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Media effects on solar panel installations across 20 states

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Introduction:

As climate change awareness becomes widespread, more households are implementing alternative and renewable sources of energy. Perhaps the most popular alternative energy source households use is solar energy. Solar energy is relatively efficient and easy to install. Furthermore, the government provides benefits for the use of solar power, which incentives individuals to purchase solar panels. The most common form of solar energy is solar panels, which use photovoltaics to convert solar energy into direct current electricity. While photovoltaic solar power seems to be a valuable substitute for oil or gas, it still is not very popular nation wide. There is no doubt that there has been an increase in the number of solar panels installed in the past several years, but traditional sources of energy continue to dominate. Thus, an important question to ask is: how can solar energy become more popular? One potential answer is through the media. If the media focuses on solar energy, more people will become aware of its benefits and install solar panels. I hypothesize this is the case; that is, the more media articles about solar energy that are in a state, the more solar panel installations there will be. If this is true, media outlets could make more of an effort to publish articles and stories about solar energy to influence more households to install solar panels. This would reduce households' reliance on environmentally harmful energy sources. Households are focused on in this study because households are more likely to change environmental behavior due to media articles compared to businesses or large organizations. I look at the number of media articles about solar energy of 20 states and the number of installations for that state over 6 years to determine if there is a correlation between the two.

Previous Literature

Using media presence is a fairly common method for studying information-based approaches in environmental economics. Zivin and Neidell (2009) study the effect of media issued smog alerts on discretionary outdoor activities. They find that if there are 2 smog alerts in a row, people will avoid the outdoor activity on the first day, but this response largely disappears the second day. This study shows that media alerts do have some effect on the behavior of individuals. Cutter and Neidell (2009) look at the effect of "Spare the Air" days on traffic. "Spare the Air" days call for voluntary reduction in ozone producing activities. They find that "Spare the Air" days reduce traffic, but do not significantly reduce ozone. Finally, Jacobsen (2011) studies if Al Gore's documentary An Inconvenient Truth caused an increase in purchases of voluntary carbon offsets. Jacobsen finds that 2 months after the film's release, there was a 50% increase in purchases within a 10-mile radius of the zip code in which the film was shown. All the above papers demonstrate that media does influence the environmental behavior of individuals, which supports my hypothesis that more media coverage would increase solar panel installations.

There has also been a significant amount of studies about the economics of solar power and the influence on media for environmental behavior, but there is surprisingly little literature on the relationship between the two. For instance, Bollinger and Gillingham (2012) study the presence of a peer effect for solar panels in Southern California. They find that there is a geographic clustering of solar panels at the zip code and neighborhood level, and this does not simply match population density or "greenness" of a given zip code, thus indicating that there is a peer effect. In other words, one's neighbor influences the decision to install a solar panel. Similarly, Graziano and Gillingham (2015) look at the peer effect using data in Connecticut. They find that there is a specific form of clustering such that smaller centers adopt more solar than larger-urban areas, and occurs in a wave-like pattern. Furthermore, their empirical evidence shows a strong relationship between adoption of solar and nearby previously installed systems, which also heavily supports the presence of a peer effect. Noll, Dawes, and Rai (2014) study the peer effect of Solar Community Organizations (SCOs). SCOs are organizations that provide credible information about the benefits of local solar installations and campaign to encourage others to adopt solar energy in the local area. It was found that there was an SCO-driven peer effect that encouraged installations of solar panels. The paper demonstrates that people are more likely to adopt solar energy if they receive more information of its benefits and if their neighbors adopt as well.

This paper aims to do show this at a larger scale. It explores if media attention across several states influences more solar installations. If this is found to be true, then the peer effect found in the above papers would have a multiplying effect on the amount of solar panels adopted. So if the presence of media articles influences an individual to install a solar panel, perhaps it will convince several neighbors to also adopt solar panels. Thus, if media articles do influence the number of solar installations, it could have major implications of the total amount of solar energy adopted.

Data

The data used in this study is adequate but admittedly quite limited. To test if media articles have an influence on the installations of solar panels in the United States, I would ideally obtain every solar installation and solar energy media article for the past few years in every single state, but this data was not available. To obtain the number of solar panel installations, I used an online database called The Open PV Project. The Open PV Project is a database of PV installation across the United States. The data is contributed voluntarily by sources such as solar incentive programs, installers, and the general public, thus giving a general overlook of the solar market in the United States. I used installation data from 2009 to 2014. Installations before 2009 seemed scarce, and data from 2015 was not up to date. I then divided the amount of installations by the population of a state to get

installations per capita. This assures that states do not have more solar panels simply because they have a larger population.

I used ProQuest Newsstand to find all media articles about solar energy. To find media articles about solar energy, I used the phrase "solar energy" and "solar panel" in a Boolean search. This method provided me with articles that were about the topic; however, there was no good way to distinguish whether the articles were about positive or negative aspects of solar energy. As a result, I assume that all articles will affect the reader the same. In other words, regardless of whether the article portrays solar energy is a positive or negative light, the reader will be aware that solar energy is beneficial to the environment and that there are private benefits to adopting solar power, such as credits. This would mean that the influence of media on solar power is greater than the results because some articles are negatively portraying solar energy, dissuading individuals to install solar panels. According to my hypothesis, if all articles positively portrayed solar panels, there would be more installations. Although this is not the most accurate assumption, it is the only effective method I could use rather than attempt to differentiate thousands of media articles manually.

Furthermore, I used newspaper articles, as these were easier to find the place of publication. I picked the top newspapers in each state as the main source for the media articles of each state. However, many states did not have any newspaper article options concerning solar energy on the database, hence this study only includes 20 states. These states are CA, CT, DC, FL, GA, HI, IL, MA, MD, ME, MN, NH, NJ, NM, NV, NY, OR, PA, TX, and WI. Another limitation is (for example) residents of California and Minnesota could read the New York Times because it is a national newspaper. I could not find distribution distance of each newspaper on ProQuest, so I kept each newspaper at a state level to account for this. So, only New York residents read the New York Times and Wall Street Journal. This underestimates the amount of media articles about solar energy in each state. While this is a limitation of my research, it is likely that residents of a state read their own newspaper articles more than national newspapers. Including national newspapers would have overestimated the amount of newspapers read in a state. Additionally, it was difficult to obtain the distribution radius of each newspaper used in the study. For instance, a newspaper in Western Massachusetts could be delivered to a handful of towns in Southern Vermont. Using ProQuest's data set, I was unable to tell when this occurred, therefore I used the method I did.

Several other factors could affect the adoption of solar energy as well. The factors I used in my study were: education, solar potential, income, and the political stance of the state. If a state has high levels of education, the its residents are more likely to be aware of climate change and the environmental and private benefits of using solar energy. Education level was measured by the percentage of individuals in a state with a bachelor's degree or more. I obtained this data from the United

States Census estimates. Furthermore, if an individual has a higher income, the person would be able to afford the initial purchase of a solar panel. The median state income was also taken from the United States Census estimates. The solar potential of a state should also result in more solar panel installations; when more energy can be produced from a solar panel, there should be more solar panels. The data for solar potential is from the National Renewable Energy Laboratory, which develops clean and efficient energy technologies and provides knowledge for individuals to integrate green energy systems. This data gives thorough solar potential data of each state measured in the average annual kilowatt-hour per meter squared, per day. Finally, since climate change and environmentalism is more of a liberal issue, more liberal states would probably have more solar panel installations. I measured this using the 2012 presidential elections. If a state had 52% of the population that voted for Barack Obama, the liberal variable for this state would be 52. This gives a general summary of which way the states vote and thus the political stance of the state.

Variable Name	*Description*	*Units*	*Mean*	*Median*	*Standard Deviation*
installpercap	# of solar installations per state population	Installations/person	2.23×10^{-4}	9.66×10^{-5}	3.03×10^{-4}
media	# of newspaper articles about solar energy in a state	Newspaper articles	36.54	22.00	42.56
%liberal	% of state that voted for Obama in 2012 elections	Percentage	57.05	55.00	10.08
income	Median income of a state	US Dollars	58,204.85	57,400.00	8,660.08
solar_potential	Amount of energy that can be produced from a solar panel	Avg annual $kWh/m^2/day$	4.65	4.08	1.13
edu	Percent of state that holds a bachelors degree or higher	Percentage	31.69	30.40	6.37

Table 1: Summary statistics of variables.

Table 1 displays the summary statistics of the primary variables across the 20 states. These show the average, median, and standard deviation of the variables of the 120 observations. Installations and income have very high standard deviations, which suggests the spread of these variables. Furthermore, the mean of the percent liberal is 57, which demonstrates that most states used in this study are predominantly liberal.

Empirical Methods

To test the hypothesis that media articles affect the number of solar panel installations in a given state, I regress the number of installations on the number of media articles as well as the other variables. The model is as follows:

(1) $\text{installations}_{it} = \alpha + \beta_1 \text{media}_{it} + \beta_2 \text{income}_i + \beta_3 \text{solar\_potential}_i + \beta_4 \%\text{liberal}_i + \beta_5 \text{education}_i + \varepsilon$

The i indexes the state of the variable and t indexes the year. The primary coefficient of concern is β_1 because it quantifies the change in installations for a given change in media. According to the hypothesis, this coefficient should be positive so that an increase in media will cause an increase in the number of solar panels increased for a given state in a given year.

installpercap~a	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
media	1.45e-06	5.49e-07	2.65	0.009	3.67e-07	2.54e-06
liberal	-5.14e-06	3.96e-06	-1.30	0.197	-.000013	2.71e-06
income	1.24e-08	3.62e-09	3.43	0.001	5.24e-09	1.96e-08
solar_potential	.0001231	.000024	5.13	0.000	.0000755	.0001707
edu	.0000225	7.53e-06	2.99	0.003	7.60e-06	.0000374
_cons	-.0015448	.0002315	-6.67	0.000	-.0020035	-.0010862

Table 2: The results after running the first regression. P-values below 0.05 are significant at a 95% level. Coefficients are in the first column and standard errors are in the second column.

Table 2 shows the primary results from the regression. As displayed in the table, the coefficient of media is positive and statistically significant. This confirms my hypothesis that the number of installations increases when there are more media articles about solar energy. The results indicate that an increase in 1 media article will cause a 1.45×10^{-6} increase in solar installations. While this is a quite modest relationship, media articles do create more solar panel installations within a state. However, there is a potential endogenous relationship between these two variables. It is unclear whether an increase in media articles causes an increase in installations of solar panels or if increases in installations then causes an increase in media articles. The media could write more articles on solar energy if a state has more installations. Furthermore, media articles and installations could affect each other such that more media coverage causes more installations, which then causes more media coverage. This endogeneity is admittedly a relatively strong disadvantage of the paper. Future research could address the potential endogeneity by lagging the media article variable. For example, it could show whether media articles from one period affect solar installations in the next period. Lagging the media variable is outside of the scope of this paper, but it would be a good place to start for a further

study as it disentangles the endogeneity between media articles and solar installations.

Most of the other variables in the regression affect solar installations as predicted. Income is positive and statistically significant, such that a dollar increase in the median state income causes 1.24×10^{-8} increase in solar panels. Solar potential is also positive and statistically significant. Solar potential has the largest effect on installations as it has the highest coefficient and is the most statistically significant. An increase in one average annual kilowatt-hour per meter squared, per day increases installations by 0.00012. It is logical that this is the most significant variable because states with high solar energy potential can benefit the most energy by adopting to solar so it is logical that these states install the most solar panels. Education is another strong determinant of solar installations. It is positive and statistically significant. It makes sense that the more educated individuals in a state would result in more knowledge around climate change and both the public and private benefits of adopting solar energy. The variable coefficient that was most unexpected was the political stance of the state. This coefficient is negative and statistically insignificant. Although this result is not statistically significant, it is still strange. Because environmentalism and alternative energy sources are such a political focus for the Democratic Party, it is surprising that solar installations for each state do not reflect this. Perhaps this is because there is more solar installations in southern states, which have more solar potential, and southern states tend to be more conservative than northern states.

Following the above results, I adjusted the model to disaggregate the media influence in liberal and conservative states. I added a dummy variable of 1 if a state was liberal and 0 if the state was conservative. If the state had 50% or more votes for Obama in the 2012 election, it was deemed as liberal. The dummy variable was then multiplied by the amount of media articles in the state. This variable was called "mediadummy" and it indicates the additional influence media articles have on solar installations when published in liberal states. These variables were added to the regression model, which was adjusted to:

(2) $\text{install/capita}_{it} = \boldsymbol{\alpha} + \beta_1 \text{media}_{it} + \beta_2 \text{income}_i + \beta_3 \text{solar\_potential}_i + \beta_4 \text{libdummy}_i + \beta_5 \text{education}_i + \beta_6 \text{mediadummy} + \varepsilon$

The coefficients of interest for this regression model are β_1 and β_6 as these will indicate the difference in influence of media in conservative and liberal states. I predict that β_6 will be much larger than β_1 suggesting that liberals are more inclined to adopt solar panels due to media articles.

installpercap~a	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
media	5.10e-07	6.98e-06	0.07	0.942	-.0000133	.0000143
libdummy	.0000766	.0001847	0.42	0.679	-.0002892	.0004425
income	1.15e-08	3.71e-09	3.10	0.002	4.16e-09	1.89e-08
solar_potential	.0001145	.0000231	4.95	0.000	.0000687	.0001604
edu	.0000151	5.09e-06	2.96	0.004	5.00e-06	.0000252
mediadummy	7.31e-07	7.01e-06	0.10	0.917	-.0000132	.0000146
_cons	-.0015695	.0002907	-5.40	0.000	-.0021454	-.0009935

Table 3: The results after running the second regression. P-values below 0.05 are significant at a 95% level. Coefficients are in the first column and standard errors are in the second column.

As shown in Table 3, the media effects in liberal states are larger than conservative ones. The conservative baseline of media effects is an increase in 1 media article in a conservative state will cause a 5.10×10^{-7} increase in solar panel installations. In liberal states, the effect is an additional 7.31×10^{-7} solar panel installations, so the true effect in a liberal state is the sum of the two results, or 1.24×10^{-6}. In a liberal state, an additional media article will cause 1.24×10^{-6} installations, which is much more than 5.10×10^{-7} installations in conservative states, hence liberal states are much more influenced by media articles. Unfortunately, these results are not statistically significant. Despite that the results are not statistically significant, the positive signs of the coefficients and the increase in the "mediadummy" coefficient suggest that liberal states are more influenced to install solar panels by media articles.

Conclusion

This paper looks at the relationship between solar panel installations and media articles about solar power as well as other variables such as a state's income, education, solar potential, and liberalness. From 2009 to 2014, the evidence supports that a positive relationship exists between media articles published and solar panels installed in a state. There is also evidence that liberal states are more influenced to install solar panels by media articles. However, there remains some endogeneity; do more media articles cause more installations, or do more installations create more media attention. Disentangling this endongeneity would be a ripe area of further study. Moreover, future studies could also seek to use a more detailed database for media articles. They could obtain the exact publication areas as well as information on whether the articles positively or negatively represent solar energy. While this study has lots of room for further research and improvement, it provides a rather robust foundation for the positive relationship between media articles and solar panels. My study does provide evidence of a positive relationship, which is an important finding. Since media articles encourage

more solar adoption, an increase of solar energy in the media could cause a much more environmentally friendly nation, especially when combined with the peer effect. There is no way to force the media to increase coverage on solar power, but perhaps there could be some incentive structure put in place to encourage the media to report more information about solar and other alternative energy sources to inform more of the American public.

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