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The comparative effectiveness of residential solar incentives

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ABSTRACT

We use temporal and spatial variation to evaluate the effectiveness of nearly all (over 400) state and utility incentives that promote the installation of residential solar photovoltaic (PV) panels. Using a unique data set that values a wide array of solar incentives including cash incentives, tax credits, and solar renewable energy credits, we evaluate and compare the impact of incentives using a standardized net present value of each incentive. We pair these data the amount of new residential solar installations within each state and year to examine the relationship between incentive type and new residential PV installations. We find that each additional dollar of incentives has led to on average, an additional 500 W of additional installed capacity per thousand residential electric customers. This effect is enabled by the presence of net metering and financing availability. Direct cash incentives, when coupled with financing initiatives and net metering, drive much of the impact on installations. Results are consistent with research that shows that incentive salience may drive variation in effectiveness. Results suggest that approximately 67% of state and utility incentives, up to $1.9 billion over 11 years, were likely spent on incentives that did not increase residential solar PV installations.

1. Introduction

Concerns about local and global environmental damages from fossil fuel combustion for electricity generation have led governments to incentivize renewable electricity generation. A number of reasons might motivate policymakers to incentivize renewable energy production including the desire to drive down costs of new technologies through market transformation; concerns about pollution from fossil fuel based electricity production; and the price volatility of fossil fuels, among others. In addition, policy makers may simply seek to signal constituents that they have strong environmental values. As a result of these policy efforts, a significant amount of incentives has been directed at the installation of small-scale, distributed generation such as rooftop solar photovoltaic (PV) panels. Due to the varied types of incentives and the ability of multiple tiers of governments and electricity companies that offer incentives for new PV installations, little peer reviewed empirical work has comprehensively examined the comparative effectiveness of these incentives.[1] If some types of incentives are more likely to stimulate investment in distributed generation than others, governments can design policies to take advantage of these policy characteristics. Moreover, other incentives may be scaled back or eliminated if they are being paid to investments that would have been made without incentives.

Local and state governments and electric power companies provide a wide array of incentives for households and business to install new residential rooftop solar photovoltaic panels in addition to federal programs such as the Solar Investment Tax Credit. Among the state and local incentives are Renewable Portfolio Standards (RPSs), tax credits, property tax easements, and direct cash incentives. In this paper, we use a net present value calculation to standardize the value of nearly all state and local solar incentives offered in the United States from 2002 to 2012. We also measure several policy indicators that might serve as enablers: net metering and government subsidized financing availability may facilitate other incentives. We combine these incentives data with state-level data on residential PV installations to estimate the response of homeowners to different types and magnitudes of solar incentives.[2]

Installing solar panels require households to make a large up-front investment with variable and uncertain returns, potentially dependent on the design of particular solar incentives. RPSs, for example, award Renewable Energy Credits (RECs) to producers of solar electricity that can be sold for an uncertain future value, dependent upon the demand for RECs and the performance of the PV panels. In contrast, other policies such as cash rebates provide fixed financial incentives for

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[1] There are a number government reports and other grey literature that attempts to understand the relationship between the effectiveness of incentives and their design (e.g. Barbose et al., 2006; Bird et al., 2012; Bolinger and Wiser, 2003, 2004; Couture and Cory, 2009; Hoff, 2006; Lantz and Doris, 2009).

[2] Our empirical strategy does not allow us to identify the effect of any federal incentives for solar generators.

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households to install PV panels. These programs may provide a payment that is tied to the capacity of PV panels (rather than the performance) and provide certainty about the net costs of the PV installations by providing cash transfers, tax credits, or low interest loans. In many jurisdictions, households qualify for a mix of fixed financial incentives and performance incentives.

In addition to direct financial incentives, we observe the presence of net metering policies and government sponsored solar financing programs that we expect to facilitate solar PV uptake. Net metering programs allow residential customers to offset the cost of retail electricity price. It is possible that without net metering or capital financing availability, consumers are unable to take advantage of much of the value of solar (Kollins et al., 2010). Stated sponsored solar financing programs, including provisions to allow for or back solar loans, third party ownership models, or power purchase agreements from residential homeowners, and make capital more accessible to potential solar installers (Coughlin and Cory, 2009). Because solar panels are both costly and there was not much market experience with them, private banks were unlikely to provide loans at competitive interest rates. State sponsored financing programs may have provided for a more conducive environment for solar (Mendelsohn and Kreycik, 2012).

The complexities of diverse solar incentives at the utility and state-levels, and limited data on residential solar installations provide barriers to rigorous quantitative analysis of the impacts of incentives for PV installations. Research to date has focused on several highly visible policies, such as RPSs (Carley and Miller, 2012; Delmas and Montes-Sancho, 2011; Johnson, 2014; Yin and Powers, 2010) or California's Solar Initiative (Hughes and Podolefsky, 2015; Van Benthem et al., 2008), rather than on the diverse array of incentives available to households. Policies such as RPS typically target all renewable energy rather than just PV. Typically, RPS have the largest effects on low cost renewable generators such as wind. Thus, most research on the impact of regulatory incentives on renewable energy has been driven by large-scale wind farms, rather than distributed solar PV.[3] While a number of studies have employed dichotomous metrics to understand policy drivers of solar PV installation, we go beyond dichotomous metrics and quantify the wide range of geographically and temporally variant residential solar incentives and their impacts.

We find that while states use a variety of different mechanisms to incentivize investments in residential solar PV including cash rebates, property tax credits, sales tax rebates, income tax credits, and renewable portfolio standards, only cash rebates appear to be effective and they appear to only be effective when implemented in states with net metering or financing availability. The effectiveness of cash rebates appears to be enhanced when households have access to financing mechanisms. Importantly, approximately two-thirds of the value of available incentives to households has been directed at programs that do not appear to be effective. This research has implications for the effective design of incentives aimed at shaping household behavior.

2. Theory and literature review

2.1. Understanding the effects of renewable incentives

This study offers improvements to the study of individual programs by translating all regulatory incentives to a standardized dollar per watt incentive, allowing the aggregation of incentives and comparison of the effectiveness across incentives. This study offers improvements to existing research (Sarzynski et al., 2012; Shrimali and Jenner, 2013; Shrimali and Kniefel, 2011) that employ a dichotomous metric of policy type over a limited number of programs and states. Uniquely, our research translates RPS requirements for solar generation to time-variant subsidies based on market values of solar renewable energy credits (SREC) from REC exchanges and proprietary market data. To the best of our knowledge, this study offers the most complete view of incentives for residential solar PV provided by governments and utilities.

2.2. Comparative impacts and salience of market incentives

A growing body of research that suggests that the mechanism though which incentives are paid may generate different consumer responsiveness (Gallagher and Muehlegger, 2011; Sarzynski et al., 2012; Shrimali and Jenner, 2013; Zindler and Tringas, 2009). Further, research in the solar PV market suggests that households face limited information sets and do not possess good information about the incentives available to them (Rai and Beck, 2015). This research parallels recent developments seeking to understand the role of tax salience on consumer behavior (Chetty, 2009; Li et al., 2014; Schenk, 2011). Li et al. (2014) demonstrate that consumers respond more strongly to changes in a gasoline tax when that tax is included in the total price, due to the strong salience of tax debates or the perceived permanence of tax rate changes, relative to gasoline commodity prices. Similarly research on sales taxes (Chetty, Looney, and Kroft, 2009) shows that because sales taxes on products may not be visible, consumer behavior will be more impacted when prices are included in the label, rather than calculated at the register.

With increasing evidence that people respond differently to varied price structures, the design of taxes and incentives may impact the amount of PV capacity. While in some circumstances it may be justifiable to make taxes less salient to reduce distortions to consumer behavior, in some circumstances the entire purpose of incentives is to impact behavior, and the effectiveness of public policy can be maximized by increasing the salience of a policy. Because policy makers have broad discretion in the manner in which they design a tax or incentive, if consumers perceive uncertainty in long-term benefits and risks of an incentive, they may not respond as strongly as policymakers intend.[4]

To our knowledge, no research has attempted to standardize incentives for renewable energy in such a way that the total value of incentives can be quantified and the tradeoffs of impacts of different incentive structures can be compared. Sarzynski et al. (2012) and Shrimali and Jenner (2013) provide an early examination of the impacts of a range of policies on solar PV installation using dichotomous policy adoption metrics of 27 programs across 16 states. While they find that cash incentives seemed to be more effective than tax incentives, the dichotomous metrics used do not capture the financial value or changing temporal characteristics of the incentives. Mormann (2014) hypothesizes that tax credits may be an inefficient way to finance solar PV due to large capital costs, and suggests that policy tools that address the upfront capital costs will be more impactful. Gallagher and Muehlegger (2011), provide the closest comparison by examining the comparative effects of incentives for hybrid vehicles, finding that sales tax incentives vastly outperform tax credits to promote the adoption of hybrid vehicles, after controlling for the value of the incentives. This research contributes to this burgeoning literature that empirically and experimentally assesses the salience of taxes and subsidies on consumer behavior.

[3] Some states' RPS have a specific, small "carve-out" that can only be met with solar PV installations to specifically encourage PV deployment. These carve-outs are the portions of the RPSs that we consider relevant to our current study and ignore all RPSs or portions thereof which can be met with non-PV resources.

[4] Policy makers also face political constraints on their actions due to potentially competing interest groups and conflicting priorities. Thus, it may be optimal from the individual policy maker's perspective to minimize the political cost and political salience of enacting a policy on preferred subject even at the cost of some of the efficacy of the policy. We acknowledge that we cannot measure, directly, the salience of an incentive. But we rely on past research that suggests that direct cash transfers are more salient than tax credits or other complex ways of providing subsidies.