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Belt and Suspenders and More: The Incremental Impact of Energy Efficiency Subsidies in the Presence of Existing Policy Instruments

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“Belt and Suspenders and More: The Incremental Impact of Energy Efficiency Subsidies in the Presence of Existing Policy Instruments”

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Introduction

Over the past 40 years, policymakers have implemented an array of instruments - regulatory mandates, information campaigns, and technology subsidies - to promote energy efficiency. For instance, large appliances are subject to Federal minimum energy efficiency standards, information disclosure on typical annual energy usage, and occasionally various kinds of local, state, and Federal rebates and tax credits. Given scarce resources and the existing overlay of policy instruments, what is the incremental impact of energy efficiency subsidies on energy use?

To address this question, we evaluate the State Energy Efficient Appliance Rebate Program (SEEARP), implemented through the 2009 American Recovery and Reinvestment Act. The program, informally known as the “Cash for Appliances” program (“C4A”), delivered $300 million to state governments to provide rebates to consumers purchasing residential appliances that met or exceeded the ENERGY STAR (ES) certification requirement. Using transaction-level data, we estimate the energy savings for the three major appliance categories that attracted the most funds: refrigerators, clothes washers, and dishwashers.

Through our empirical analysis, we find that the program did not have a meaningful impact on aggregate electricity consumption. For example, the average energy savings for refrigerator rebate programs was a statistically significant, but economically minuscule 0.08%. We find that the cost per kilowatt-hour saved is on the order of about $0.25 to $1.50, depending on assumptions and appliance category. There are several possible explanations for these results. First, the large ES share of these appliance markets indicates that many consumers purchase ES-rated appliances even in the absence of rebate programs. Second, some consumers responded to the program by simply delaying their purchases until their state’s rebate program opened. Third, the rebate program’s focus on ES certified-appliances -- where the maximum amount of energy a given appliance model can consume is a function of size and other attributes -- influenced the behavioral response to rebates. Under the program, for example, a consumer was able to receive a rebate for an ES-certified refrigerator with special features that ultimately requires more electricity annually than a non-certified appliance with fewer features. Finally, we also find some evidence that the generous rebates may have induced a small income effect that led consumers to purchase larger appliances.

Overall, this paper illustrates – theoretically and empirically – the net impact of multiple policy instruments and can inform the nascent literature on the effects of overlapping regulatory and fiscal policies. In the energy and environmental context, this is an important question given that energy efficiency subsidies are likely to play an important role in the upcoming years in greenhouse gas emission reduction efforts. The following section describes the extensive, overlapping, and complicated set of policy instruments focused on residential energy efficiency. The third and fourth sections present our framework for evaluating energy efficiency policy instruments and the data. The fifth section presents our empirical strategy and main results, and investigates whether the program induces an income effect and upgrading. The sixth section presents a cost-effectiveness analysis, and conclusions follow. The paper this policy brief is based on, "Belt and Suspenders and More: The Incremental Impact of Energy Efficiency Subsidies in the Presence of Existing Policy Instruments," addresses these topics in greater detail.

Appliance Efficiency Policy Landscape

Since the oil shocks of the 1970s, local, state, and federal governments have employed an array of policy instruments to promote the energy efficiency of appliances (and energy efficiency more generally). These include the 1975 Energy Policy and Conservation Act, the 1987 National Appliance Energy Conservation Act, and, in 1992, The Environmental Protection Agency's (EPA) ENERGY STAR (ES) program. An appliance model can earn the ES label, a simple brand-like logo, if its efficiency exceeds the minimum standard for that appliance category by a certain percentage.

State and local governments as well as utilities also implement a wide array of efficiency policies, including tax credits, tax deductions, and rebates. The Energy Policy Act of 2005 created the State Energy Efficient Appliance Rebate Program (SEEARP) to provide guidance in the design of and federal support for state rebate programs. In 2009, the American Recovery and Reinvestment Act made the initial appropriation to SEEARP, in what became informally known as "Cash for Appliances." SEEARP allocated federal funds to state programs and required states to use ES certification or more stringent criteria for rebate eligibility. Under SEEARP, states had sovereignty over the design of several elements of their rebate programs. As a result, the C4A program gave rise to a collection of 56 different programs that differed in the rebate amounts offered, appliances covered, eligibility criteria, timing and duration, and mechanisms to claim the rebates. The states offered a variety of economically significant rebates, on average 12%-15% of sales prices for refrigerators, dishwashers, and clothes washers. States also varied in the timing of the implementation of their rebate programs, with some beginning to advertise their programs in late 2009 and more than 80% of states launching their programs by April 2010.

The Simple Economics of Energy Efficiency Rebates

An important feature of minimum energy efficiency standards is that the regulation is set as a function of size and other attributes. Because larger appliances are allowed to consume more electricity, energy efficiency is a relative concept. The ES certification requirement is set relative to the minimum standard, thus it also varies with non-energy attributes. As a result offering rebates for ES-certified products does not ensure that an appliance that consumes less energy will be purchased. For instance, a large dishwasher with many special features may qualify as an ES product within its size and model category, and thus will qualify for a rebate, but it still may consume more energy overall than a smaller, simpler model without the ES label. In such cases, rebates become implicit subsidies for specific attributes other than energy efficiency.

This problem is exacerbated when consumers value both size and efficiency, and choose an appliance model that offers the optimal bundle of size and efficiency subject to their budget constraint. Offering a rebate for purchasing an ES product may then induce a small income effect, resulting in a consumer purchasing a more efficient, but larger appliance than they would without a rebate. .

Finally, another source of economic inefficiency associated with energy efficiency rebates is the well-known freerider problem. Program administrators cannot restrict access to a rebate program to consumers who would have still purchased an ES product in the absence of the program. This is important given pre-program ES market shares on the order of 50-75% across our major appliance categories.

Data

The design and implementation of this program facilitate our empirical analysis. Because the Federal government allocated funds to the states on a per capita basis, the "size" of this stimulus program at the state level is exogenous of the state's economic condition in 2009 and 2010. Second, the states had significant discretion in the design of their programs, in terms of start dates, eligible appliance categories, rebate amounts, and other characteristics. We have access to these detailed data of C4A participants, and we combine this rich source of variation with unique micro-data on individual appliance sales from a major, national retailer – including data such as purchase price, model number, and model-specific energy consumption - matched with demographic information. We use a difference-in-differences strategy that exploits the variation in program coverage and rebate amount across appliance categories, time, and states. The retailer data allows us to construct a counterfactual of appliance purchasing behavior by consumers in the absence of rebates, which we use to assess the effect of rebates on purchases and energy savings.

Energy Savings

Empirical Strategy

Our empirical strategy consists of looking at total sales and the energy consumption of the products purchased by each household, and estimating these outcome variables at different points in time. We model the decision to replace an energy-intensive durable as a two-step decision where consumers first decide when to replace and then what new model to purchase. Rebates impact consumer decisions in two ways. First, consumers who want to take advantage of a rebate program can do so by waiting for the start of the program or pulling forward their decision to replace their durable during the program window. Second, when the rebate program is active, consumers can substitute away from rebate-ineligible products and purchase rebate-eligible products. Rebates then lead to energy savings via two mechanisms. First, consumers who pull forward their purchases accelerate the replacement of older and less efficient appliances and decrease energy demand, and, conversely, consumers waiting for the start of a program contribute to an overall increase in energy demand by holding on to their old appliances longer. Second, consumers may substitute toward more energy-efficient products. The energy savings associated with the rebate program is the average energy consumption purchased over the entire time horizon for which rebates impacted consumers' decisions, minus the counterfactual quantity where rebates do not impact decisions.

Results

We estimated the regression models separately for the three appliance categories. Specifications that estimate the impact of rebates on sales use the log of the weekly sales in each state, and use all observed sales. To estimate the impact of rebates on electricity consumption purchased, we use the log of the annual electricity consumption purchased by each consumer as the dependent variable. We also include demographic variables when available. We distinguish among four distinct time periods of the rebate program – the pre-announcement period, the period between the announcement and the start of a rebate program (the pre-rebate period), the rebate period, and the post-rebate period – and allow for the impacts of the rebate programs to vary by time period

Focusing on sales, we observe that the rebate programs had a large impact mostly in the first three weeks of the program, and especially in the first week. We also found evidence that consumers waited a few weeks to replace their current appliance. For refrigerators, we observe a 14% increase in sales in the first week of the rebate programs, but this is partly offset by a statistically significant reduction of 5% in the week just prior to the start of the programs, and a statistically significant reduction of 4% two to three weeks prior. There were also reductions of about 4% in the four to six and seven to nine weeks prior. For clothes washers, sales decrease by 6% in the week prior to the start of the rebate programs, which offset as much as 45% of the increase in sales of the first week of the programs. For dishwashers, the reduction in the week prior is not statistically significant, but reductions in some prior weeks were significant, offsetting some of the 25% increase in sales increased in the first week of the rebate programs. Additional analysis shows that the share of consumers who pulled forward their purchase decisions into the rebate period is only about 1%-2% of total sales. Altogether, the estimates of rebates on sales suggest that the effects of the rebates were short-lived, and some consumers who took advantage of the rebates would have still replaced their appliances in the year that the rebates were offered.

To estimate the impact of rebates on electricity consumption purchased by individual households, we use the log of the annual electricity consumption purchased by each consumer as the dependent variable. For refrigerators, the rebates had very small effects on electricity consumption – reducing annual energy consumption by 1 kWh on average. Interestingly, rebates spurred a 25% increase in sales in the first week of the dishwasher programs, but a statistically insignificant 0.4% decline in electricity consumption. For clothes washers, there is a more substantial short-term effect that rapidly fades off. Electricity consumption purchased fell a statistically significant 5% in week one and a statistically significant 2% in weeks two and three. However, statistically significant increases in electricity consumption purchased in several of the weeks in each of the pre- and post-rebate periods illustrate the cumulative zero impact of rebates on clothes washers' electricity consumption.

Switchers, Freeriders, and Non-takers

A unique feature of our data is that we observe the number of rebate participants shopping at our retailer in a number of states. This allows us to quantify the take-up rate, and distinguish among different types of participants. We define as takers the consumers who claimed a rebate. They fall into two categories: (1) switchers -- the consumers who substituted away from a non-ES product, and purchased an ES product because of the existence of rebates; and (2) freeriders -- the consumers who purchased an ES product and claimed a rebate, but would have bought an ES product in the absence of the rebate program. Non-takers either purchased a non-ES product, or purchased a certified product, but did not claim a rebate. The share of consumers that bought non-ES appliances varies between 10% and 30% of the market. The fact that these consumers did not purchase an ES product even in the presence of the generous subsidies implies that financial incentives may not be the best way to change their behavior.

We find that the proportion of switchers tends to be small relative to the proportion of freeriders. If one focuses only on the estimates for the rebate period, the ratio of switchers to freeriders is 1:4, 2:5, and 13:3 for refrigerators, clothes washers, and dishwashers, respectively. Accounting for intertemporal substitution, however, results in significantly lower ratios of 1:10, 1:12, and 3:8. Thus, these estimates imply that among the program participants, 91% (refrigerators), 92% (clothes washers), and 73% (dishwashers) of the participants were freeriders.

Income Effect and Upgrading

We now investigate if rebates induced an income effect and led consumers to purchase higher quality appliances. Our outcome variables are various product attributes, such as appliance size, style, and other add-ons. Our hypothesis is that if consumers are prone to a small income effect, the characteristics of the ES product purchased should be affected by the rebate programs. Overall, we found mixed evidence that rebates led to an important income effect. We only find robust evidence that rebates led consumers to purchase higher quality models for dishwashers. For refrigerators, we observe the opposite effect, and no effect for clothes washers. On the other hand, our results clearly show the nature of the ES certification requirement also induced consumers to choose different appliance styles.

Cost-Effectiveness Analysis

Our empirical analysis allows us to estimate the cost-effectiveness of the C4A program by accounting for the impacts of intertemporal substitution, upgrading and income effects, and program freeriding. Table 1 presents our estimated measures of cost-effectiveness, i.e., dollars per kilowatt-hour of power saved. We present two sets of estimates. In the first, we assume that freeriders do not contribute to energy savings, and that the energy savings are the difference in the average electricity consumption between the eligible models and non-eligible models offered on the market, multiplied by a 15-year lifespan. In the second, we assume that the energy savings reflects accelerated replacement of about five years – based on evidence in a few states that rebate claimants replaced 10-year old refrigerators – so that the comparison is based on a time-weighted average of the difference between an ES-eligible model and a 10-year old refrigerator and the difference between ES eligible and non-eligible models. We find that the C4A did not perform well. At the average rebate amount offered for all three appliance categories, the dollar amount spent for each kWh saved is $1.46 for refrigerators, $0.44 for clothes washers, and $0.61 for dishwashers, when we do not account for accelerated replacement. These expenditures per kWh saved fall to $0.98, $0.26, and $0.25, respectively, under accelerated replacement. These estimates well exceed the cost found for other utility-funded programs, which is $0.06, on average. Even under substantially lower freeriding rates, these programs do not compare well with others evaluated in the literature. For example, *if* C4A programs could somehow target only the switchers and thereby reduce freeriding rates to 0%, only the clothes washers rebates would deliver energy savings with costs on par with other utility-funded programs.

Conclusion

In this policy brief, we investigate the incremental impact of the Cash for Appliances program. Our national estimators suggest energy savings of less than 1 kWh/year for refrigerators, and fairly precise statistical zero effects for clothes washers and dishwashers. The modest energy savings reflect several factors. First, consumers substituted over time to take advantage of the rebates: some consumers who took advantage of the rebates by purchasing energy-efficient appliances would have made a similar purchase a few weeks earlier if the rebates had not been offered. Second, the reliance on ES certification, which itself relies on attribute-based minimum standards, appeared to undermine the energy-saving objective of the rebate programs. The ES requirement and minimum efficiency standards define energy efficiency as a function of size, style, and other features, and thus rebates for ES products act as an implicit subsidy for some attributes. Moreover, we also find that the generous rebates induced a small income effect, and led consumers, at least some, to purchase larger appliances. Third, program administrators could not identify switchers from freeriders. By making all ES purchases eligible for a rebate within a given program, many consumers who already planned to buy an ES-rated appliance could claim the rebate without a change in behavior. We estimate freeriding rates of 73% to 92% across our three appliance categories. As a result, our measures of cost-effectiveness, ranging from $0.44 to $1.46 per kWh saved, are an order of magnitude greater than the $0.06 per kWh average cost-effectiveness estimated for utility-sponsored energy efficiency programs.

While our empirical analysis focused on the implementation of a 2009 Recovery Act program, it has implications for energy efficiency policies in an array of contexts. First, energy-efficient appliance rebate programs are a common element of state, local, and utility energy programs and an emerging element of U.S. climate change policy. The Northeast and Mid-Atlantic states that operate the Regional Greenhouse Gas Initiative, a utility-sector carbon dioxide cap-and-trade program, direct some of the revenues generated through the quarterly auctions of emission allowances to energy-efficient appliance rebate programs. The Environmental Protection Agency has also identified energy-efficient appliance rebate programs as one policy option in implementing power sector greenhouse gas emission performance standards. Second, the energy policy space is characterized by a mix of overlapping policy instruments. This analysis illustrates the potential for the presence of multiple pre-existing instruments to undermine the cost-effectiveness of a new (marginal) policy instrument. Instrument design that fails to account for this complicated policy space may risk higher costs and/or lower efficacy.

Table 1. Estimated Cost-Effectiveness of Cash for Appliances Program

	ES kWh/y	Non-ES kWh/y	Average Rebate	Estimated Proportion of Freeriders	Cost-Effectiveness ($/kWh saved) Proportion of Freeriders		
					Estimated	50%	0%
Without Accelerated Replacement							
Refrigerators	478	543	$128	91%	1.46	0.26	0.13
Clothes Washers	163	364	$107	92%	0.44	0.07	0.04
Dishwashers	279	313	$84	73%	0.61	0.33	0.16
With Accelerated Replacement							
Refrigerators	478	543	$128	91%	0.98	0.18	0.09
Clothes Washers	163	364	$107	92%	0.26	0.04	0.02
Dishwashers	279	313	$84	73%	0.25	0.14	0.07