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Estimating Arizona residents' willingness to pay to invest in research and development in solar energy

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HIGHLIGHTS

- We estimate Willingness to Pay using Bayesian and Maximum Likelihood.
- Willingness to Pay estimates are robust to estimation techniques.
- Arizona residents are willing to pay $17 to invest in R&D in solar energy.

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ABSTRACT

We estimate Arizona residents' Willingness to Pay (WTP) to invest in a solar energy research and development fund using data obtained from a Dichotomous-Choice Contingent Valuation mail survey. We examine differences in WTP estimates using different categorizations for respondent uncertainty. We also employ both commonly used Maximum Likelihood and less frequently applied Bayesian estimation techniques. We find that respondent uncertainty has an economically significant impact on WTP estimates, while WTP estimates are robust to different estimation techniques. Our robust specification with strict uncertainty coding indicates the average Arizona household is WTP approximately $17 per month to invest in research and development in solar energy.

1. Introduction

Energy prices are volatile due to the current economic slowdown, and reliance on foreign oil remains troubling. The idea that the U.S. needs to increase energy independence is relatively non-controversial, however, the ways in which energy independence can be achieved are highly debated issues. Increased investment into renewable resources such as solar, wind, biomass, and geothermal would increase energy independence without the negative environmental impacts associated with the use of non-renewable resources such as coal and natural gas. Arizona is the second-fastest growing state in the U.S., with the population increasing by 40% from 1990 to 2000. The state of Arizona has the highest potential for solar energy provision in the U.S.[1] In fact, Arizona could meet 150% of the state's energy demand with solar energy. However, renewable sources of energy currently comprise less than 1% of the energy generated in Arizona (Madsen and Brown, 2005).

The composition of energy generated is going to change in the future, as Arizona is one of the 26 states (plus Washington DC) to enact a Renewable Energy Standard.[2] The Renewable Energy Standard approved by the Arizona Corporations Commission states that by 2025, 15% of the energy generated in Arizona must be generated from renewable resources. Given the potential for solar energy in Arizona, current production of solar energy is surprisingly low. The lack of solar energy is attributable to the relatively high costs of producing solar energy, especially compared to non-renewable alternatives. For example, solar thermal electric is estimated to cost approximately $150 per megawatt-hour (MW h) while hydroelectric costs only $50/MW h (Black and Veatch, 2007). If Arizona consumers are willing to pay to contribute to increased research and development into solar energy, it may increase the speed and efficiency with which Arizona meets its mandated renewable portfolio goals. Increased funding for research and development in solar energy may increase the speed with which new technologies are adopted and decrease costs of implementation.

Contingent valuation is a well-established survey method of eliciting values for goods, services, and environmental amenities not usually bought and sold in well-established markets. Contingent valuation has been used to measure damages and benefits

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[1] http://www.censusscope.org/us/rank_popl_growth.html.

[2] http://www.dsireusa.org/library/includes/tabsrch.cfm?state=AZ&type=RPS&back=regt.

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in environmental litigation and policies since a blue ribbon panel of expert environmental economists was hired to determine the validity of contingent valuation to measure values from the 1990 Exxon Valdez oil spill (Boyle, 2003). Renewable energy provides the benefits of reduced pollution and increased energy independence, both of which are benefits not priced by traditional markets, and thus necessitating contingent valuation techniques to measure their value.

Several studies have investigated willingness to pay (WTP) to obtain renewable energy using contingent valuation techniques. Two different studies by Champ and Bishop (2000 and 2001) found estimates for WTP for wind power for residents of Madison, WI. Their estimates ranged from $3.00–8.40 per month. Zarnikau (2003) found WTP for renewable energy for Texas residents to be approximately $7 per month. In a national study, Wiser (2007) found WTP for renewable energy to be approximately $8 per month. Thus, several previous studies provide evidence that residents of different regions in the U.S. are willing to pay to obtain renewable energy. In addition, studies have shown that WTP for renewable energy varies by age, education, and income (Zarnikau, 2003 and Batley et al., 2001). Our study focuses on WTP for research and development for renewable resources.

In a national study, Li et al. (2009) found WTP for research and development into renewable technologies to be approximately $3.66 per month. To the author's knowledge, no contingent valuation studies of WTP for research and development have been conducted focusing on the Southwestern United States or Arizona in particular. While other studies provide the valuable insight that U.S. citizens are willing to pay more for energy provided by renewable sources, if Arizona residents have different preferences for renewable energy or specifically solar energy, the results from national studies may not be accurate measures of Arizona residents' WTP. This study estimates what Arizona residents are WTP to invest in renewable energy from the dominant resource in the state—solar energy. Estimation of WTP from survey data involves limited dependent variable techniques most commonly estimated using Maximum Likelihood. Few studies have employed Bayesian estimation techniques despite their applicability with small samples (Albert and Chib, 1993). Our study applies both traditional Maximum Likelihood (ML) and Bayesian estimation to determine the mean WTP for solar energy in Arizona in order to compare point estimates and inform further research applying Bayesian techniques.

2. Data

Our data are obtained from a dichotomous-choice contingent valuation survey mailed to randomly chosen households in the state of Arizona. Addresses were obtained from Survey Sampling International. 600 surveys were mailed following the Tailored Survey Method by Dillman (2007). We sent an initial contact letter, followed by a survey booklet and cover letter with original signature. Shortly thereafter, we sent non-respondents a reminder postcard. We followed with a second cover letter and complete booklet mailing to the remaining non-respondents. We had a final response rate of 25.86% with 48 un-deliverables and 143 returned surveys. The effective sample size for the full Bayesian specification is 118 observations. The survey is an 8 page booklet including the title pages and back cover. Pages 2–3 ask questions to determine respondents' opinions about energy and environmental issues relative to other issues facing Arizona. We also wanted to investigate if respondents were concerned about global climate change. Pages 4 and 5 of the survey present and ask the WTP question and then gather information about protest responses and respondent certainty. The sixth page asks several questions about respondent demographics, and the seventh page was blank for comments.[3]

Table 1
Relative importance of issues in Arizona.

Variable	Number of Obs	Mean	Std. Dev.
National security	115	3.99	0.99
Health care	116	4.20	0.91
Air and water quality	116	4.03	0.90
State of the economy	116	4.38	0.72
Future price of energy	115	3.95	0.96
Future availability of energy	115	3.87	1.00
Energy cost	115	4.14	0.86
Foreign dependence	116	4.43	0.86

Table 2
Relative importance of renewable energy.

Variable	Number of Obs	Mean	Std. Dev.
Importance of energy	100.00	4.06	0.76
Importance of environment	117.00	3.72	0.96
Confidence in energy sources	116.00	3.26	1.07
Fragility of nature	116.00	3.56	1.05

2.1. Respondent opinions of energy, environment, and pertinent issues in Arizona

We first asked respondents to indicate their level of concern about pertinent issues in the state of Arizona on a scale of 1 to 5, with 1 meaning not at all concerned and 5 very concerned. Table 1 shows Likert Scale frequencies with mean and standard deviations for respondent answers to questions about issues in Arizona. Although respondents are generally concerned about all of the listed issues, reduction of U.S. dependence on foreign sources of energy generates the highest level of concern, with a mean on the Likert scale of 4.43 followed by the economy at 4.38. The relative strength of the importance of the reduction of dependence on foreign oil versus the economy is noteworthy in a state that has suffered deeply from the recession, with an unemployment rate of 9.6% in May of 2010, and foreclosure rates as high as 1 in 217 households in Yavapai County.[4,5]

Next, respondents were asked about the importance of energy and environmental issues on a scale of 1 to 5 where 1 means not at all important and 5 means extremely important. The questions were phrased as follows, "Concerning the full range of issues we face today, how important are energy [environmental] issues to you?" The results indicate that respondents are relatively more concerned about energy issues than the environment. Table 2 shows the responses to the questions on the relative importance of renewable energy. The importance of Energy Issues had the highest average rating of 4.06.

We also wanted to obtain information about respondents' confidence in adequate energy sources for the future. We asked, "How confident are you that there will be adequate sources of energy to meet the needs of Arizona residents during the next 20 years? Please think about energy needs overall, including transportation, heating, electricity, and other energy requirements when considering your answer." As shown in Table 2, the mean response was 3.23, indicating that respondents are generally

[3] See Appendix A for the entire survey.
[4] http://www.bls.gov/lau/.
[5] http://www.npr.org/templates/story/story.php?storyId=111494514.