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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.

## 3. Methods and data

### 3.1. Understanding solar PV installations

Spatially disaggregated data on residential PV installations in the United States is difficult to obtain. We use data on the amount of new residential PV installations in each state, beginning in 2002, from the Interstate Renewable Energy Council (IREC). IREC is a trade association that promotes the adoption of renewable energy technologies, particularly solar PV, and works toward regulatory reform for distributed generation. IREC's PV installation data is more complete than the National Renewable Energy Lab's Open PV project or other national lab produced estimates and closely matches the Energy Information Administration's estimates. We proceed by using PV installation data from IREC and treat this as an unbiased estimate of the true amount of PV installations in the US.

### 3.2. Solar incentives and their value

The Database for State Incentives for Renewable Energy (DSIRE) provides a description of solar and renewable incentives, as well as links to authoring legislation and changes that have occurred in the legislation over time. Because DSIRE did not always keep track of historical (expired) incentives, we conducted structured Google searches and called state energy offices to supplement the dataset. When information regarding the history of a policy was incomplete, or when insufficient information to value a policy was included in the authoring legislation or DSIRE summary of the policies, state energy agency, municipality, or utility officials were contacted to gather the appropriate information. In addition, state energy agencies were contacted to get information about program budgets and expenditures, to get an improved understanding of the average payment of programs and ensure that programs with authoring legislation were, in fact, paying incentives.

This rich data set provides information on incentives that has not only geographic variation – in the sense that the incentive is limited to a geographic target (state or utility service area) but also temporal variation. Spatial and temporal variation in the presence of incentives and their values allows us to identify the impact of changes in incentive values on installation patterns. There are seven primary types of incentives that we focus on in our analysis. These include direct cash incentives (including feed in tariffs), property tax incentives, sales tax incentives, tax credits, renewable portfolio standards (RPS), financing programs, and net metering policies.[5] While we control for the availability of these programs at the state-level, we are only able to value direct cash incentives, sales tax incentives, tax credits, RPS programs, net metering programs,[6] and certain types of property tax incentives since the other types of incentives do not have a clear monetary value.

To standardize the wide range of solar incentives, a number of assumptions were made about how these incentives were to be valued. The annual average installed cost of residential solar system were taken from the SunShot initiative (Barbose et al., 2013) via the U.S. Department of Energy. To qualify as a residential incentive, incentives must have been aimed at system sizes less than 10 kW (kW).

Since some incentives are paid as a lump sum while other incentives are paid out over a period of time based on system performance, we make a few simplifying assumptions. We translate all incentives into an incentive per watt ($/W), which requires for some programs, knowledge of the size of the residential systems. We assume that all residential PV systems are five kilowatts direct current, the median system size reported by Lawrence Berkeley National Lab in 2011 (Barbose et al., 2013). Because solar density is geographically variant, we use the average daily number of solar radiation hours within each state (National Renewable Energy Laboratory, 1961) to assign an expected amount of output to each installation. While the amount of solar radiation hours varies within each state, given the limitation that installation data is only available at the state level, this is the best we can do. Finally, when an incentive is paid over a period of time, we compute the net present value of the incentive using a 5% discount rate.[7]

Below, we describe each of these five types of solar incentives that were translated into a financial value over the 2002–2012 time period.

*Direct cash incentives* include rebates, buy downs, grants, and performance-based incentives. These incentives vary in value and structure, but most award a fixed $/W or fixed $/kWh.

*Property tax incentives* include exemptions, abatements, tax credits, or other special assessments. There are three typical structures, 1) solar system installation will not add to your taxable property value for a set amount of years or until the property is sold 2) a percentage reduction in property tax, or 3) a $/W or $/kWh type of incentive. We were unable to value incentives that provided property tax easements, and because installed costs have unclear implications for property tax bills, these incentives likely offset costs associated with systems that are not calculated. Property tax incentives that provide a $/W or $/kWh were handled similarly to direct cash incentives.

*Sales tax incentives* typically allow for the exemption or refund from local or state sales tax when purchasing and installing solar systems. These incentives were valued based on the total cost of solar panel systems in each year multiplied by the tax abatement rate.

*Tax credits* offer a reduced tax payment. Typically, the local or state governments give tax credits to the owner of a solar system. Many of the incentives are based on a $/W or $/kWh incentive. These have been handled similar to direct cash incentives. In some cases, local laws have excluded third party ownership (e.g. SolarCity) from tax possible tax credits.

*Renewable portfolio standards* provide requirements for renewable electricity generation by state. Certain RPS programs have solar "carve-outs", or a subset of requirements that require the installation of solar generation in each state. Because RPS requirements are typically met with tradable Renewable Energy Credits (RECs), we use the average annual value of RECs in the market to estimate the value provided by RECs to potential PV system owner. These data were purchased from Marex Spectron.

We consider the presence of two other types of government programs that aim to increase distributed PV capacity. First, a number of states and localities have financing programs to help households purchase a PV system. Over our sample period, an average system cost decreases from $54,000 in 2002 to $26,000 in 2012. Because this is a large capital expense, some governments have set up a network of banks and credit unions that can offer streamlined financing options or discounted interest rates subsidized by a government agency. State treasuries may also guarantee these loans. These programs also enable power purchase agreements, solar leasing and third party ownership, and other innovative financing models.

The second policy we examine is net metering statutes that allow electricity consumers to pay for the net amount of electricity they use each month. This policy is equivalent to selling electricity generated from the solar panel back to the local electricity retailer at the retail price. Thus, our metric of average electricity price likely captures the

[5] Some states or localities also provide incentives to recruit, support, or encourage expansion of clean energy businesses as well as provide temporary discount on permitting costs to install PV systems. Since these are primarily directed toward PV installers and not households, we do not include these in our analysis.

[6] As discussed later, net metering price is not separately identifiable from electricity price. Net metering benefits users because they can off-set electricity expenditures at the retail price of electricity.

[7] Alternative rate assumptions are explored in the Appendix, though our results are robust to a range of plausible discount rates.

value of the metering program. While our empirical specifications include information on the electricity price which is the vast majority of the financial value of net metering policies, it is possible that some customers actually receive payments from their electricity provider if they generate more electricity than they consume in a given year. We are unable to include this, likely small, portion of the value of net metering policies.

To calculate a total state-level incentive, by year, we aggregate all state-level incentives and weight each utility-level incentive by the number residential customers that utility has in each state it operates.[8] Because some utilities cross state lines, we utilize customer data from the EIA to weight utility-level incentives and calculate an average utility incentive for each customer, for each state.

Fig. 1 and Table 1 aggregates average (non-zero) incentives by year across states to demonstrate the changing incentive environment across the US. These data combine state-level and utility-level incentives and are divided by incentive type.[9] Direct Cash incentives begin near $1.74/Watt in 2000, rise to $2.58 in 2003, then dip to $0.99/Watt in 2009, and then dip to $0.89 in 2012. In contrast, Sales Tax rebates vary between $0.41 and $0.60; Tax Credits vary between $0.79 and $1.66, and the value of tradable SRECs is $3.61 in 2006, drops to $1.62 in 2010, and increases to $2.29 in 2011. The overall total value of state and utility solar incentives is $1.24 per Watt in 2000 and fluctuates throughout the time frame, rising to $2.36 in 2003, and drops back to $1.63 in 2012. These data highlight the volatile nature of incentives for solar customers and that this volatility can come from changes in the amounts and types of incentives offered or from fluctuations in the market value of SRECs.

There is significant variation in the types of incentives offered. Descriptive statistics (see Table 2) demonstrate a mean total incentive amount of $0.91 per watt (including state-years with no incentives) on a total installed purchase price of $8.05 per watt. However, the price was as low as $5.30 by 2012, and total incentives were as high as $8.63 per watt during the 2002–2012 time period. Of the $0.91 average total incentive, $0.52, on average was a cash incentive, $0.03 was a property tax incentive, $0.06 is a sales tax incentive, $0.16 is a tax credit, and $0.09 was derived from solar renewable energy credits (SRECs). In addition, 31% of observations have financing policies and 73% have net metering policies, which we expect may enable the operation of many of these other incentives.

While our data is the most complete data to our knowledge regarding incentives for residential PV installation across the entire United States, there are a number of important caveats. First, since the data were collected by looking backwards in time, the most recent years of data are likely to be more accurate and complete than earlier years since some incentives that have expired are difficult to observe. Second, our source for the incentives, the DSIRE database has become more complete over time and now more accurately keeps track of expired incentives.

### 3.3. Understanding the relationship between solar incentives and residential installations

We estimate how the amount of financial support provided by utilities and state and local governments affect the amount of new residential photovoltaic installations. In addition to the amount of financial support, we also examine how policies that may enable the installation of rooftop PV and characteristics of the electricity market

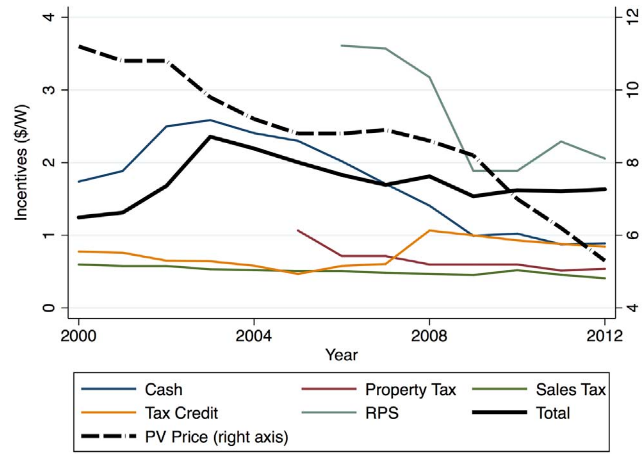


**Fig. 1.** Average Value of Non-zero Incentive by Type and Year ($/Watt).

and residential consumers may affect new residential PV installations. A fixed effects model accounts for time-invariant characteristics across states as well as flexibly controls for state-invariant changes over time. Our primary estimating equation is:

$$(PVAdditions)_{it} = \alpha_0 + \beta(PVIncentiveValue)_{it} + \varphi Policy_{it} + \theta X_{it} + \mu_i + \gamma_t + \epsilon_{it} \quad (1)$$

where *(PV Additions)*$_{it}$ is the kilowatts of residential PV installations per 1000 customers, the *PV Incentive Value* variable is the calculated value of all PV incentives in state *i* in year *t* described above, *Policy* is a vector of indicator variables if state *i* has a particular type of policy in year *t*, *X* contains other covariates that are likely correlated with the equilibrium outcome quantity including if the state has a net metering policy, residential electricity price, median income in the state, gross state product per capita, and citizen liberalism (Berryet al, 1998). $\mu_i$ is a set of state fixed effects that controls for time invariant state characteristics that are unobservable or not included in the regression including things such as the solar insolation within a state,[10] state political culture, and environmental preferences of households within a state. $\gamma_t$ is a set of year fixed effects that control for changing federal incentives over time, decreases in solar technology costs, and secular technological change.

For a second specification, we interact the value of the incentives with the availability of distributed enabling policies: nete metering and financing programs in the state (described above). The estimating equation becomes:

$$\begin{aligned}(PVAdditions)_{it} = {} & \alpha_0 + \beta(PVIncentiveValue)_{it} + \varphi Policy_{it} \\ & + \lambda[(PVIncentiveValue)*(PVEnablingPrograms)]_{it} + \theta X_{it} \\ & + \mu_i + \gamma_t + \epsilon_{it} \end{aligned} \quad (2)$$

Our third set of regressions examine if particular types of policies (direct cash incentives, tax credits, etc.) differentially increase the amount of new PV installations in a state. Standard decision theory suggests that consumers are concerned with the total value of incentives, and that the incentive structures should not matter. However, research on tax salience, discussed above, suggests that incentives that are more salient to the consumer will have more impact. We also include specifications that interacts the different incentives with an indicator variable for the same PV enabling programs. This

[8] If a utility serves customers in multiple states, we consider only the customers within the appropriate state when weighting the incentives within a state.

[9] Mormann (2012) distinguishes between inter-policy and intra-policy volatility. Inter-policy volatility is defined as the variance of policies in longevity and stability, while intra-policy volatility is defined as changes in the values of policies over time. We primarily investigate intra-policy volatility. To the extent that policies enter and exit the dataset, we also allow for inter-policy volatility, though this appears much less prevalent.

[10] It is worth noting that the state fixed effects may not completely control for variations in solar insolation. If incentives in the sunnier portions of states are production based and therefore sensitive to our estimates of solar insolation and incentives in less sunny portions of states are not production based, our estimates will be biased due to this variation. We find this story to be unlikely and we have run a similar set of regressions using only state level incentives, which circumvents this problem, and find similar results to what we present here.

**Table 1**
Average value of incentive by type and year ($/Watt)[a].

| Year | Direct cash | Property tax | Sales tax | Tax credit | SRECs | Total | PV price |
|---|---|---|---|---|---|---|---|
| **2000** | $1.74 | | $0.60 | $0.78 | | $1.24 | $11.20 |
| **2001** | 1.88 | | 0.58 | 0.76 | | 1.31 | 10.80 |
| **2002** | 2.50 | | 0.58 | 0.65 | | 1.68 | 10.80 |
| **2003** | 2.58 | | 0.53 | 0.64 | | 2.36 | 9.80 |
| **2004** | 2.41 | | 0.52 | 0.58 | | 2.19 | 9.20 |
| **2005** | 2.30 | $1.07 | 0.51 | 0.47 | | 2.00 | 8.80 |
| **2006** | 2.02 | 0.71 | 0.51 | 0.58 | $3.61 | 1.83 | 8.80 |
| **2007** | 1.71 | 0.71 | 0.48 | 0.60 | 3.57 | 1.69 | 8.90 |
| **2008** | 1.41 | 0.60 | 0.47 | 1.07 | 3.18 | 1.81 | 8.60 |
| **2009** | 0.99 | 0.60 | 0.45 | 1.00 | 1.89 | 1.54 | 8.20 |
| **2010** | 1.02 | 0.60 | 0.52 | 0.93 | 1.89 | 1.62 | 7.00 |
| **2011** | 0.87 | 0.51 | 0.46 | 0.88 | 2.29 | 1.60 | 6.20 |
| **2012** | 0.89 | 0.54 | 0.41 | 0.84 | 2.06 | 1.63 | 5.30 |

[a] Average of non-zero incentives.

**Table 2**
Descriptive Statistics of State and Utility Solar PV Incentives, Residential Sector.

| | Mean | SD | Min | Max | N |
|---|---|---|---|---|---|
| Residential PV capacity additions (kW AC) per 1000 customers | 0.94 | 6.46 | 0 | 139.57 | 561 |
| Total price per watt of PV ($/W) | 8.33 | 1.52 | 5.3 | 10.8 | 561 |
| Number of residential customers (000's) | 2465 | 2516 | 210 | 13,140 | 561 |
| Total incentive amount ($/W) | 0.91 | 1.55 | 0 | 8.63 | 561 |
| Total cash incentive amount ($/W) | 0.52 | 1.07 | 0 | 6.09 | 561 |
| Total property tax incentive amount ($/W) | 0.03 | 0.16 | 0 | 1.2 | 561 |
| Total sales tax incentive amount ($/W) | 0.06 | 0.17 | 0 | 1.28 | 561 |
| Total tax credit incentive amount ($/W) | 0.16 | 0.5 | 0 | 4.15 | 561 |
| Total RPS incentive amount ($/W) | 0.13 | 0.65 | 0 | 7.14 | 561 |
| Fraction observations with cash incentive | 0.62 | 0.49 | 0 | 1 | 561 |
| Fraction observations with RPS incentive | 0.09 | 0.29 | 0 | 1 | 561 |
| Fraction observations with property tax incentive | 0.35 | 0.48 | 0 | 1 | 561 |
| Fraction observations with sales tax incentive | 0.16 | 0.37 | 0 | 1 | 561 |
| Fraction observations with tax credit incentive | 0.24 | 0.43 | 0 | 1 | 561 |
| Fraction observations with financing incentive | 0.31 | 0.46 | 0 | 1 | 561 |
| Fraction observations with net metering | 0.73 | 0.44 | 0 | 1 | 561 |
| Residential electricity price (c/kWh) | 10.58 | 3.67 | 5.66 | 37.36 | 561 |
| Median Income (2012 Dollars, 000's) | 53.78 | 8.16 | 36.64 | 77.51 | 561 |
| Citizen liberalism index | 52.42 | 15.74 | 8.45 | 95.97 | 550 |
| Per capita gross state product (thousands of dollars) | 48.35 | 18.42 | 29.15 | 173.31 | 561 |

leads to the following equation:

$$(PVAdditions)_{it} = \alpha_0 + \sum_{j=1}^{5} \beta_j (PVIncentiveValue)_{it} + \varphi Policy_{it} + \sum_{j=1}^{5} \lambda_j [(PVIncentiveValue)*(PVEnablingPrograms)]_{it} + \theta X_{it} + \mu_i + \gamma_t + \epsilon_{it} \quad (3)$$

where $X$ is the same set of controls, $\mu_i$ is a set of state fixed effects and $\gamma_t$ is a set of year fixed effects.

While we believe this to be the most rigorous and comprehensive studies of its kind to date, below we enumerate a number of potential weaknesses and limitations of our study. We assume that states adopt policies, conditional on observable and unobservable state-level characteristics that are included in the model (residential electricity price, median income in the state, gross state product per capita, and citizen liberalism, state fixed effects, time fixed effects, and the presence of other renewable energy policies). One potential concern is that states and utilities choose the types and levels of incentives that are most effective for their populations, or conditional upon existing solar installations. This concern is most acute for REC prices, which may drop when installations increase, but increase when there are few installations.

While our fixed effects model controls for temporal changes that are common across all states (e.g. all federal policies and technological change) and static heterogeneity across states (e.g. state political culture), it does not control for factors that change heterogeneously within states over time that are not included in the model. We include personal and state-level economic trends, changes in state political ideology, and changes in electricity rates that vary across states. A variety of robustness checks, such as excluding California (which has a unique policy environment for solar PV), including changes in state environmental preferences over time, or interacting electricity price with net metering did not produce statistically significantly different results. Altering discount rate assumptions, available in Appendices A and B, also did not statistically significantly change results. We are not able to fully control for changes in peer effects that vary across states, changes in tiered electricity pricing structures in some areas, changes in administrative costs associated with different incentives, or changes in soft costs that vary across states. Research that illuminates these factors would be prime candidates for future research. Because we only measure the impact of incentives on residential PV installations, it is possible that policies impacting commercial or utility scale installations produce different impacts.

Existing research (Lyon and Yin, 2007; Matisoff, 2008; Matisoff and Edwards, 2014) suggests that the adoption of renewable energy policies at the state level is largely driven by political factors, which are included in the model, reducing the concern for state-level selection bias. Nevertheless, this selection bias would make our point estimates an upper bound on the effectiveness of PV incentives. Another potential source of bias is that we use national average prices for PV and many incentives are tied to the purchase price of PV panels. If states that have lower installed system costs have more generous incentives, for instance due to learning-by-doing, our point estimates will be biased upward. Alternatively, if states with high installed system costs have more generous incentives our estimates will be biased downward. Some programs may have limited budgets and do not fund all applications for incentives.[11] In these cases, we will be underestimating the effect of the PV incentives because the true average incentive level is lower than our estimated values, since only a fraction of installed panels received the incentive. Similarly, because our dependent variable is measured at the

[11] Many budget-constrained programs have a fixed total budget (instead of a yearly budget) and through discussions with state energy offices, we determined the year at which the funding ran out. This is likely only a small problem for incentives in which the budget was depleted at near beginning of the calendar year. Moreover, these budget-constrained programs tend to be limited to direct cash incentive programs.

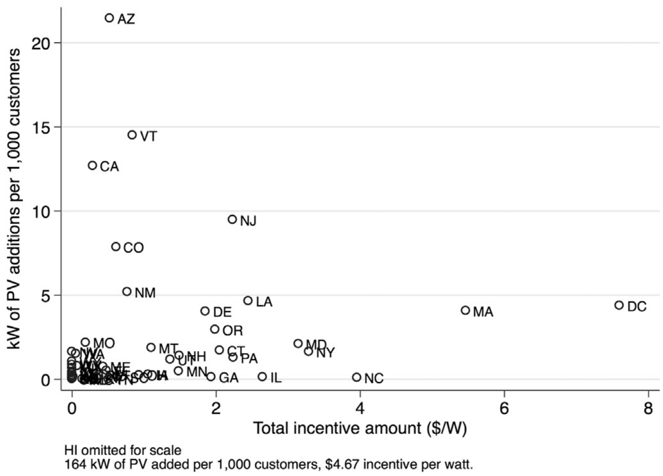


**Fig. 2.** PV Installation rates per 1000 customers, 2012.

state level, and because information about local and utility level programs is limited, we use an average value of utility level incentives at the state level, which likely biases our results towards 0.

## 4. Results

### 4.1. Understanding levels of support for solar PV and solar installations

The variation in incentives produced differential responses by residential PV owners (see Fig. 2 for a graphical depiction). California has a large number of solar PV installations, while having incentives that are not nearly as high as Maryland, the District of Columbia, Massachusetts, or North Carolina. Meanwhile, Arizona has relatively high installations with virtually no state support for solar PV. Nevertheless, this variation may be driven by variation in solar intensity and electricity prices.

### 4.2. Relationship between state incentives and installation rates

Table 3 presents regression results for estimating several specifications of Eqs. (1) and (2). Columns 1–3 present results from regressing the value of all the incentives available for PV installations in a year on the number of kilowatts of PV additions per 1000 residential electricity customers in each state. Column 1 presents the most parsimonious specification with only the value of incentives in each year, state and year fixed effects, and other control variables. The coefficient implies that every additional dollar per watt of incentives offered for rooftop solar installations is associated with an additional 616 W of capacity per 1000 customers, though this is not statistically significant. The residential price of electricity has the expected positive, and statistically significant ($p < 0.1$), sign indicating that PV installations are a substitute for purchasing electricity from an electricity retail company. Column 2 adds fixed effects for the type of incentives available within the state and provides a slightly larger estimate of incentive effects.

Column 3 interacts the value of the incentives within a state with an indicator variable that is equal to one if there is a net metering program within the state. The primary estimate flips to a negative valence; however, the interaction effect with net metering is statistically significant at the 5% level and is substantially larger in magnitude than the estimate without net metering available. This estimate suggests that if net metering is in place, each dollar of incentive per watt produces 1.6 kW of PV additions. Column 4 interacts incentive value with state financing provisions. This estimate suggests that each dollar of incentives produces 3.5 kW of capacity additions per 1000 customers, if a state has adopted legislation to enable financing availability. Finally, column 5 includes both interactions, showing that total incentive value, when interacted with net metering and financing availability, remain positive. While the main effect is negative, the magnitude of the interaction terms indicate that the total effect is positive.

Finally, we present estimates in column 6 using only a subset of our

**Table 3**
Effects of solar incentives on residential level installations dependent variable: kilowatts of PV additions per 1000 customers.

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| **Total incentive amount ($/W)** | 0.616 | 0.492 | −0.845* | −0.113 | −0.885* | −1.041 |
| | (0.612) | (0.603) | (0.366) | (0.395) | (0.384) | (0.564) |
| **Total incentive amount X Net Metering** | | | 1.562* | | 0.931* | 0.602 |
| | | | (0.621) | | (0.419) | (0.665) |
| **Total incentive amount X financing available** | | | | 3.520* | 3.377* | 4.623* |
| | | | | (1.580) | (1.543) | (1.983) |
| **Net metering** | −0.165 | −1.188 | −2.179* | −1.134 | −1.727* | −2.075 |
| | (0.505) | (0.804) | (1.098) | (0.739) | (0.871) | (1.166) |
| **Residential electricity price (c/kWh)** | 2.567 | 2.621 | 2.604 | 2.537 | 2.530 | 3.656* |
| | (1.388) | (1.481) | (1.465) | (1.352) | (1.349) | (1.744) |
| **Median Income (2012 Dollars, 000's)** | −0.288 | −0.254 | −0.262 | −0.269 | −0.274 | −0.279 |
| | (0.199) | (0.184) | (0.185) | (0.178) | (0.179) | (0.195) |
| **Citizen Liberalism Index** | −0.0806 | −0.0607 | −0.0601 | −0.0405 | −0.0410 | 0.0165 |
| | (0.0756) | (0.0713) | (0.0705) | (0.0608) | (0.0606) | (0.0622) |
| **Per Capita Gross State Product (thousands, real dollars)** | 0.00439 | 0.0779 | 0.0928 | 0.0253 | 0.0363 | −0.0061 |
| | (0.0932) | (0.112) | (0.116) | (0.0932) | (0.0947) | (0.116) |
| **Fixed effects for policy categories** | | X | X | X | X | X |
| **Year and State fixed effects** | X | X | X | X | X | X |
| **Observations** | 550 | 550 | 550 | 550 | 550 | 350 |
| **R-squared** | 0.466 | 0.505 | 0.513 | 0.552 | 0.554 | 0.660 |

Robust standard errors in parentheses. All specifications include state and year fixed effects. **$p < 0.01$.
* $p < 0.05$.

**Table 4**
Regression estimates by incentive type dependent variable: kilowatts of PV additions per 1000 customers.

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Total cash incentive amount ($/W) | 0.761<br>(0.774) | −0.832*<br>(0.417) | −0.574*<br>(0.284) | −0.830<br>(0.566) | −0.834<br>(0.633) |
| Total property tax incentive amount ($/W) | −2.564<br>(2.286) | 165.6<br>(135.1) | −6.885<br>(4.355) | 134.1<br>(118.1) | −53.15<br>(184.6) |
| Total sales tax incentive amount ($/W) | −5.143<br>(2.647) | −8.006<br>(4.567) | −5.332*<br>(2.281) | −9.167<br>(4.692) | −12.67<br>(7.711) |
| Total tax credit incentive amount ($/W) | −0.853<br>(0.957) | −1.700<br>(1.544) | −0.237<br>(0.746) | −0.310<br>(1.633) | −6.918<br>(3.580) |
| Total RPS incentive amount ($/W) | −0.216<br>(0.680) | −0.00223<br>(0.750) | −1.172<br>(0.856) | −1.178<br>(0.878) | −0.724<br>(1.146) |
| Cash incentive amount ($/W)×net metering available | | 1.958*<br>(0.771) | | 0.337<br>(0.578) | −0.215<br>(0.936) |
| Property tax incentive amount ($/W)×net metering available | | −168.1<br>(135.7) | | −141.2<br>(120.4) | 50.35<br>(183.1) |
| Sales tax incentive amount ($/W)×net metering available | | 3.468<br>(3.070) | | 4.754<br>(3.408) | 12.48<br>(8.029) |
| Tax credit incentive amount ($/W)×net metering available | | 0.778<br>(0.912) | | 0.0592<br>(1.464) | 1.540<br>(2.160) |
| Cash incentive amount ($/W)×financing available | | | 6.552*<br>(2.584) | 6.410*<br>(2.581) | 6.411*<br>(2.993) |
| Property tax incentive amount ($/W)×financing available | | | 9.285<br>(6.039) | 9.657<br>(6.238) | 6.402<br>(10.11) |
| Sales tax incentive amount ($/W)×financing available | | | −20.45<br>(10.57) | −21.79<br>(11.41) | −14.69<br>(9.374) |
| Tax credit incentive amount ($/W)×financing available | | | 5.208<br>(3.103) | 5.280<br>(3.129) | 8.175<br>(6.318) |
| RPS incentive amount ($/W)×financing available | | | 0.240<br>(1.228) | 0.397<br>(1.272) | 1.756<br>(1.784) |
| Net metering | −1.514<br>(0.952) | −2.606<br>(1.382) | −1.639<br>(0.886) | −1.992<br>(1.056) | −2.969<br>(1.924) |
| Residential electricity price (c/kWh) | 2.651<br>(1.485) | 2.625<br>(1.478) | 2.563<br>(1.394) | 2.613<br>(1.429) | 3.407<br>(1.815) |
| Median Income (2012 Dollars, 000's) | −0.273<br>(0.189) | −0.280<br>(0.187) | −0.234<br>(0.158) | −0.225<br>(0.152) | −0.134<br>(0.171) |
| Citizen Liberalism Index | −0.0643<br>(0.0724) | −0.0648<br>(0.0728) | −0.0418<br>(0.0604) | −0.0455<br>(0.0626) | −0.0053<br>(0.0637) |
| Per capita gross state product ($ 000's) | 0.130<br>(0.134) | 0.155<br>(0.143) | 0.167<br>(0.135) | 0.176<br>(0.140) | 0.009<br>(0.117) |
| Year and State fixed effects | X | X | X | X | X |
| Fixed Effects for Policy Categories | X | X | X | X | X |
| Observations | 550 | 550 | 550 | 550 | 350 |
| R-squared | 0.513 | 0.523 | 0.604 | 0.606 | 0.688 |

Robust standard errors in parentheses. All specifications include state and year fixed effects. ** $p < 0.01$.
* $p < 0.05$.

data. As discussed in Section 3.2, it is possible that there are more errors in our data the further back in time it goes. Therefore, column 6 restricts the sample to the final years in our data, 2006–2012 using an identical specification to column 5. The results from this limited sample are largely similar to those in column 5, though we lose some statistical power to identify the coefficient on the interaction of the value of the incentive and net metering. These results suggest that we do not have systemic measurement error in the earlier period.

Table 4 disaggregates the $/W value of each subsidy to new PV installations. The five categories of subsides included are: direct cash payments, property tax reductions, sales tax rebates, tax credits, and RPS payments by selling SRECs. Because results from Table 3 suggest that the presence of laws allowing financing innovation and net metering availability have a complementary effect on PV subsidies, we interact the value of each type of subsidy with the availability of state laws allowing innovative financing arrangements for PV purchases as well as net metering policies.

Column 1 of Table 4 presents the results of regressing the value of each type of incentive on kilowatts of PV additions per 1000 customers. Cash incentives have a positive valence, with all other policy values seemingly negatively correlated with installations though none of the estimates are statistically different from zero. Column 2 interacts the level of each of the incentive types with net metering availability. The sign on the interaction term flips to positive and is statistically significant ($p < 0.05$) with all of the other interaction terms remaining statistically insignificant.

Columns 3 instead interacts of the value of incentives with our indicator variable for financing availability. While the parameter estimate for cash incentives in states with financing availability is large with every dollar per watt of cash incentive in a state with subsidized financing available leading to an additional 6.5 kW of capacity additions per 1000 customers. Column 4 includes both interactions (net metering and financing availability). In this specification, cash incentives coupled with net metering remains positive, though is no longer statistically significant while cash incentives coupled with low cost financing availability remains positive and statistically significant. Column 5 repeats the specification in column 4, but on the restricted sample of our data, 2006–2012 as in Table 3. The results in column 5 are nearly identical to those in column 4 suggesting that mismeasurement of incentives early in our sample is not driving these results either.

## 5. Discussion

Our results highlight the role that net metering and state financing programs play in facilitating the effectiveness of financial incentives. One way to view the results might be that financial incentives, without prerequisite policy changes, such as net metering and enabling financing availability, are ineffective. Another way to interpret these results is that because these policies are not randomly adopted, states are likely to direct financial incentives for solar PV only if they have also made requisite policy changes, such as adopting a net metering program. Indeed, 73% of the observations in the dataset are state-years where net metering has been in effect. Thus, another way to look at the results is that until net metering is adopted, financial incentives are unlikely to be effective.

Once these requisite policies are adopted, our results demonstrate that on a per-$/W basis, cash incentives vastly outperform other incentive types, which do not appear to alter residential PV installation behavior. Other incentives – such as property tax incentives and tax credits are unlikely to have any impact at the residential level. Property tax incentives and tax credits only affect potential installers of solar through tax bills, which may be temporally removed from the time of sale. This issue is compounded if consumers need to carry forward tax credits to future years to take advantage of their value. Because many homeowners pay property taxes in a bundle with insurance and mortgage costs, these benefits may not be salient to homeowners. Similarly, tax credits provide a delayed benefit and reduce payments through the total tax bill. Separating the cost of purchasing solar PV from the tax related benefits might add uncertainty or reduce salience to consumers.

In contrast to the tax salience literature, where research is primarily concerned with avoiding distortionary effects of revenue generation (Schenk, 2011), the goal of policy-makers when providing PV incentives ought to be aimed at providing the largest impact per dollar spent. Our research demonstrates that the design of incentives, and packaging them with net metering and financing availability matters. Further, directing the payments via cash payments seems highly. Other incentives (tax credits, property tax credits, sales tax credits, and RPSs) are payments or deductions off of other future tax bills. For instance, property tax incentives often reduce a house's taxable value over a period of years. Tax credits are not realized until tax returns are filed at the beginning of the next calendar year. RPSs generate streams of revenue over the life of the PV panel, and sales tax credits may require filing paperwork with the tax authority, potentially delaying the receipt of compensation by many months. Our results are consistent with those from Gallagher and Muehlegger (2011), who find that rebates at the point of sale are eight times more effective than tax credits worth the same dollar amount and with Sarzynski et al. (2012), who find that the presence of cash incentives is correlated with an increased number of installations while the presence of tax credits is not. These results also appear consistent with Hughes and Podolefsky (2015) who find a significant impact of cash incentives in California.

Our results are also consistent with research (Benzion et al., 1989; Greene, 2011; Hausman, 1979; Loewenstein and Prelec, 1992) that shows very high short-term discount rates for consumers or rational inattention to small financial incentives. We acknowledge that recent research debates the appropriateness of a 5% discount rate; however, the choice of discount rate only matters to the extent that the different incentives have temporally variant values, and alternative discount rates do not substantively or statistically change results (see tables in Appendices for robustness checks employing alternative discount rates). For a typical residential consumer, the average property tax value of just $100 over twenty years on a 5 kW system is unlikely to have any effect. Further, SRECs from RPS pose a different problem. These programs provide owners of PV systems an incentive that has uncertain value (it trades in a market), and that may be illiquid. Because most residential users will only generate a few SRECs, the transaction costs associated with exchanging these may substantially reduce their value to residential system owners. Our results show that any incentive that is not immediately included in the price to the consumer is unlikely to be effective. If true consumer discount rates for durable energy investments are higher than 5%, incentives that are easily valued at the point of sale, such as cash rebates, would be relatively more valuable.

Government and third party financing programs, where states intervened to facilitate capital availability for solar ownership, facilitate the effectiveness of PV incentives by reducing transaction costs for individual consumers, and reducing the role of uncertainty driving residential consumer behavior. Our research window ends in 2012, prior to the third-party ownership and solar leasing model becoming more common. However, our results highlight the importance of financing availability to facilitate the installation of rooftop solar. Our results show that financial incentives available are effective through financing availability and net metering availability. We might expect the third-party ownership model, which takes further efforts to reduce upfront costs, transaction costs, and simplify the installation decision and process for individuals to be an important driver of solar installations.

Given that many renewable energy and energy efficiency investments are incentivized through tax credits, this finding emphasizes that using the public finance system to achieve a wide range of policy goals may reduce the effectiveness of those policies, and that the manner in which states and utilities design solar incentives matters. Incentives that are highly salient at the time of purchase seem to be much more effective than incentives that affect a year-end tax bill, or those that require an additional transaction to capture value.

Other researchers highlight additional mechanisms that could produce similar results. Zindler and Tringas (2009) suggest other problems with tax credits, including costs of capital, tax credit liquidity and changing wholesale electricity prices that might favor cash incentives rather than production tax credits. Mormann (2012) highlights an array of transaction costs present in some policies that might lead feed in tariffs and other cash incentives to be more efficient than other policy approaches. While some of these factors are embedded in the concept of incentive salience, issues like transaction costs, search costs, and volatility in future incentive value are also plausible explanations for many of our results.

In our preferred estimation, where each type of incentive is interacted with an indicator variable for both net metering and financing programs, direct cash programs in combination with low-cost financing lead to a positive statistical effect on PV installations while we provide suggestive evidence that net metering coupled with direct cash programs is also important. This suggests that many subsidy programs are delivered to customers who would likely have invested in PV anyway. If all purchasers take advantage of all of the subsidies available to them but only cash incentives paired with financing incentivize additional PV purchases, we provide back-of-the envelope estimates of the amount of subsidies that have no statistical effect on PV purchases by multiplying the amount of non-cash incentive available in each state by the amount of PV installed in that state in that year.

In total, states offer an average of $5 million in solar subsidies annually, $1.6 million of which was through cash incentives that also had financing options available. This translates to a total of $920 million potentially spent on cash incentives with financing and $1.9 billion potentially spent on other incentives. According to these estimates, 67% of PV incentives were potentially spent on programs that have no positive statistically significant relationship with new PV installations.

## 6. Conclusion

Similar to research demonstrating that nearly half of the funds spent in the “Cash for Clunkers” auto purchase stimulus program spent money incentivizing consumers who would have purchased a car anyway (Li et al., 2013), our research demonstrates that much of the funding allocated by states towards incentivizing solar PV investment has likely been directed in a manner that did not achieve policy goals. In the case of state and utility solar incentive programs, some types of incentives are ineffective at modifying consumer behavior. While our data does not allow us to know why these programs are ineffective, we speculate that several factors play a role in driving the effectiveness of consumer incentives. Incentives that reduce the price to consumers at the point of purchase, and without administrative burden appear to be more effective. In contrast, many of the incentives directed at solar PV provide incentives that are delivered over a long period of time, require an administrative burden, or cannot be collected until taxes are paid.

This research has important implications for policy design. Careful attention ought to be paid to designing incentives that maximize the impact on consumer behavior. Our research demonstrates that by directing the same dollar value away from tax credits and towards cash rebates, an incentive can be many times as effective. These results are consistent with similar studies that show that consumer responses vary based on tax and incentive structures. By increasing the salience of consumer incentives, public policies are likely to be vastly more effective.

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## Appendix A. Results with alternative discount rate assumptions

| VARIABLES | Baseline (5% discount) | 0% discount | 3% discount | 8% discount | 15% discount |
|---|---|---|---|---|---|
| **Total incentive amount ($/W)** | −0.788* | −0.440* | −0.644* | −0.987 | −1.355* |
| | (0.386) | (0.192) | (0.301) | (0.507) | (0.654) |
| **Total incentive amount ($/W) X Net Metering** | 0.815* | 0.669 | 0.759* | 0.884* | 0.990 |
| | (0.401) | (0.377) | (0.385) | (0.450) | (0.559) |
| **Total incentive amount X financing available** | 3.401* | 2.685* | 3.171* | 3.601* | 3.538* |
| | (1.558) | (1.213) | (1.440) | (1.676) | (1.717) |
| **Net metering** | −0.117 | −0.0963 | −0.110 | −0.127 | −0.138 |
| | (0.0736) | (0.0703) | (0.0723) | (0.0756) | (0.0797) |
| **Residential electricity price (c/kWh)** | 2.631 | 2.521 | 2.590 | 2.680 | 2.753 |
| | (1.381) | (1.316) | (1.355) | (1.415) | (1.477) |
| **Median Income (2012 Dollars, 000's)** | −0.276 | −0.279 | −0.278 | −0.273 | −0.265 |
| | (0.180) | (0.175) | (0.178) | (0.181) | (0.182) |
| **Per Capita Gross State Product (thousands, real dollars)** | 0.0507 | 0.0311 | 0.0428 | 0.0620 | 0.0813 |
| | (0.0991) | (0.0921) | (0.0964) | (0.103) | (0.110) |
| **Citizen Liberalism Index** | −0.0426 | −0.0387 | −0.0409 | −0.0454 | −0.0520 |
| | (0.0618) | (0.0601) | (0.0611) | (0.0630) | (0.0659) |
| **Fixed effects for policy categories** | X | X | X | X | X |
| **Year and State fixed effects** | X | X | X | X | X |
| **Observations** | 550 | 550 | 550 | 550 | 550 |
| **R-squared** | 0.552 | 0.566 | 0.558 | 0.545 | 0.531 |

## Appendix B. Results with alternative discount rate assumptions

| VARIABLES | Baseline (5%) | 0% discount | 3% discount | 8% discount | 15% discount |
|---|---|---|---|---|---|
| Total cash incentive amount ($/W) | −0.777 | −0.613* | −0.740 | −0.787 | −0.889 |
| | (0.570) | (0.303) | (0.430) | (0.804) | (1.094) |
| Total property tax incentive amount ($/W) | 176.9 | 169.5 | 172.5 | 185.3 | 316.3 |
| | (129.4) | (121.9) | (125.9) | (135.2) | (208.0) |
| Total sales tax incentive amount ($/W) | −9.320 | −7.753 | −8.732 | −10.04* | −11.21* |
| | (4.773) | (4.265) | (4.580) | (5.017) | (5.483) |
| Total tax credit incentive amount ($/W) | −0.00972 | 1.402 | 0.549 | −0.752 | −1.914 |
| | (1.617) | (2.020) | (1.740) | (1.520) | (1.562) |
| Total RPS incentive amount ($/W) | −1.212 | −0.743 | −1.011 | −1.531 | −2.407 |
| | (0.890) | (0.580) | (0.758) | (1.097) | (1.600) |
| Cash incentive amount ($/W) X net metering available | 0.242 | 0.268 | 0.266 | 0.186 | 0.199 |
| | (0.579) | (0.474) | (0.503) | (0.747) | (0.992) |
| Property tax incentive amount ($/W) X net metering available | −183.7 | −175.7 | −179.1 | −192.5 | −323.9 |
| | (132.1) | (124.4) | (128.5) | (138.0) | (211.9) |
| Sales tax incentive amount ($/W) X net metering available | 4.874 | 3.652 | 4.421 | 5.414 | 6.287 |
| | (3.498) | (3.094) | (3.347) | (3.688) | (4.042) |
| Tax credit incentive amount ($/W) X net metering available | −0.137 | −1.276 | −0.591 | 0.470 | 1.427 |
| | (1.460) | (1.964) | (1.634) | (1.271) | (1.133) |
| Cash incentive amount ($/W) X financing available | 6.479* | 5.397* | 6.203* | 6.544* | 5.796* |
| | (2.611) | (2.147) | (2.474) | (2.700) | (2.526) |
| Property tax incentive amount ($/W) X financing available | 9.678 | 8.021 | 8.948 | 10.81 | 13.41 |
| | (6.266) | (5.305) | (5.847) | (6.911) | (8.458) |
| Sales tax incentive amount ($/W) X financing available | −21.31 | −19.41 | −20.58 | −22.27 | −23.88 |
| | (11.20) | (10.26) | (10.82) | (11.71) | (12.65) |
| Tax credit incentive amount ($/W) X financing available | 5.265 | 5.063 | 5.207 | 5.248 | 4.957 |
| | (3.121) | (2.901) | (3.037) | (3.207) | (3.263) |
| RPS incentive amount ($/W) X financing available | 0.295 | 0.307 | 0.295 | 0.347 | 0.555 |
| | (1.247) | (0.833) | (1.073) | (1.518) | (2.129) |
| Net metering | −0.152 | −0.105 | −0.135 | −0.170 | −0.196 |
| | (0.0909) | (0.0790) | (0.0868) | (0.0959) | (0.105) |
| Residential electricity price (c/kWh) | 2.737 | 2.461 | 2.627 | 2.885 | 3.128 |
| | (1.479) | (1.355) | (1.427) | (1.552) | (1.683) |
| Median Income (2012 Dollars, 000's) | −0.229 | −0.230 | −0.229 | −0.228 | −0.231 |
| | (0.154) | (0.148) | (0.151) | (0.157) | (0.164) |
| Citizen Liberalism Index | −0.0469 | −0.0423 | −0.0445 | −0.0512 | −0.0631 |
| | (0.0637) | (0.0608) | (0.0623) | (0.0658) | (0.0714) |
| Per capita gross state product ($ 000's) | 0.193 | 0.174 | 0.187 | 0.198 | 0.198 |
| | (0.147) | (0.136) | (0.144) | (0.150) | (0.149) |
| Year and State fixed effects | X | X | X | X | X |
| Fixed Effects for Policy Categories | X | X | X | X | X |
| Observations | 550 | 550 | 550 | 550 | 550 |
| R-squared | 0.604 | 0.627 | 0.614 | 0.591 | 0.567 |

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