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Strike while the rebate is hot: Savvy consumers and strategic technology adoption timing

D.C. Reeves[a,*], V. Rai[a,b]

[a] LBJ School of Public Affairs, The University of Texas at Austin, USA
[b] Department of Mechanical Engineering, The University of Texas at Austin, USA

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ABSTRACT

The California Solar Initiative (CSI) rebate program disbursed more than two billion dollars in incentives to install solar photovoltaics (PV) over roughly a decade while "stepping-down" rebate levels as installed capacity goals were reached. The exact dates (i.e., timing) of the stepdown events were not known, yet recent analyses find evidence of an "announcement effect" wherein consumer adoption is "pulled-forward" across these step-down events. We analyze unique data from our recent household-level survey on the decision-making process for 194 of these very consumers within a narrow window of eight CSI rebate stepdown events, comparing the decision-making processes of pulled-forward consumers to their counterparts that adopt just after a rebate stepdown.

We find evidence that a subset of pre-stepdown adopters engage in more "savvy" decision-making behaviors from their post-stepdown counterparts, including strategic adoption timing. Given these behavioral differences, we conclude that future analyses should carefully consider aspects of individual decision-making processes as potential confounders and control for them if possible. Experience is identified as a potential pathway through which this non-negligible subset of adopters may gain the ability to execute savvy decision-making behaviors; future research should assess the degree to which policy implementation can explicitly leverage this pathway.

1. Introduction

An important question that has received much attention in the literature is about the *pass-through rate* (Delipalla and O'Donnell, 2001; Sijm et al., 2012; Stern, 1987; Weyl and Fabinger, 2013): what portion of government subsidies make their way to the intended beneficiaries? Over the past decade, owing primarily to concerns about both local and global negative environmental externalities and positive knowledge externalities (Chu and Majumdar, 2012; Jaffe et al., 2005), governments at all levels in several countries have ramped up support for clean energy technologies. The research community has recently turned its attention to the pass-through rates of these subsidy schemes (Pless and van Benthem, 2017; Dong et al., 2016). Some recent empirical work has begun to address this gap in the solar photovoltaic (PV) industry, in particular in the California solar market – one of the largest solar markets globally. The California Solar Initiative (CSI) rebate program disbursed just more than two billion dollars in incentives to install solar photovoltaics (PV) over roughly a decade (2007–2016). Across California, several program administration areas (often corresponding to utility service areas) issued rebates that decreased stepwise over time as area-wide capacity goals were reached. This policy design provides a quasi-experiment to study the linkage between rebates and prices, and hence pass-through rates, around each rebate step using regression discontinuity (RD) with time as the forcing variable. Such analyses further require that the cutoff date for each stepdown is exogenous and a window near to the cutoff partitions consumers (solar adopters) into pre- and post-stepdown groups as-if-randomly so that installed prices are not prone to selection bias.

Recent research suggests that in order to avail themselves of higher rebates, some solar PV adopters are strategically timing their adoption just before a rebate stepdown event (Pless and van Benthem, 2017; Gillingham and Tsvetanov, 2016; Hughes and Podolefsky, 2015)[1]; possibly as precisely as one week before the stepdown (Dong et al., 2016). Such behavior potentially confounds causal estimation of key market-level measures such as the pass-through rate. Furthermore, in the context of a technology diffusion characterized by both informational and economic barriers to adoption, such as residential solar PV (Rai and Robinson, 2013; Rai et al., 2016), adopters must balance two competing drives: installing earlier to benefit from higher rebate levels against installing later to benefit from the reduced uncertainty

* Corresponding author.
E-mail address: d.cale.reeves@utexas.edu (D.C. Reeves).

[1] A similar phenomenon has been observed in advance of decreases in German feed-in tarrifs (Leepa and Unfried, 2013).

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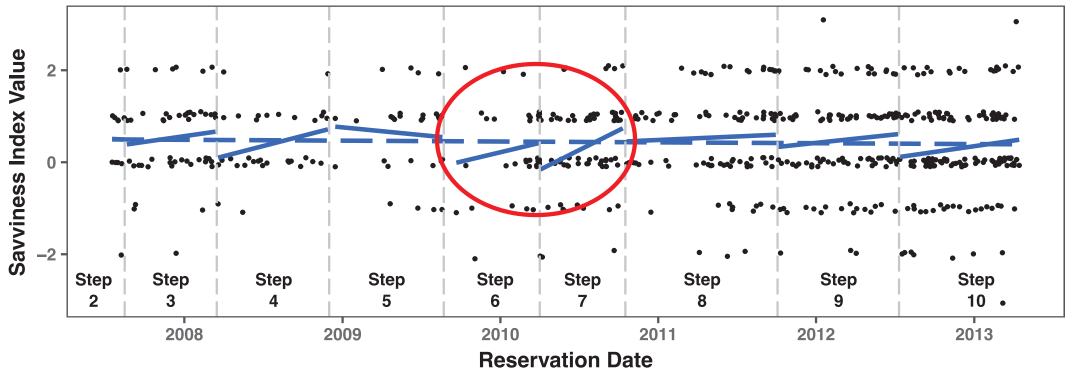

Fig. 1. Savviness index over time. "Savviness," an index comprised of specific behavioral actions (described in Section 3.2.2), varies across solar PV adopters (black dots). Interestingly, savviness is relatively stable over time (the dashed line), but rises and falls in shorter time-frames, especially around rebate stepdowns. For example, notice in the region highlighted by the circle, *within* rebate step six, savviness (the solid line) is increasing, but *across* the stepdown from step six to step seven savviness drops before increasing again *within* step seven.

associated with a longer information search, more information available about the technology in the market, and also potentially lower technology costs (Gürtler and Sieg, 2010). Yet little is known about the subgroup of adopters that strategically time their adoption, particularly with respect to *how* they choose to time their adoption. Put another way, given that a subset of adopters are able to strategically time their adoption, what *else* do those adopters do that sets them apart from the rest of adopters? Understanding how adopters strategically time their adoption would both allow researchers to control for confounding in estimates of policy impact and generate insights that can inform future policies for supporting the diffusion of environmentally friendly technologies by identifying aspects of consumers that can be leveraged to design policy and implement programs more effectively.

We address this gap by leveraging unique behavioral data on solar PV adopters in California to answer three questions: 1) apart from adoption timing, do pre-stepdown adopters differ in their decision-making process from post-stepdown adopters, 2) are these differences in the decision-making process associated with manipulation of the forcing variable (time of adoption) by adopters, and 3) at what time threshold can we detect evidence of strategic adoption timing in this dataset? By analyzing the individual-level decision-making process that drives adoption timing, we find that "savvy" behaviors co-occur with choosing to adopt just before a rebate stepdown as illustrated in Fig. 1. Consumer savviness is discussed as an example of a policy lever that could be used to reduce informational barriers to adoption broadly and to reduce soft costs associated with installing solar PV specifically.

This paper aims to contribute both to the growing literature on solar PV adoption decision-making (De Groote et al., 2016; Rai et al., 2016; Gillingham and Tsvetanov, 2016; Balta-Ozkan et al., 2015; Rai and Sigrin, 2013; Rai and Robinson, 2013; Rai and McAndrews, 2012; Jager, 2006; Faiers and Neame, 2006) and to an emerging literature for estimating solar PV rebate pass-through (Pless and van Benthem, 2017; Dong et al., 2016, 2014; Fabra and Reguant, 2015; Hughes and Podolefsky, 2015). Analyses of the performance of policies designed to accelerate technology adoption, such as rebate pass-through estimates, together with analyses of individual-level behavioral drivers of adoption, such as this work, combine to create a cohesive understanding how consumer decision-making is embedded in a policy context. From that perspective, this paper also highlights the linkage between changes in policy context that spur changes in decision-making outcomes, which in turn can impact policy outcomes. Overall, by developing insights based on a novel combination of data sources we highlight an important caveat – that estimates of adoption subsidy policy outcomes, such as rebate pass-through, that are agnostic to heterogeneous decision-making processes on the part of adopters may overlook critical confounding variables.

2. Background

The CSI residential solar PV rebate program was implemented such that higher rebates were issued earlier in the program, transitioning to lower rebates later in the program. Discrete transitions from higher rebates to lower rebates – referred to as "stepdown events" or simply "stepdowns" – were triggered by the attainment of installed capacity goals within an administrative area. The left panel of Fig. 2 shows the changes in rebate levels over time in the area analyzed decreasing from \$2.5/Watt to \$0.2/Watt. Notice, for example, that an adopter who installed in late-2009 through early-2010 (step six) obtains a rebate of \$1.10/W, while an adopter who installed just slightly too late to take advantage of the step six rebate level obtains only the step seven rebate of \$0.65/W. Since the exact dates of rebate stepdown events were not pre-specified, but instead were triggered by the attainment of pre-specified installed capacity goals, only potential adopters that are particularly attentive (on their own or due to information from installers) to the installed capacity in their administrative area could strategically time their adoption so as to take advantage of higher rebate levels, while still gathering sufficient information to make the decision to adopt.

The tendency for individuals to strategically time their consumption decisions in order to take advantage of subsidy policies – particularly just before the subsidies expire or are reduced – is recognized in the literature. This phenomenon is known by several names including "bunching," the "announcement effect," and the "pull-forward" effect (Gürtler and Sieg, 2010; Saez, 2010). The right panel in Fig. 2 shows this effect at the population level in the area analyzed; notice that reservation requests per day increase just before a stepdown event. Because the CSI program provides more beneficial rebate levels on the earlier side of each threshold, it is intuitive to think of consumers that strategically time their adoption as being "pulled forward" in time towards the more beneficial rebate level. Thus we will use the term pull-forward throughout to refer to this phenomenon.

Recent analyses of rebate pass-through rates[2] find evidence that consumers *are* being pulled forward, but that system prices in the aggregate are relatively stable before and after the discontinuity (Pless and van Benthem, 2017; Hughes and Podolefsky, 2015; Dong et al., 2016). Even without lower prices, the rebate itself is an incentive for pull-forward – particularly when there is high pass-through. In a market characterized by informational barriers (such as residential solar PV), consumers have an incentive to postpone adoption while searching for information to reduce residual uncertainties (Rai et al., 2016; Rai and

[2] For a good that is subject to a purchase subsidy, or rebate, pass-through is the portion of a rebate that is incident on the consumer, as opposed to incident on the supplier.