	0	0	59	59	0	0	0	0	0	0	0	0	0
MA	0	0	0	0	0	0	0	0	2.9	2.9	2.9	22.3	2.9	42.7	42.7	2.9	42.9	41.6	40	40	67	78.7	78.7	78.7
MN	0	0	0	0	0	0	0	0	0	0	0	0	2.2	7	7	2.2	0.4	5.6	3	3	0.9	3	0.9	0.9
MO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
MT	0	0	0	0	0	0	0	0	0	0	43.1	0	0	0	0.9	0.9	0.9	0.9	0.9	0.9	15.3	15.3	15.3	16
NH	0	0	0	0	0	35.2	35.2	35.2	35.2	35.2	35.2	35.2	0	2.1	2.1	0	42.6	42.6	7.4	7.4	49.2	49.2	0	0
NV	0	0	0	0	0	0	0	0	0	94.9	94.9	47.5	0	47.5	47.5	0	0	47.5	47.5	47.5	0	38	38	38
NY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.8	6.8	6.8	6.8	4.1	4.1	4.1	4.1
OR	0.4	0.4	0.4	0.4	3.1	3.9	4.1	4.4	5.1	6.8	7.5	7.5	7.5	12.4	12.8	10.3	7.8	7.8	7.8	2.3	8.7	9	9	9.7
RI	0	0	0	0	0	0	0	0	0	0	0	0	49.4	49.4	49.4	49.4	34.6	34.6	34.6	34.6	24.7	24.7	24.7	24.7
SD	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0.6	0	0	0	0	0	0	0	0	0
VT	0	0	0	0	0	0	0	0	0	0	0	0	50	50	50	50	50	50	50	50	0	50	50	50
WA	0	0	1.4	1.4	1.4	11.6	19.5	19.6	31.5	41.2	33.2	31.4	37.3	39.5	39.5	43.4	44.2	44.2	44.2	44.2	43.5	69.2	43.9	43.9
WI	0	0	0	0	0	0	0	0	0	0	0	0	16.3	66.3	66.3	16.3	0	100	100	100	0.2	100.2	0.2	0.2
WY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.3	4.3	4.3	4.3

Table 10: **Simple Average of Dishwasher Rebate Values**

	2001				2002				2003				2004				2005				2006			
State	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
CA	0	0	0	0	0	0	0	0	50	50	50	50	50	50	54.2	54.2	47.9	47.9	47.9	48.1	47.3	46.3	45	44.5
CO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	50	50	50	50	50	50	50	50	50
IA	0	0	0	0	0	0	0	0	0	0	0	0	37.5	37.5	37.5	37.5	25	25	25	25	28.2	28.2	28.2	28.2
ID	0	0	0	0	25	25	25	25	25	25	25	25	25	27.5	27.5	20	10	10	10	10	27	27	27	27.5
MA	0	0	0	0	0	0	0	0	0	25	25	25	0	25	25	25	0	0	0	0	0	0	0	0
MN	0	0	0	0	0	0	0	0	0	0	0	0	50	50	50	50	50	50	50	50	33	33	33	33
MT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	25	25	25	25	25	27.5	27.5	27	27
NV	0	0	0	0	0	0	0	0	0	35	35	0	0	15	15	0	0	0	0	0	0	0	0	0
OR	30	30	30	30	27.5	27.5	25	22.9	25.6	25.6	28.2	28.2	29	28.2	30.8	32.8	28.3	28.3	28.3	28.8	27.8	27.5	27.5	27.7
WA	0	0	50	50	50	56.3	51.9	48.1	43.4	43.4	50.2	50.2	52.8	52.8	52.8	57.8	58.2	58.2	58.2	58.2	57.5	53.2	53.2	53.2
WI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	30	30	27.5	27.5	27.5	27.5
WY	0	0	0	0	0	0	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20

Table 11: **Weighted Average of Dishwasher Rebate Values**

	2001				2002				2003				2004				2005				2006			
State	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
CA	0	0	0	0	0	0	0	0	0.4	0.5	0.5	0.5	27.8	27.8	10.3	10.3	19	19	19	19.4	18.3	18.3	18.1	17.7
CO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
IA	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0.5	0.5	0.1	0.1	0.1	0.1	2.3	2.3	2.3	2.3
ID	0	0	0	0	0.8	0.8	0.8	1.3	1.3	1.3	1.3	1.3	1.3	1.5	1.5	1.3	0	0	0	0	1.9	1.9	1.9	1.5
MA	0	0	0	0	0	0	0	0	0	1.4	1.4	1.4	0	1.4	1.4	1.4	0	0	0	0	0	0	0	0
MN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0.4	0.4	0.4	0.8	0.8	0.8	0.8
MT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.3	0.3	0.3	0.3	0.3	2.2	2.2	5.1	5.1
NV	0	0	0	0	0	0	0	0	0	24	24	0	0	14.2	14.2	0	0	0	0	0	0	0	0	0
OR	0.1	0.1	0.1	0.1	1.9	1.9	1.9	2.3	2.4	2.4	2.8	2.8	2.8	2.8	3.4	3.1	2.3	2.3	2.3	2.2	4.1	4.3	4.3	3.6
WA	0	0	0.1	0.1	0.1	3.7	3.8	3.8	10.6	10.6	10.7	10.7	7.6	7.6	7.6	10.9	13.8	13.8	13.8	13.8	11.1	11.5	11.5	11.5
WI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	30	30	0.1	0.1	0.1	0.1
WY	0	0	0	0	0	0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4

Table 12: **Simple Average of Refrigerator Rebate Values**

	2001				2002				2003				2004				2005				2006			
State	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
CA	100	100	100	100	100	100	100	100	112.5	110	112.5	112.5	96.9	103.6	104.2	104.2	85	85	71.3	64.7	73	73.2	76.5	78.4
CO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	75	75	75	75	75	75	55	55	55	55
CT	0	0	0	0	0	0	0	0	25	25	25	25	0	0	0	0	0	0	0	0	50	50	50	50
DE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	100
IA	0	0	0	0	0	0	0	0	0	0	0	0	50	50	50	50	0	0	0	0	33.4	33.4	33.4	33.4
ID	0	0	0	0	0	0	0	0	0	0	0	0	0	32.5	32.5	15	15	15	15	15	28.8	28.8	28.8	30
MN	0	0	0	0	0	0	0	0	20	20	20	20	50	50	50	50	37.5	37.5	37.5	37.5	31.9	31.9	31.9	31.9
MT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60	60	60	60	60	60	46.3	46.3	42	42
NV	0	0	0	0	0	0	0	0	0	0	0	0	0	50	50	0	0	50	50	50	30	27.5	27.5	27.5
OR	50	50	50	50	41.7	41.7	33.8	30	24.2	24.2	24.2	27.9	28.3	29.3	33.1	35.7	39.2	39.2	39.2	39.2	30.7	30	30	29.7
TX	0	0	0	0	0	0	0	0	0	0	0	0	0	35	35	35	35	35	35	35	0	0	0	0
VT	0	0	0	0	0	0	0	0	0	25	25	0	25	25	25	0	0	30	30	30	30	30	30	30
WA	0	0	50	50	50	83	83	72.1	66.1	66.1	73.4	69.6	64.7	64.7	64.7	71.4	82.1	82.1	82.1	82.1	70.7	65	65	65
WI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	50	50	47.5	47.5	47.5	47.5
WY	0	0	0	0	0	0	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25

Table 13: **Weighted Average of Refrigerator Rebate Values**

	2001				2002				2003				2004				2005				2006			
State	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
CA	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1.6	1.9	2.2	2.2	23.4	18.7	27.2	27.2	33.4	33.4	33.4	33.6	38	42.9	41.9	41.5
CO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.6	1.6	1.6	1.6	1.6	1.6	2.6	2.6	2.6	2.6
CT	0	0	0	0	0	0	0	0	23.4	23.4	23.4	23.4	0	0	0	0	0	0	0	0	36.9	36.9	36.9	36.9
DE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	100
IA	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0.4	0.4	0.4	0	0	0	0	7.3	7.3	7.3	7.3
ID	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0.2	0	0	0	0	0	1.1	1.1	1.1	0.7
MN	0	0	0	0	0	0	0	0	1.1	1.1	1.1	1.1	0	0	0	0	0.3	0.3	0.3	0.3	1	1	1	1
MT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0.7	0.7	0.7	0.7	0.7	3.2	3.2	6	6
NV	0	0	0	0	0	0	0	0	0	0	0	0	0	47.5	47.5	0	0	47.5	47.5	47.5	28.5	26.1	26.1	26.1
OR	0.2	0.2	0.2	0.2	0.6	0.6	0.6	0.8	0.8	0.8	0.8	0.9	0.8	1	1.6	1.5	55.9	55.9	55.9	55.9	58	58.1	58.1	56.9
TX	0	0	0	0	0	0	0	0	0	0	0	0	0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	0	0	0	0
VT	0	0	0	0	0	0	0	0	0	25	25	0	25	25	25	0	0	30	30	30	30	30	30	30
WA	0	0	0.1	0.1	0.1	0.9	0.9	0.9	1	1	1.1	0.7	3.9	3.9	3.9	3.8	9.5	9.5	9.5	9.5	7.1	7.5	7.5	7.5
WI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	50	50	8.1	8.1	8.1	8.1
WY	0	0	0	0	0	0	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8

Table 14: **Fraction of Consumers Exposed to Clothes Washer Rebates**

	2001				2002				2003				2004				2005				2006			
State	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
CA	0.09	0.09	0.19	0.19	0.19	0.19	0.19	0.19	0.2	0.2	0.2	0.2	0.56	0.6	0.24	0.2	0.59	0.59	0.59	0.6	0.44	0.44	0.44	0.43
CO	0	0	0	0	0	0	0	0	0	0	0.03	0.03	0.03	0.04	0.07	0.05	0.05	0.07	0.07	0.05	0.14	0.15	0.15	0.14
CT	0	0	0	0	0	0	0	0	0.94	0.94	0.94	0.94	0	0	0	0	0.94	0.94	0.94	0.94	0.94	0.94	0	0
DE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
IA	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.01	0.01	0	0	0	0	0.07	0.07	0.07	0.07
ID	0	0	0	0	0.03	0.03	0.03	0.05	0.05	0.06	0.06	0.06	0.06	0.13	0.13	0.07	0	0	0	0	0.06	0.06	0.06	0.06
IL	0	0	0	0	0	0	0	0	0	0	0	0	0	0.67	0.67	0	0	0	0	0	0	0	0	0
MA	0	0	0	0	0	0	0	0	0.06	0.06	0.06	0.45	0.06	0.85	0.85	0.06	0.86	0.86	0.8	0.8	0.85	0.85	0.85	0.85
MN	0	0	0	0	0	0	0	0	0	0	0	0	0.03	0.1	0.1	0.03	0.01	0.06	0.06	0.06	0.03	0.08	0.03	0.03
MO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MT	0	0	0	0	0	0	0	0	0	0	0.57	0	0	0	0.01	0.01	0.01	0.01	0.01	0.01	0.18	0.18	0.18	0.18
NH	0	0	0	0	0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0	0.04	0.15	0	0.85	0.85	0.15	0.15	0.98	0.98	0	0
NV	0	0	0	0	0	0	0	0	0	0.95	0.95	0.95	0	0.95	0.95	0	0	0.95	0.95	0.95	0	0.95	0.95	0.95
NY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
OR	0.01	0.01	0.01	0.01	0.04	0.04	0.04	0.05	0.06	0.09	0.09	0.09	0.09	0.16	0.17	0.14	0.1	0.1	0.1	0.04	0.18	0.18	0.18	0.15
RI	0	0	0	0	0	0	0	0	0	0	0	0	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
SD	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0	0	0	0	0	0	0	0	0
VT	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	1	1	1
WA	0	0	0.01	0.01	0.01	0.11	0.22	0.22	0.55	0.69	0.7	0.68	0.74	0.82	0.82	0.75	0.83	0.83	0.83	0.83	0.77	0.79	0.79	0.79
WI	0	0	0	0	0	0	0	0	0	0	0	0	0.31	1	1	0.31	0	1	1	1	0	1	0	0
WY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.07	0.07	0.07	0.07

Table 15: **Fraction of Consumers Exposed to Dishwasher Rebates**

	2001				2002				2003				2004				2005				2006			
State	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
CA	0	0	0	0	0	0	0	0	0.01	0.01	0.01	0.01	0.56	0.56	0.2	0.2	0.56	0.56	0.56	0.56	0.53	0.53	0.53	0.52
CO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
IA	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.01	0.01	0	0	0	0	0.07	0.07	0.07	0.07
ID	0	0	0	0	0.03	0.03	0.03	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.05	0	0	0	0	0.07	0.07	0.07	0.06
MA	0	0	0	0	0	0	0	0	0	0.06	0.06	0.06	0	0.06	0.06	0.06	0	0	0	0	0	0	0	0
MN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.01	0.01	0.03	0.03	0.03	0.03
MT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.01	0.01	0.01	0.01	0.07	0.07	0.18	0.18
NV	0	0	0	0	0	0	0	0	0	0.69	0.69	0	0	0.95	0.95	0	0	0	0	0	0	0	0	0
OR	0.01	0.01	0.01	0.01	0.07	0.07	0.07	0.09	0.09	0.09	0.1	0.1	0.1	0.1	0.11	0.09	0.09	0.09	0.09	0.09	0.16	0.17	0.17	0.13
WA	0	0	0	0	0	0.09	0.09	0.09	0.43	0.43	0.43	0.43	0.37	0.37	0.37	0.36	0.51	0.51	0.51	0.51	0.46	0.48	0.48	0.48
WI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
WY	0	0	0	0	0	0	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07

Table 16: **Fraction of Consumers Exposed to Refrigerator Rebates**

	2001				2002				2003				2004				2005				2006			
State	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
CA	0	0	0	0	0	0	0	0	0.01	0.02	0.02	0.02	0.44	0.35	0.43	0.43	0.79	0.79	0.79	0.8	0.87	0.97	0.96	0.96
CO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0.02	0.02	0.02	0.02	0.02	0.05	0.05	0.05	0.05
CT	0	0	0	0	0	0	0	0	0.94	0.94	0.94	0.94	0	0	0	0	0	0	0	0	0.74	0.74	0.74	0.74
DE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
IA	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.01	0.01	0	0	0	0	0.18	0.18	0.18	0.18
ID	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0	0	0	0	0	0.04	0.04	0.04	0.03
MN	0	0	0	0	0	0	0	0	0.05	0.05	0.05	0.05	0	0	0	0	0.01	0.01	0.01	0.01	0.03	0.03	0.03	0.03
MT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.01	0.01	0.01	0.01	0.07	0.07	0.18	0.18
NV	0	0	0	0	0	0	0	0	0	0	0	0	0	0.95	0.95	0	0	0.95	0.95	0.95	0.95	0.95	0.95	0.95
OR	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.05	0.04	1	1	1	1	1	1	1	1
TX	0	0	0	0	0	0	0	0	0	0	0	0	0	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0	0	0	0
VT	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	0	0	1	1	1	1	1	1	1
WA	0	0	0	0	0	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.13	0.13	0.13	0.13	0.17	0.17	0.17	0.17	0.19	0.2	0.2	0.2
WI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0.11	0.11	0.11	0.11
WY	0	0	0	0	0	0	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07

A.2 Alternative Specification

Table 17 below estimates our models with average rebate amounts, *not* weighted average rebate amounts.

Table 17: FE Models for (Log) Share of Individual ENERGY STAR Appliances

	FE1	FE2	FE3	FE4
CW*Avg. Rebate Amount	0.960^a	0.933^a	0.242^a	0.284^b
	(0.128)	(0.123)	(0.064)	(0.110)
DW*Avg. Rebate Amount	1.563^a	1.498^a	-0.376^a	-0.299^c
	(0.207)	(0.214)	(0.085)	(0.173)
RF*Avg. Rebate Amount	1.043^a	0.962^a	0.025	0.081
	(0.162)	(0.150)	(0.083)	(0.101)
State Fixed Effects	Yes	Yes	Yes	
Year-Quarter-State Fixed Effects				Yes
Appliance Fixed Effects	Yes			
Quarter-Appliance Fixed Effects		Yes		
Year-Quarter-Appliance Fixed Effects			Yes	Yes
Observations	3,598	3,598	3,598	3,598
Adjusted R^2	0.291	0.340	0.923	0.906

Clustered standard errors in parentheses
^{a}, ^{b}, ^{c}: Significant at the 1%, 5% and 10% levels respectively
Utility rebate amounts re-scaled
CW: Clothes Washers, RF: Refrigerators, DW: Dishwashers

A.3 Robustness

A.3.1 Pseudo Rebates

In this section we provide robustness checks to our assumption of a common trend in specifications FE1, FE2 and FE3. We drop all states that had positive rebate values from 2001 to 2006. These were the states of California, Colorado, Connecticut, Idaho, Massachusetts, Montana, New Hampshire, Nevada, Oregon and Washingtonfor clothes washers. We also drop California, Idaho, Massachusetts, Nevada, Oregon, Washington and Wyoming for dishwashers and the states of California, Connecticut, Minnesota, Oregon, Vermont, Washington and Wyoming for refrigerators. We then consider all states that did not have a rebate in 2001, 2002 and 2003 but had rebates in subsequent years. Those states were Delaware, Iowa, Illinois, Missouri, New York, Rhode Island, South Dakota and Wisconsin for clothes washers, Iowa and Wisonsin for dishwashers, and Delaware, Iowa, Idaho, Texas, and Wisconsin for refrigerators. In other words, positive rebate values are for states that did not have rebates in the first three years of our sample but have rebates in the last three. For those states, and the appliances that had rebates in place after 2003 we perform some falsification tests to check for the common trends assumption in specifications FE1, FE2, FE3, and FE4. In what follows, all observations from 2004, 2005 and 2006 are dropped in the regression models and all standard errors, as in the main text, are clustered by state. The acronyms CW, DW, and RF refer to clothes washers, dishwashers, and refrigerators, respectively.

In the first table, table 18, true rebate values from 2004, 2005 and 2006 are used as pseudo rebates for 2001, 2002 and 2003, respectively. The coefficient for the clothes washer pseudo rebate is significant and positive at the 5% level of significance while the pseudo rebate does not impact ENERGY STAR dishwasher or refrigerator shares (the coefficients are insignificant). Next, in table 19, we assign a rebate value of zero to 2001, and actual rebate values from 2005 and 2006 to 2002 and 2003, respectively. We see that, in this case, the coefficient for clothes washer pseudo rebates becomes statistically insignificant. As before, the coefficients for dishwasher and refrigerator shares remain insignificant. Thirdly, in table 20, we assign rebate values of zero to 2001 and 2002, and use the actual rebate values from 2006 in 2003. All relevant coefficients remain statistically insignificant. Finally, we present another pseudo rebate test in table 21. We use data for the first three years for states where no rebates are offered. We construct a pseudo rebate by randomly assigning rebates to 2002 and 2003 from a uniform $[0, 1]$ distribution. However, these rebates are only assigned to states that provide rebates in 2004, 2005, and 2006.

If the common trends assumption holds we should expect the coefficient for the "Pseudo Rebate" variables to be insignificant in FE1, FE2, and FE3 since those states did not actually have rebates in place. The results show that the rebate variables are significant. This is an indication that our assumption of common trends does not appear to be valid and, therefore, emphasizes the importance of each state having its own time fixed effect. This is what we do in our preferred specification FE4 and the results in tables 18, 19, 20, and 21 show that the coefficient for the pseudo rebate values are all statistically insgnificant, as we would expect. The only exception is the estimated coefficient for clothes washers in table 18 that is statistically significant at the 5% level of significance.

Table 18: FE Models for (Log) Share of Individual ENERGY STAR Appliances

	FE1	FE2	FE3	FE4
CW*Pseudo Rebate	0.769[b]	0.695[b]	0.756[b]	1.023[b]
	(0.300)	(0.298)	(0.311)	(0.498)
DW*Pseudo Rebate	-0.314	-0.706	-1.526[a]	-0.589
	(0.717)	(0.683)	(0.267)	(1.201)
RF*Pseudo Rebate	0.824[a]	0.169	-0.094	0.430
	(0.277)	(0.129)	(0.092)	(0.458)
State Fixed Effects	Yes	Yes	Yes	
Year-Quarter-State Fixed Effects				Yes
Appliance Fixed Effects	Yes			
Quarter-Appliance Fixed Effects		Yes		
Year-Quarter-Appliance Fixed Effects			Yes	Yes
Observations	1,511	1,511	1,511	1,511
Adjusted R^2	0.204	0.363	0.895	0.861

Clustered standard errors in parentheses
[a], [b], [c]: Significant at the 1%, 5% and 10% levels respectively
Utility rebate amounts re-scaled

Table 19: FE Models for (Log) Share of Individual ENERGY STAR Appliances

	FE1	FE2	FE3	FE4
CW*Pseudo Rebate	1.118[a]	1.029[a]	0.586[b]	0.836
	(0.296)	(0.297)	(0.238)	(0.527)
DW*Pseudo Rebate	-0.173	-0.532	-1.684[a]	-0.953
	(0.868)	(0.847)	(0.225)	(1.199)
RF*Pseudo Rebate	0.774[a]	0.202	-0.195[c]	0.295
	(0.226)	(0.141)	(0.105)	(0.421)
State Fixed Effects	Yes	Yes	Yes	
Year-Quarter-State Fixed Effects				Yes
Appliance Fixed Effects	Yes			
Quarter-Appliance Fixed Effects		Yes		
Year-Quarter-Appliance Fixed Effects			Yes	Yes
Observations	1,511	1,511	1,511	1,511
Adjusted R^2	0.206	0.366	0.893	0.856

Clustered standard errors in parentheses
[a], [b], [c]: Significant at the 1%, 5% and 10% levels respectively
Utility rebate amounts re-scaled

Table 20: FE Models for (Log) Share of Individual ENERGY STAR Appliances

	FE1	FE2	FE3	FE4
CW*Pseudo Rebate	1.430[a]	1.348[a]	0.559	0.750
	(0.389)	(0.409)	(0.347)	(0.544)
DW*Pseudo Rebate	22.577[a]	21.685[a]	-2.506	-7.714
	(4.032)	(4.314)	(2.623)	(4.861)
RF*Pseudo Rebate	0.821[b]	0.435	-0.190[b]	0.130
	(0.366)	(0.424)	(0.071)	(0.176)
State Fixed Effects	Yes	Yes	Yes	
Year-Quarter-State Fixed Effects				Yes
Appliance Fixed Effects	Yes			
Quarter-Appliance Fixed Effects		Yes		
Year-Quarter-Appliance Fixed Effects			Yes	Yes
Observations	1,511	1,511	1,511	1,511
Adjusted R^2	0.208	0.368	0.891	0.852

Clustered standard errors in parentheses
[a], [b], [c]: Significant at the 1%, 5% and 10% levels respectively
Utility rebate amounts re-scaled

Table 21: FE Models for (Log) Share of Individual ENERGY STAR Appliances

	FE1	FE2	FE3	FE4
CW*Pseudo Rebate	0.923[a]	0.917[a]	0.410[b]	0.419
	(0.205)	(0.198)	(0.175)	(0.256)
DW*Pseudo Rebate	0.575[a]	0.565[a]	-0.310[b]	-0.392
	(0.093)	(0.087)	(0.152)	(0.343)
RF*Pseudo Rebate	0.804[a]	0.754[a]	-0.032	-0.040
	(0.119)	(0.125)	(0.069)	(0.144)
State Fixed Effects	Yes	Yes	Yes	
Year-Quarter-State Fixed Effects				Yes
Appliance Fixed Effects	Yes			
Quarter-Appliance Fixed Effects		Yes		
Year-Quarter-Appliance Fixed Effects			Yes	Yes
Observations	1,511	1,511	1,511	1,511
Adjusted R^2	0.215	0.376	0.893	0.855

Clustered standard errors in parentheses
[a], [b], [c]: Significant at the 1%, 5% and 10% levels respectively
Utility rebate amounts re-scaled

A.3.2 Excluding "Bad States"

Table 22 below repeats the estimation presented in our paper (see table 4) without states that have a very low coverage of rebates. We refer to these states as the "bad states". The states excluded are Iowa, Idaho, Minnesota, Missouri, Montana, South Dakota, and Wyoming. These states have a rebate coverage of less than 10% of their population (see Tables 14, 15 and 16 above). Montana's coverage is higher than 10% for certain quarters in 2006. However, its coverage is significantly lower than 10% for all other quarters and years. Just to be sure about this exclusion, we also run these specifications with Montana included and find that the results are unchanged.

The columns in table 22 are similar to those in table 4 of our paper. Thus, FE1 includes state and appliance fixed effects, FE2 includes state and quarter-appliance fixed effects, FE3 includes state and year-quarter-appliance fixed effects, and finally FE4 includes year-quarter-state, and year-quarter-appliance fixed effects. In the first two specifications, FE1 and FE2, ENERGY STAR rebates have a positive and significant impact on the sales for clothes washers, dishwashers, and refrigerators, although coefficient values differ slightly from our specification in the paper. In FE3, and FE4 specifications, we find that while dishwashers and refrigerators sale shares are unaffected, the sales share for clothes washers increases with the rebate. FE4 is the preferred regression in our paper. The results show that the coefficient for the clothes washers rebate amount remains positive and stable over all specifications and are very close to the estimates that we originally obtained without the "bad states".

Table 22: FE Models for (Log) Share of Individual ENERGY STAR Appliances

	FE1	FE2	FE3	FE4
CW*Wt. Avg. Rebate Amount	1.190[a]	1.167[a]	0.270[a]	0.426[a]
	(0.163)	(0.166)	(0.079)	(0.139)
DW*Wt. Avg. Rebate Amount	2.267[a]	2.213[a]	-1.088[b]	-0.561
	(0.367)	(0.381)	(0.431)	(0.431)
RF*Wt. Avg. Rebate Amount	1.116[a]	0.981[a]	0.042	0.305[c]
	(0.260)	(0.263)	(0.113)	(0.156)
State Fixed Effects	Yes	Yes	Yes	
Year-Quarter-State Fixed Effects				Yes
Appliance Fixed Effects	Yes			
Quarter-Appliance Fixed Effects		Yes		
Year-Quarter-Appliance Fixed Effects			Yes	Yes
Observations	3,094	3,094	3,094	3,094
Adjusted R^2	0.294	0.344	0.922	0.902

Clustered standard errors in parentheses

[a], [b], [c]: Significant at the 1%, 5% and 10% levels respectively

Utility rebate amounts re-scaled

CW: Clothes Washers, RF: Refrigerators, DW: Dishwashers

A.4 Spot Prices

Table 23: Peak Spot Prices for Major Pricing Points (in $/MWh)

	On-Peak Spot Prices				Off-Peak Spot Prices			
	2003	2004	2005	2006	2003	2004	2005	2006
Northeast								
Mass Hub	59.05	61.47	89.87	70.33	41.80	42.94	61.79	47.45
NY Zone G	61.73	61.74	92.46	76.53	42.12	42.86	63.70	50.54
NY Zone J	77.82	76.63	110.03	86.47	48.70	48.28	72.61	55.05
NY Zone A	51.36	52.49	76.04	59.34	35.78	36.82	53.26	42.20
PJM West	48.49	51.10	76.64	62.92	24.14	30.15	40.72	36.36
Southeast								
VACAR	41.60	48.27	71.88	57.20	19.44	25.23	38.13	34.96
Southern	41.55	48.67	70.88	56.15	19.51	26.01	37.54	33.86
TVA	38.90	44.23	67.39	53.91	18.73	22.14	34.24	32.76
Florida	52.21	58.31	84.95	65.06	22.25	29.02	42.88	39.78
Entergy	41.47	45.76	69.95	56.65	18.39	23.04	38.02	34.06
Southeast								
Cinergy	37.57	43.31	63.76	52.39	15.91	19.88	29.12	29.93
ECAR North	38.41	45.58	67.13	55.94	16.54	21.00	30.84	29.30
MAIN North	43.14	47.94	64.70	58.67	16.47	20.28	28.78	25.73
NI Hub	37.11	42.03	61.76	53.15	15.44	17.57	28.71	28.35
MAIN South	38.43	42.85	63.38	51.73	16.06	18.41	28.70	25.54
MAPP North	45.18	47.06	65.06	58.67	17.22	19.12	28.57	25.73
MAPP South	43.29	45.90	65.48	55.56	16.93	19.00	28.01	32.61
South Central								
SPP North	41.66	45.19	67.44	56.23	18.48	20.55	34.82	33.91
ERCOT	46.49	47.32	70.95	58.74	30.51	31.45	47.95	39.09
Southwest								
Four Corners	48.55	50.51	69.39	58.79	32.28	35.45	46.74	36.45
Palo Verde	49.10	50.09	67.39	57.85	32.84	35.44	47.10	36.91
Mead	50.65	51.91	70.18	59.79	33.75	37.43	49.02	38.44
Northwest								
Mid- Columbia	40.73	44.54	62.95	49.52	34.04	39.27	50.21	37.23
COB	44.49	49.09	66.95	55.08	35.23	40.58	51.71	39.14
California								
NP 15	49.13	54.46	72.49	60.81	35.76	41.35	51.35	39.17
SP 15	51.25	55.20	73.03	61.77	35.15	39.26	51.22	40.07

Source: Federal Energy Regulatory Commission

A.5 Power Calculations

We expect all the coefficients for the respective appliance rebates to be positive but find that the coefficient for dishwasher rebates is insignificant while that for refrigerators is positive and significant but only at the 10% level in our preferred specification FE4 in table 4. The issue of measurement error may lead to this result and to get an idea of the extent to which this may be a problem we perform power calculations. We use the `clustersampsi` command (Hemming and Marsh, 2013) in STATA to perform the power calculations. We use the mean and standard deviation of the market share of our control group. The baseline correlation is set to 0.9 due to the high R^2 values from our fixed effects estimation procedure. The number of clusters is set equal to the number of states receiving the treatment of positive rebate amounts. We are making the assumption of equal group sizes. The size of the cluster is set equal to the number of time periods, i.e. 24 quarters. The intracluster corelation (ICC) coefficient is calculated from the within and between variation of the market share of ENERGY STAR appliances for states receiving the treatment. The ICC is calculated according to the following equation: $s_b^2/(s_b^2 + s_w^2)$ where s_b^2 is the between standard deviation of the ENERGY STAR market share in the treated states and s_w^2 is the within standard deviation of the ENERGY STAR market share in the treated states. We obtain a minimum detectable effect (MDE) for clothes washers and refrigerators to be a 2% change in the market share of ENERGY STAR appliances. The MDE for dishwashers is a 3% change in the market share of ENERGY STAR dishwashers. The MDE for clothes washers and refrigerators are quite similar. We also perform the MDE calculations based on the assumption of a low ICC of 0.1. Using this value we find that the MDE for clothes washers and refrigerators is a 2% change in the market share for ENERGY STAR clothes washers and refrigerators while the MDE for dishwashers is 6%.

The MDE for dishwashers tends to be higher than the MDE for clothes washers and refrigerators. The fraction of population covered by rebates is highest for clothes washers, followed by refrigerators and then dishwashers. The variation, as indicated by the standard deviation (SD) in table 3, also shows much more variability for clothes washers than for refrigerators and dishwashers. This could be a reason why we find a strong statistically significant effect for clothes washers while the effect is statistically weak for refrigerators and insignificant for dishwashers.