Agricultural and Resource Economics Review (2024), **53**, 185–207
doi:10.1017/age.2023.36

RESEARCH ARTICLE

Renewable energy prosocial behavior, is it source dependent?

Bhagyashree Katare[1†], H. Holly Wang[1†], Michael Wetzstein[1], Yu Jiang[2] and Brandon Weiland[1]

[1]Department of Agricultural Economics, Purdue University, West Lafayette, IN, USA and [2]Western Research Center, Southwest University of Finance and Economics, Chengdu, China
Corresponding author: H. Holly Wang; Email: wanghong@purdue.edu

(Received 23 November 2022; revised 6 September 2023; accepted 14 November 2023; first published online 12 February 2024)

Abstract

Facing increasing nonrenewable and environmental concerns with fossil power generation, renewable energy is being supported by government mechanisms. With the power generation cost of renewables generally higher than fossil fuels, determining the optimal level of these mechanisms requires an understanding of households' prosocial behavior toward renewables. The issue is determining the magnitude households are willing to pay (WTP) for alternative renewables. Our hypothesis is this behavior varies by the type of renewable energy. As a test of this hypothesis, we apply a discrete choice experiment to measure households' WTP. Results support our hypothesis with a positive WTP for solar energy, leading to a 62% reduction in solar subsidy, and a negative WTP for biomass and wind sources.

Keywords: Biomass; green energy; prosocial behavior; solar energy; wind energy; WTP

Introduction

A significant share of energy production in the United States, around 80%, comes from fossil fuels (Sanchez 2020). This presents a major challenge to reduce CO_2 emissions under the Affordable Clean Energy (ACE) rule. While coal consumption has declined under ACE, it still remains a major source of energy production, resulting in local emissions and greenhouse gases (EIA 2020). The most effective method to reduce emissions and greenhouse gases is by shifting toward renewable energy sources, such as biomass, solar, and wind sources (IEA 2017). However, because the cost of producing energy from these new sources under current technology is higher than from fossil fuels, this shift largely depends on households' willingness to pay (WTP) for renewable energy, which is driven by their prosocial desire. Households' prosocial behavior is the intrinsic motivation to take action in a community's best interest (Bénabou and Tirole 2006). Previous research indicates that households' willingness to be taxed serves as a signal of their prosocial identity, leading to subsequent behavior in line with that self-perception (Gneezy et al. 2012). When households

[†]The two authors will share the senior authorship equally. Wang is the corresponding author.

recognize that their contributions help society, there is an increased likelihood of engaging in prosocial action and demonstrating prosocial WTP (Guerra and Harrington 2021; Thornton et al. 2019).

Households are increasingly aware and concerned about the production process of products and services, and are now valuing it in addition to the finished products. Recent literature reveals that consumers now prefer products that exhibit eco-friendly traits, such as animal welfare and fair-trade practices (Loureiro and Lotade 2005; Lai et al. 2018; Delmas and Gergaud 2021). In the context of power generation, households' prosocial behavior/green pricing, measured by their WTP for renewable energy, may vary depending on the type of renewable energy source, such as (biomass, solar, and wind.[1] Existing literature does not address the possibility of prosocial behavior in power generation. The objective of this study is to fill this knowledge gap by examining the extent of prosocial behavior/green pricing for renewable energy sources. We hypothesize that the WTP for renewable energy sources will be positive but will vary across different types of renewables and household prosocial characteristics, especially attitude toward the environment.

We test the hypothesis using choice experiments conducted in the United States. Households are presented with a choice of energy produced with different percentages of renewable sources blended with fossil fuel at alternative price levels. Results from choice experiments are employed in the context of random utility theory to estimate households' marginal WTP for competing energy sources.

Our choice experiment and WTP analysis contribute to the knowledge base of household values for alternative renewable energy sources. We build on the work of Noblet et al. (2015), which focused on the choices households made when asked to express their willingness to support proposed energy policies. Our extension provides estimates on the magnitude of households, by region and demographics, on WTP for alternative renewables (biomass, solar, and wind). Our research design improves previous research and contributes to the literature in three unique ways. First, we differentiate between three sources of renewable energy sources (biomass, solar, and wind) as compared to a single renewable source or an aggregate of all renewable sources as done in previous literature. Second, the experimental design incorporated individual households' base energy consumption. This allows us to anchor price premiums and avoid overestimation of WTP. Third, we also incorporate the effect of emotions related to climate change in estimating households' WTP for renewables. Specifically, our results indicate that households' WTP for renewables varies by type of energy source. Prosocial behavior, as indicated by WTP for renewables, is positive for solar power, whereas no prosocial behavior toward their adoption of biomass and wind power is observed. Although our empirical test confirms our hypothesis of varying WTP across renewable energy sources, the nonpositive WTP for biomass and wind deserves some attention.

Our results are not restricted to just an empirical WTP exercise. They have major policy implications. In August 2022, Congress passed an extension of the Solar Investment Tax Credit, raising it to 30% for solar installation. The question is whether such a subsidy was required given the relatively high level of prosocial behavior existing with solar technology. This is in contrast to biomass and wind, which do not exhibit such high prosocial choices. Failure to consider this embedded behavior can lead to inefficient policies at best and failed

[1]The link between prosocial behavior and WTP for renewable energy is contingent on limited if any household financial benefits from renewable energy over nonrenewable energies. Even with the substantial reduction in renewable fixed and variable costs, in almost all regions within the U.S. nonrenewable energy is not competitive with nonrenewable without government support.

policies at worst. In the following, we will present the literature review first, then explain our empirical framework, followed by the experiment design. Results, policy discussion and conclusions are presented at the end.

Literature

There exists literature assessing the WTP for renewable energy sources focusing on the environmental attributes associated with them. For instance, some studies have estimated the WTP for utility investments in renewable power generation (Zarnikau 2003; Bergmann et al. 2006; Scarpa and Willis 2010), while others have estimated the WTP for increased renewable energy (Byrnes et al. 1999; Ethier et al. 2000; Gossling et al. 2005; Borchers et al. 2007; Longo et al. 2008; Li et al. 2009; Erdem et al. 2010; Vainio et al. 2017; Bamwesigye 2023). However, these studies are limited in their scopes as they focus on only a few specific renewable energy sources or specific regions. For example, Roe et al. (2001) estimated the WTP for renewable energy's environmental attributes without delving into individual preferences for renewable energy sources. Similarly, Borchers et al. (2007) compared WTP for renewable energy by the source to generic "green energy" in Delaware., while Mozumder et al. (2011) investigated households' WTP for a renewable energy program in New Mexico. Murakami et al. (2015) performed a comparative analysis of WTP for nuclear and renewable energy between four states within the United States and Japanese households.

Several studies have elicited consumers' WTP for renewable energy using methods, such as contingent valuation surveys (Koundouri et al. 2009; Zografakis et al. 2010; Mozumder et al. 2011) and discrete choice experiments (Roe et al. 2001; Scarpa and Willis 2010). Discrete choice experiments are effective in eliciting consumers' WTP based on the energy bundles' attributes (Boxall et al. 1996). The participant's choice reflects the tradeoff they make among the attributes. In our case, the product is the energy bundle, and the attributes are the renewable energy sources blended in the bundle.

Previous research did not consider consumers' energy bills before presenting price increases to them (Borchers et al. 2007; Mozumdar et al. 2011; Murakami et al. 2015). Consumers were only asked to consider the dollar increase to their monthly bills, without considering the percentage increase of the renewable energy component nor average energy expenditures (Longo et al. 2008). Longo et al. (2008) estimated a 54% price premium for renewable energy, which is larger than one standard deviation in energy expenditure. With price premiums not anchored in energy bills as a percentage, it may lead to an overestimation of WTP, the reason why some studies employ percentage price changes such as Ortega et al. (2014). It is important to anchor price premiums from a policy design perspective. Policy decisions are usually made as a percentage increase rather than large lump-sum increases on bills regardless of usage (United States Energy Information Administration 2009).

Previous studies have shown that negative emotions, such as worry and fear, have a stronger impact on national policy support compared to positive emotions (Smith and Leiserowitz 2014; Rodriguez-Sanchez et al. 2018). Smith and Leiserowitz (2014) found hope to be a positive predictor of climate change policy acceptance, while Truelove (2012) discovered that positive emotions were associated with support for wind energy, and coal and nuclear were viewed more negatively. On the other hand, a study by Sjöberg (2007) revealed that negative emotions, such as fear and anger can influence the perception of genetically modified food, cell phones, terrorism, and radiation. Consumers' valuation represented by their WTP has also been found to be influenced by their emotions. For example, Kessler et al (2022) found short-term emotions influence economic decision-making.

Built upon the strands of these studies, we employ choice experiments to elicit consumers' WTP for alternative renewable energy sources, considering their emotions. The WTPs are measured by percentage increases in consumers' energy bills when their energy mix has one percent increase in a particular renewable energy source. We also employ a national survey representing consumers in the entire United State.

Empirical framework

In contrast to treating commodities as homogeneous in quality and divisible in quantity, recent studies focus on product quality attributes. Lancaster utility theory (1966) is the paradigm, that assumes households derive utility from attributes of commodities they consume. Households' decision is then what commodity attributes they would select instead of quantities to maximize utility. This is a hedonic study (Rosen 1974) and describes our study of energy type selection.

Random utility models, developed by McFadden (1975), are generally adopted for empirical studies employing survey data measuring consumer-stated preference. The randomness in utility is a result of either the random preferences of survey participants or a random subset of the complete set of information available to participants. In this framework, consider a household exposed to n combinations of alternative energy sources, then the random utility function for household i with combination j is

$$U_{ij} = V_{ij} + \varepsilon_{ij}, \quad j = 1 \text{ to } n, \tag{1}$$

where V_{ij} is the non-stochastic utility function and ε_{ij} is the stochastic component.

We consider four energy sources (biomass, solar, wind, and fossil), with denoting the share of source l in the energy mix. For the traditional fossil source (coal, natural gas, or oil), $l = 0$ and $l = 1$, 2, and 3 represent wind, solar, and biomass, respectively. Thenon-stochastic part is then

$$V_{ij} = \beta_{iP}P_{ij} + \Sigma_l \beta_{il} x_{ijl} + \beta_{i0}, \tag{2}$$

where P_{ij} is household i's price premium for the j^{th} combination of alternative energy sources, and x_{ijl} denotes for household i's share of energy source l in combination j. Variable x_{ijl} is the quantitatively measured attribute, which contributes to utility (see detailed description in the choice experiment design section below). With all shares adding up to one, we normalize the traditional energy x_{ij0} to be one for all i and j. Coefficient β_{iP} is the marginal utility of price for household i which should be negative, and β_{il} for $l = 0$, 1, 2, and 3 is the marginal utility of each energy source.

Household i's marginal WTP for energy source l is the utility tradeoff, where it is indifferent between paying a price premium for consuming a one percent increase in energy l or not

$$WTP_{il} = -\frac{\partial V_{ij}}{\partial x_{ijl}} \Big/ \frac{\partial V_{ij}}{\partial P_{iP}} = -\beta_{il}/\beta_{iP}. \tag{3}$$

In a choice experiment, each household is presented with m choice sets with each set containing the three energy sources (biomass, solar, and wind). Each household is asked to choose a single source k from each choice set. Household, i, will choose k only when it provides the highest utility among the three. Denoting Y as the observed choice number

$$Prob(Y_i = k) = Prob(U_{ik} \geq U_{il}), \; for \;\; l \neq k, \text{ and } l = 1, 2, 3. \tag{4}$$

A random parameter logit model is employed for estimating the attribute coefficients in (2) using a choice experiment survey with n participants, m choice sets, and s sources (total mns observations). Allowing for household heterogeneity, the estimated coefficients vary by household, are then treated randomly, and follow a joint normal distribution. The marginal WTP for each energy source then varies by household and is also random.

Choice experiment and survey

Survey design

Energy WTPs for traditional and renewables are estimated by applying a hedonic price model. This requires survey data on energy prices by a combination of energy sources and characteristics of the energy combination, household, and household property. Our choice experiment survey resulted in a nationally representative sample of United States residents. Participants were asked to choose among three energy alternatives with varying costs. The first two alternatives consisted of a combination of two energy sources and the third allowed the households to keep their current energy source (primarily sourced from fossil fuels: oil, gas, and coal).

Our experiment includes three attributes, which together define various energy plans. The first attribute is an energy source, which is a blend of renewable energy (biomass, solar, and wind) with traditional energy. Households can choose to keep their traditional energy source. The second attribute is the percentage of a renewable energy source blended with the traditional fossil-fuel-generated energy. Levels 5, 15, and 20% are used for renewable energy sources. Only one renewable energy source is included in each option, with the remaining percentage being the traditional source. The third attribute is the percentage increase (5, 15, and 20%) in the cost of monthly residential energy. Because the contribution to utility from each energy source depends on its amount in the blend, the percentage variable and the source variable enter the utility only in interaction, i.e., Solar X percentage. As a result, Equation (2) can be written specifically as the following when the energy variables are continuously measured by percentage instead of dummies and their coefficients are the marginal utilities brought by a percent point increase in the energy sources. This is under the assumption that both price and energy share are linearly related to utilities.

$$V_{ij} = \beta_{iP}P_{ij} + \beta_{i1}Solar_{ij} + \beta_{i2}Wind_{ij} + \beta_{i3}Biofuel_{ij} + \beta_{i0},\ Traditional_{ij}$$

A full factorial design results in $3^3(3^3-1)/2 = 351$choice sets. It is difficult to implement this magnitude of choice sets and obtain unbiased responses. We implemented a D-efficiency design yielding 60 choice sets divided into ten blocks. Figure 1 illustrates an example choice set. Each participant was asked to make one choice among A, B, and C options in each choice set and do this for six given choice sets. This represents the situation where households make a choice of energy produced with a particular percentage of a renewable source blended with fossil fuel at alternative price levels.

Survey characteristics

We employed a major U.S. online survey company to conduct a national online survey using their panel in 2018. The company provided incentives for participants to opt in. Our U.S. representative sample yielded 2282 surveyed households with completed answers to all questions used in this study. Summary statistics are listed in Table 1. We compare our sample characteristics to the 2017 United States Census. Households are from all 50 states

In the following section, you will be asked to make a choice among the three energy alternatives with different costs. Options A and B represent mixtures of the electricity energy sources indicated earlier, while Option C is the option to keep your current energy source without any changes. You will be asked to make such a choice six times independently.

There are several levels for each energy factor in the choice sets:

Cost refers to your total residence energy cost in a certain period, say a year, either at the current level (status quo) with 0% increase, or at an increase of 5%, 15%, and 30%.

Other than the conventional fossil fuel-generated energy you currently use, renewable energy sources are included such as wind, solar and biomass, each blended with your current energy source and replace it at a level of 5%, 10%, and 25%.	Choice A	Choice B	Choice C
Adding this renewable energy to my current one	Wind	Solar	
The percentage of the added renewable energy	5%	15%	Stay with my current energy
Your monthly energy bill will increase	15%	20%	0%
I will choose	( )	( )	( )

Figure 1. Example of a choice set.

with proportions similar to state populations. Our sample is 69% female, with an average age of 46 years, and 75% white. These statistics are slightly different from the national average of 49% female, average age of 38 years, and 61% white. The annual household income of $51,982 is slightly lower than the national median household income of $63,688.

We asked households about their energy consumption characteristics: residential size; electricity bills during the spring, fall, winter, and summer months; major energy sources used to generate their electricity; number of central air-conditioning units; and the setting of their thermostat during winter months. The average residential size is approximately 1590 square feet and average monthly electricity bills range from $138 during the spring and fall months to $178 during the winter months. The survey indicates that 81% of households use electricity generated by traditional fossil sources: coal or oil (45%) and natural gas (36%). Only 1% of households reported using wind and biofuel and 3% reported using solar as their residential energy source.

Previous research indicates emotions play a significant role in supporting environmentally friendly public policies (Smith and Leiserowitz 2014). Negative emotions concerning climate change may translate to prosocial behavior toward renewable energy. On a Likert scale, we asked households to rate the intensity of different emotions they felt while thinking about the issue of climate change. Emotional responses representing primary and emotions (Plutchik 1980) included depression, guilt, worry, interest, disgust, sadness, anger, hope, helplessness, and fear. We conducted a principal component analysis (PCA) for an ordinal scale system to create an index (Emindex), which represented these ten emotions for each household. The index represented the range of negative responses toward global warming. A higher index magnitude represents an increased intensity of negative response toward climate change. The PCA correlation matrix of ten emotion scores is reported in Appendix Table A1. The pairwise correlations are all positive and large.

https://doi.org/10.1017/age.2023.36 Published online by Cambridge University Press

Table 1. Summary statistics of the whole sample ($N = 2{,}282$)

Variable	Description	Mean	Std. Dev.	Min	Max
Demographics					
Female	Dummy for female gender	0.69	0.46	0	1
White	Dummy for race being white	0.75	0.44	0	1
Age	Age (years)	45.73	14.83	21	65
Income	Annual household income ($)	51,982	30,316	12,500	150,000
Education	Years in school (years)	13.62	1.63	10	17
Energy consumption					
Housesize	Area of house (square feet)	1590	1163	300	10,000
Elecexp	Monthly electricity bill ($)	138	143	0	1600
Winterexp	Winter month electricity ($)	174	185	0	1600
Summerexp	Summer month electricity ($)	166	177	0	1600
Sourcecoal	If major source is coal/oil	0.07	0.25	0	1
Sourcebiofuel	If the major source is biofuel energy	0.01	0.09	0	1
Sourcegas	If major source is gas	0.36	0.48	0	1
Sourcenuclear	If major source is nuclear	0.04	0.19	0	1
Sourceunkn	If major source is unknown	0.49	0.50	0	1
Sourcesolar	If major source is solar energy	0.03	0.17	0	1
Sourcewind	If major source is wind energy	0.01	0.08	0	1
Has_centAC	Has central air-conditioning	0.70	0.46	1	2
Emindex	Index created using the emotions toward global warming	−0.0001	2.233	−3.45	4.77
Consumers perceive positive or neutral environmental impact of energy sources					
Impactwind	Positive/neutral impact wind	0.93	0.26	0	1

(*Continued*)

https://doi.org/10.1017/age.2023.36 Published online by Cambridge University Press

Table 1. (*Continued*)

Variable	Description	Mean	Std. Dev.	Min	Max
Impactsolarshi	Positive/neutral impact solar shingle	0.93	0.25	0	1
Impactsolarpri	Positive/neutral impact solar private	0.93	0.25	0	1
Impactsolarfar	Positive/neutral impact solar farm	0.88	0.33	0	1
Impactcoal	Positive/neutral impact coal	0.85	0.36	0	1
Impactgas	Positive/neutral impact gas	0.93	0.26	0	1
Impactbiofuel	Positive/neutral impact biofuel	0.91	0.29	0	1
Consumers' belief that the future of energy should focus on the energy source					
Beliefgreen	Belief future renewable dummy	0.91	0.29	0	1
Beliefgas	Belief future gas dummy	0.75	0.44	0	1
Beliefsolarpri	Belief future solar private dummy	0.74	0.44	0	1
Beliefsolarshi	Belief future solar shingle dummy	0.84	0.37	0	1
Beliefbiomass	Belief future biomass dummy	0.67	0.47	0	1
Beliefbiofuel	Belief future biofuel dummy	0.52	0.50	0	1
Beliefwind	Belief future wind dummy	0.88	0.32	0	1
Democrat	If affiliated with democrat	0.19	0.39	0	1
Independent	If affiliated with independent.	0.14	0.35	0	1
Libertarian	If affiliated with libertarian.	0.01	0.07	0	1
Republican	If affiliated with republican.	0.15	0.36	0	1
Other-party	If not affiliated with the above	0.52	0.50	0	1
Midwest	Midwest region dummy	0.22	0.41	0	1
Northeast	Northeast region dummy	0.18	0.38	0	1
West	West region dummy	0.24	0.43	0	1
South	South region dummy	0.37	0.48	0	1

We also asked about households' beliefs about the environmental impact of several electricity sources: wave, tidal, wind, geothermal, solar shingles, solar private panels, solar farms, coal, natural gas, hydro, biofuel, and battery storage owed by companies or by private homes. The survey indicates that 93% of households feel that the wind, private solar panels, solar shingles, and natural gas have a positive or neutral environmental impact. In contrast, only 85% feel that way about coal. The households' perception of the environmental impact of coal is statistically different ($p < 0.01$) from their perceptions of the environmental impact of other energy sources. This implies among all sources, households considered coal as the least environmentally friendly.

Our survey also had questions to elicit households' beliefs about the environmental impact of replacing fossil fuels with renewables. Results indicate 91% of households believe renewable energy sources will be the future; ordered by solar shingles, natural gas, solar panels, biomass, and biofuels. Strong agreement exists among households concerning wind and solar energy, although there is a small disapproval for different forms of solar energy. Specifically, households consider massive solar panels installed as solar farms inferior to privately installed solar panels or solar shingles. There is also a larger disagreement concerning bioenergy.

Results

Energy preferences

Table 2 lists the WTP summary statistics. The WTP standard deviations for all four energy sources are significantly difference from zero ($p < 0.01$). This supports our adoption of the heterogeneity hypothesis of different WTPs for renewables relative to conventional energy. Further, the magnitudes of the three renewable WTP standard deviations are similar, which indicates that the level of preference heterogeneity for each of the energy types is similar among the households.

All the mean WTPs are also significantly different from zero at the 5% level. The positive marginal WTP estimate for solar energy is 0.15. This implies if 100% of the energy for a household is from a solar energy source, then the mean household is willing to pay a 15% higher energy bill. Households perceive solar energy as a higher utility compared to conventional energy. The additional utility for solar energy is likely perceived from the public environmental benefits a clean source of energy brings and households' prosocial satisfaction.

The estimated mean WTP for traditional energy is−7.1%. This implies in the absence of renewables if the only source of energy available to households is traditional energy, the households demand a discount of 7.1% off their energy bill. The estimates for the WTP for wind and biofuel are−11.5% and−65.1%, respectively. Households appear to dislike these two energy sources relative to traditional energy. Both wind and biofuel are controversial. In particular, the 65.1% discount for biofuel indicates a mean household demand to be paid for using biofuels. Their bias toward using food/feed for generating electricity and the questionable carbon footprint may explain their negative support for biofuel. The 11.25 discount of wind energy is smaller in magnitude with a lower significance level. These WTP estimates for renewable energy sources are consistent with previous studies (Borchers et al. 2007; Aguilar and Cai 2010).

WTP determinants

A WTP for each energy source is estimated for each household based on their response to six independent choice tasks. Regressing households' WTPs on their attitudes, emotions,

Table 2. Marginal WTP for alternative energy of the whole sample ($N = 2{,}282$)

	Mean	Std Dev	Covariance (nonrandom)		
			Solar	Wind	Biofuel
Solar	0.155***	1.031***			
	(0.041)	(0.053)			
Wind	−0.115**	0.991***	−0.836		
	(0.042)	(0.050)			
Biofuel	−0.651***	1.116***	−0.435	0.512	
	(0.057)	(0.048)			
Traditional	−0.071***	0.129***	0.087***	−0.082***	0.009
	(0.005)	(0.007)	(0.000)	(0.000)	
LR	7780.81***				

***, **, *denote significance at 1%, 5%, and 10% levels, respectively, with standard errors in parentheses.

and socioeconomic characteristics, we can draw inferences on factors affecting their WTPs. In Table 3, results indicate younger households have higher relative WTP for the three renewable energy sources. This is consistent with research indicating younger households have heightened environmental concerns (Shi et al. 2016). Similarly, households with higher income and education have enhanced WTP for solar and wind energy. These results are also consistent with general economic evidence that households with higher income often have higher WTP for products supporting environmental sustainability (Saphores et al. 2007) and educated households are often more aware of the environmental issues and assign higher utility to these factors (Sundt and Rehdanz 2015). Furthermore, people belonging to the White race have higher WTP for wind energy and households with a larger house have higher WTP for a biofuel source.

The seasonal electricity expenditure is generally insignificant, except for the summer months, which is significant, at the 5% level, for wind energy WTP. Households with higher summer electricity bills might be more aware of the positive aspects of renewable energy sources and concerned about the environmental effects of traditional fossil fuels.

Compared to those who don't know their current sources of energy, households knowing their current energy to be from fossil sources including coal, gas and oil show a high willingness to pay for all solar, wind, and biofuel, which is reasonable. In contrast, households with their current energy sourced from nuclear energy had lower WTP for wind power. Nuclear, itself is a type of energy that does not generate greenhouse gas nor emit any polluting emissions. Previous research indicates consumers are WTP for emission reduction via increased reliance on nuclear energy (Roe et al. 2001). Consumers with nuclear energy may not realize the benefit of adopting renewable energies for the sake of environmental protection.

The emotional index has a positive influence on households' WTP for all three renewable energy sources. Households with heightened environmental and/or climate change concerns exhibit higher WTP for renewable energy sources. Our results are supported by previous research, where environmental concern is an important determinant of WTP (Kotchen and Moore 2007; Ito et al. 2010).

Table 3. Estimation results of factors affecting WTPs from the whole sample ($N = 2,282$)

Variables	(1) Solar	(2) Wind	(3) Biofuel
Female	−0.0359	−0.0451	−0.0241
	(0.029)	(0.028)	(0.027)
White	0.0531	0.0682**	0.0255
	(0.034)	(0.032)	(0.032)
Age	−0.0079***	−0.0073***	−0.0048***
	(0.001)	(0.001)	(0.001)
Income	1.8e-6***	1.8e-6***	6e-7
	(1e-6)	(1e-7)	(1e-8)
Education	0.0234***	0.0160*	0.0014
	(0.009)	(0.009)	(0.008)
Housesize	−2.1e-6	8e-7	1.87e-5*
	(1.2e-5)	(1.2e-5)	(1e-5)
Elecexp	−0.0000	0.0000	−0.0000
	(0.000)	(0.000)	(0.000)
Winterexp	−0.0001	−0.0000	0.0000
	(0.000)	(0.000)	(0.000)
Summerexp	−0.0001	−0.0002*	−0.0001
	(0.000)	(0.000)	(0.000)
Sourcebiofuel	−0.0542	0.0131	−0.0016
	(0.094)	(0.084)	(0.113)
Sourceoil	0.1410***	0.1569***	0.1133**
	(0.054)	(0.053)	(0.054)
Sourcegas	−0.0131	−0.0205	−0.0196
	(0.030)	(0.029)	(0.028)
Sourcenuclear	−0.0929	−0.1311**	0.0333
	(0.063)	(0.066)	(0.074)
Sourcesolar	−0.0326	−0.0708	0.0129
	(0.092)	(0.086)	(0.074)
Sourcewind	−0.0131	−0.0206	−0.1960
	(0.204)	(0.174)	(0.141)
Has_centralAC	0.0054	−0.0038	0.0371
	(0.032)	(0.031)	(0.028)

(*Continued*)

Table 3. (*Continued*)

Variables	(1) Solar	(2) Wind	(3) Biofuel
Emindex	0.0571***	0.0620***	0.0248***
	(0.007)	(0.007)	(0.006)
Impactwind	0.0556	0.0609	−0.0312
	(0.061)	(0.057)	(0.067)
Impactsolarshine	−0.0539	−0.0480	−0.0324
	(0.066)	(0.065)	(0.068)
Impactsolarprivate	0.2096***	0.1565**	0.0171
	(0.063)	(0.062)	(0.067)
Impactsolarfarm	−0.0145	−0.0145	0.0165
	(0.042)	(0.041)	(0.044)
Impactcoal	−0.1709***	−0.1628***	−0.0800*
	(0.037)	(0.037)	(0.041)
Impactgas	0.0507	0.0312	−0.0244
	(0.060)	(0.058)	(0.055)
Impactbiofuel	0.0129	0.0576	0.1245**
	(0.052)	(0.050)	(0.051)
Beliefrenewable	0.0941**	0.0946**	−0.0380
	(0.047)	(0.046)	(0.047)
Beliefcoal	0.0448	0.0219	0.0696**
	(0.032)	(0.030)	(0.029)
Beliefsolarprivate	0.0047	−0.0050	−0.0064
	(0.031)	(0.030)	(0.029)
Beliefsolarshin	0.1236***	0.0916**	−0.0263
	(0.039)	(0.038)	(0.037)
Beliefbiomass	0.1274***	0.1342***	0.1166***
	(0.031)	(0.030)	(0.029)
Beliefbiofuel	−0.1515***	−0.1397***	0.0346
	(0.028)	(0.027)	(0.027)
Beliefwind	0.2213***	0.1909***	−0.0525
	(0.044)	(0.041)	(0.042)
Democrat	0.0743**	0.1014***	0.0009
	(0.037)	(0.036)	(0.034)
Independent	0.0461	0.0490	0.0061
	(0.040)	(0.037)	(0.036)

(*Continued*)

Table 3. (*Continued*)

Variables	(1) Solar	(2) Wind	(3) Biofuel
Libertarian	0.0621	0.0035	0.0863
	(0.195)	(0.153)	(0.180)
Republican	−0.0570	−0.0555	−0.0370
	(0.040)	(0.038)	(0.037)
Midwest	−0.0056	−0.0055	0.0103
	(0.037)	(0.036)	(0.035)
Northeast	−0.0922**	−0.0841**	−0.0361
	(0.041)	(0.040)	(0.037)
West	0.0056	0.0172	0.0343
	(0.036)	(0.034)	(0.033)
Constant	−0.3947***	−0.5240***	−0.5685***
	(0.139)	(0.135)	(0.135)
R-squared	0.212	0.216	0.058

***, **, *denote significance at 1%, 5%, 10% levels, respectively, with standard errors in parentheses.

To understand the beliefs and perceptions of households concerning the different energy sources, we considered households' perceptions of the positive environmental impact of energy sources. Households who believed that coal has a negative environmental impact had a higher WTP for all three renewable energy sources. We presented three alternative methods to harness solar energy: solar shingles, privately owned solar panels, and solar farms. Households believing private solar panels have a positive impact on the environment had higher WTPs for solar energy and wind energy sources, while the other two methods have no effect. Households who perceived positive impacts from biofuel energy on the environment had a higher WTP for biofuels.

We also examined households' beliefs concerning the impact of an energy source for future energy. A belief in biofuel hurts WTP for wind and solar sources, while the belief biomass will help curb pollution has a positive impact on the WTP for all three energy sources. A positive belief in wind and solar shingles has a significant increase in WTP for solar and wind energy sources. WTP for energy sources also varies with households' political status. Democrat households have higher WTP for both wind and solar energy sources. Those who live in the northeastern region of the United States have lower WTP for wind and solar energy.

The overall results indicate households perceive solar energy as the preferred energy source in terms of environmental protection followed by wind energy. Energy generated through biomass is quite controversial and has not received customer acceptance. The highest WTP occurs from younger, higher income, and better-educated households with coal and oil as a current energy source, greater concern for environmental and climate change risks, and a negative coal perception.

Robustness check

We have done a robustness check for the same analysis when excluding all households who don't know their current source of energy. Using the subsample of 1157 observations, descriptive statistics, WTP estimates, and the regression analysis of factors affecting WTP are presented in Appendix Tables A2–A4.

The descriptive statistics of all variables for the subsample are very similar to those of the whole sample. The WTP estimates also have the same signs and significance except for that WTP for wind energy is negative but insignificant for this subsample compared with the significantly small negative size. The WTP for solar energy is slightly higher for those who know their current source, 0.267 instead of 0.15.

The determinants of the WTPs also remain quite similar. Notice for the sample without those who don't know their energy source, we use those who know their energy source is biofuel as the default for those source dummy variables, so this affects the signs and significance of all dummy variables in this energy source category but no other variables. The significant variables remain highly similar with the same signs.[2]

Government mechanisms for renewables

As governmental incentives are motivating a shift toward renewables, an accurate understanding of household prosocial behavior is required to develop optimal government mechanisms. From an electric utility perspective, understanding marginal increases in household electricity expenditures from marginal shifts toward renewables aids in efficient adjustments facing a dynamic electricity market. This also allows the government to better understand the demand for renewables required for developing mechanisms that mesh with household prosocial behavior.

As an application, considering the optimal government mechanism for solar energy, Liu et al. (2018) estimated an optimal subsidy of 7.69 cents/kWh, which did not consider any possible household prosocial behavior. Mating this with our estimate of households' WTP of 15% more for solar energy and a national average of 13.14 cents/kWh instead results in a 5.71 cents/kWh optimal subsidy[3] (EIA 2020). Assuming no motivational crowding (Frey and Jegen, 2001), this results in a 26% reduction in the subsidy.[4] Furthermore, for those who know their current energy sources, this subsidy saving rises to 44.4%。 In contrast, biomass and wind energy would not exhibit any similar prosocial reduction. When determining efficient policies and programs, policymakers should consider these varying levels of prosocial behavior across renewable energy sources.

Conclusion and policy implications

As we aim to migrate away from fossil fuels and promote energy sustainability, renewable energy must play an increasingly dominant role. However, renewable energy technologies are generally more expensive than fossil fuels, especially since they are still in their early stages of development. In order for renewables to be widely adopted, the government needs to provide incentives to encourage adoption. The magnitude of these incentives depends on households' preferences for renewable energy and their associated demand.

[2]We have done the same analysis for those who don't know their sources of current energy mix. The results are by-an-large the same as the full sample. The results are not presented in the paper but can be requested from the author.

[3]The optimal subsidy calculates to 5.71 as 7.69–13.14*0.15 = 7.69–1.97 = 5.71.

[4]The reduction in subsidy amounts to (1−5.71/7.69) = 0.256.

Any positive prosocial behavior toward renewables will affect the magnitude of any governmental mechanisms. Our results indicate that households have a significant prosocial behavior toward solar energy, which reduces the optimal solar subsidy. This prosocial behavior is not universal across renewable energies. For instance, biomass energy has an inverse social behavior (anti-social behavior), so any government incentives for biomass would have to overcome both a higher cost differential and anti-social behavior. If biomass is to become a relevant feature of our energy mix, educational programs on the nature of its sustainability that change household perceptions will be required. Wind energy appears to be relatively neutral regarding its associated social behavior.

To fully comprehend the relationship between prosocial behavior, governmental mechanisms, and renewable adoption, we need to examine how they interact with each other. We have explored the varying degrees of prosocial behavior across renewable energy source alternatives. However, we also need to take into account how governmental subsidies can potentially reduce (crowd out) prosocial behavior. We have pieced together a major component of this puzzle by empirically unraveling the different magnitudes of prosocial behavior across renewable alternatives. Missing is the magnitude of possible motivation crowding out where a government mechanism may reduce (crowd out) prosocial behavior. For example, households may be less willing to voluntarily pay more for a renewable energy source if they receive a government subsidy for using it, reducing their reputation for prosocial behavior.

Understanding these differences in prosocial behavior are not only interesting theoretically, but also for determining the future of our energy power generation. Similar to markets in general, household preferences play a significant role in shaping energy markets. The market effect on nuclear power following Three-Mile Island, Chernobyl, and Fukushima Daiichi incidences is a clear example of this. The future mix of renewables with fossil fuels will be determined by these household preferences. Failure to understand households' preferences and prosocial behavior toward alternatives may lead to inefficient government mechanisms but possibly failure.

Data availability statement. Data is collected from human subjects and is protected under the Institutional Review Board (IRB) at Purdue University. It can made available on request to Purdue IRB.

Authors' contribution. The first three authors formulate the study, develop the model, advise student coauthors in survey design and econometric analysis, and write the article. Jiang conducted the econometric estimation. Weiland designed and administered the survey primarily.

Funding statement. Authors acknowledge the National Institute of Food and Agriculture, United State Department of Agriculture (USDA), Power Plants rejuvenated with Biomass: An Economic, Social, and Environmentally Sustainable Transition to Clean Power grant funding (Program director and co-investigators).

Competing interests. The authors declare that they have no conflict of interest.

Ethical standard. Approved by the IRB of Purdue University.

Code availability. Can be available on request to the authors.

Consent to participate. A paragraph is included in the survey and has been approved by IRB of Purdue University.

Consent for publication. No survey participants' individual information is in the publication. All coauthors agree to publish this manuscript.

References

Aguilar FX and Cai Z (2010) Exploratory analysis of prospects for renewable energy private investment in the US. *Energy Economics* **32**, 1245–1252.

Bamwesigye D (2023) Willingness to pay for alternative energies in Uganda: energy needs and policy instruments towards zero deforestation 2030 and climate change. *Energies* **16**, 980.

Bergmann A, Hanley N and Wright R (2006) Valuing the attributes of renewable energy investments. *Energy Policy* **34**, 1004–1014.

Borchers AM, Duke JM and Parsons GR (2007) Does willingness to pay for green energy differ by source? *Energy Policy* **35**, 3327–3334.

Boxall PC, Adamowicz WL, Swait J, Williams M and Louviere J (1996) A comparison of stated preference methods for environmental valuation. *Ecological Economics* **18**, 243–253.

Bénabou R and Tirole J (2006) Incentives and prosocial behavior. *American Economic Review* **96**, 1652–1678.

Byrnes JP, Miller DC and Schafer WD (1999) Gender differences in risk taking: a meta-analysis. *Psychological Bulletin* **125**, 367.

Delmas MA and Gergaud O (2021) Sustainable practices and product quality: Is there value in eco-label certification? The case of wine. *Ecological Economics* **183**, 106953.

Erdem C, Şentürk İ and Şimşek T (2010) Identifying the factors affecting the willingness to pay for fuel-efficient vehicles in Turkey: A case of hybrids. *Energy Policy* **38**, 3038–3043.

Ethier RG, Poe GL, Schulze WD and Clark J (2000) A comparison of hypothetical phone and mail contingent valuation responses for green-pricing electricity programs. *Land Economics*, 54–67.

E&E Publishing, LLC (2016) E&E's Power Plan Hub: Indiana. Available at http://www.eenews.net/interactive/clean_power_plan/states/indiana.

EIA, Energy Information Administration, Department of Energy, Electric Power Monthly (2020) https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_6_a

Frey B and Jegen R (2001) Motivation crowding theory. *Journal of Economic Surveys* **15**, 589–611. https://doi.org/10.1111/1467-6419.00150

Gneezy A, Imas A, Brown A, Nelson LD and Norton MI (2012) Paying to be nice: Consistency and costly prosocial behavior. *Management Science* **58**, 179–187.

Gossling S, Kunkel T, Schumacher K, Heck N, Birkemeyer J, Froese J, Naber N and Schliermann E (2005) A target group-specific approach to "green" power retailing: students as consumers of renewable energy. *Renewable and Sustainable Energy Reviews* **9**, 69–83.

Guerra A and Harrington B (2021) Why do people pay taxes? Explaining tax compliance by individuals. *Handbook on the Politics of Taxation*, 355–373.

IEA I (2017) Energy technology perspectives 2017. *Catalysing Energy Technology Transformations.* https://www.eia.gov/todayinenergy/detail.php?id=43895#

Ito N, Takeuchi K, Tsuge T and Kishimoto A (2010) Applying threshold models to donations to a green electricity fund. *Energy Policy* **38**, 1819–1825.

Kessler JB, McClellan A, Nesbit J and Schotter A (2022) Short-term fluctuations in incidental happiness and economic decision-making: experimental evidence from a sports bar. *Experimental Economics* **25**, 141–169.

Kotchen MJ and Moore MR (2007) Private provision of environmental public goods: Household participation in green-electricity programs. *Journal of Environmental Economics and management* **53**, 1–16.

Koundouri P, Kountouris Y and Remoundou K (2009) Valuing a wind farm construction: A contingent valuation study in Greece. *Energy Policy* **37**, 1939–1944.

Lai J, Wang HH, Ortega DL and Widmar NJO (2018) Factoring Chinese consumers' risk perceptions into their willingness to pay for pork safety, environmental stewardship, and animal welfare. *Food Control* **85**, 423–431.

Lancaster KJ (1966) A new approach to consumer theory. *Journal of Political Economy* **74**, 132–157.

Li H, Jenkins-Smith HC, Silva CL, Berrens RP and Herron KG (2009) Public support for reducing US reliance on fossil fuels: Investigating household willingness-to-pay for energy research and development. *Ecological Economics* **68**, 731–742.

Liu S, Colson G and Wetzstein M (2018) Biodiesel investment in a disruptive tax-credit policy environment. *Energy Policy* **123**, 19–30.

Longo A, Markandya A and Petrucci M (2008) The internalization of externalities in the production of electricity: willingness to pay for the attributes of a policy for renewable energy. *Ecological economics* **67**, 140–152.

Loureiro ML and Lotade J (2005) Do fair trade and eco-labels in coffee wake up the consumer conscience? *Ecological Economics* **53**, 129–138.

McFadden D (1975) The revealed preference of a public bureaucracy: Theory. *The Bell Journal of Economics* **6**, 55–72.

Mozumder P, Vásquez WF and Marathe A (2011) Consumer" preference for renewable energy in the southwest USA. *Energy Economics* **33**, 1119–1126.

Murakami K, Ida T, Tanaka M and Friedman L (2015) Consumer" willingness to pay for renewable and nuclear energy: A comparative analysis between the US and Japan. *Energy Economics* **50**, 178–189.

Noblet CL, Teisl MF, Evans K, Anderson MW, McCoy S and Cervone E (2015) Public preferences for investments in renewable energy production and energy efficiency. *Energy Policy* **87**, 177–186.

Ortega DL, Wang HH, Widmar NJO and Wu L (2014) Chinese producer behavior: Aquaculture farmers in southern China. *China Economic Review* **28**, 17–24.

Plutchik R (1980) A general psychoevolutionary theory of emotion. In Plutchik R and Kellerman H (eds), *Emotion: Theory, Research, and Experience, Vol. 1: Theories of Emotion*. New York: Academic Press, pp. 3–31.

Rode DC, Fischbeck PS and Páez AR (2017) The retirement cliff: Power plant lives and their policy implications. *Energy Policy* **106**, 222–232.

Roe B, Teisl MF, Levy A and Russell M (2001) US consumers' willingness to pay for green electricity. *Energy Policy* **29**, 917–925.

Roddis P, Carver S, Dallimer M, Norman P and Ziv G (2018) The role of community acceptance in planning outcomes for onshore wind and solar farms: An energy justice analysis. *Applied energy* **226**, 353–364.

Rodriguez-Sanchez C, Schuitema G, Claudy M and Sancho-Esper F (2018) How trust and emotions influence policy acceptance: The case of the Irish water charges. *British Journal of Social Psychology* **57**, 610–629.

Rosen S (1974) Hedonic prices and implicit markets: product differentiation in pure competition. *Journal of Political Economy* **82**, 34–55.

Sanchez B (2020) Fossil fuels continue to account for the largest share of U.S. energy. *Today in Energy*, U.S. energy Information Administration, September 14. https://www.eia.gov/todayinenergy/detail.php?id=45096

Sánchez-Pantoja N, Vidal R and Pastor MC (2018) Aesthetic impact of solar energy systems. *Renewable and Sustainable Energy Reviews* **98**, 227–238.

Saphores JDM, Nixon H, Ogunseitan OA and Shapiro AA (2007) California household" willingness to pay for 'green' electronics. *Journal of Environmental Planning and Management* **50**, 113–133.

Scarpa R and Willis K (2010) Willingness-to-pay for renewable energy: Primary and discretionary choice of British households' for micro-generation technologies. *Energy Economics* **32**, 129–136.

Shi J, Visschers VH, Siegrist M and Arvai J (2016) Knowledge as a driver of public perceptions about climate change reassessed. *Nature Climate Change* **6**, 759–762.

Smith N and Leiserowitz A (2014) The role of emotion in global warming policy support and opposition. *Risk Analysis* **34**, 937–948.

Sjöberg L (2007) Emotions and risk perception. *Risk Management* **9**, 223–237.

Sundt S and Rehdanz, K (2015) Consu'er" willingness to pay for green electricity: A meta-analysis of the literature. *Energy Economics* **51**, 1–8.

Thornton EM, Aknin LB, Branscombe NR and Helliweal JF (2019) Prosocial perceptions of taxation predict support for taxes. *PLoS ONE* **14**, e0225730.

Truelove HB (2012) Energy source perceptions and policy support: Image associations, emotional evaluations, and cognitive beliefs. *Energy Policy* **45**, 478–489.

US Energy Information Administration (2009) Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009. http://www.eia.doe.gov/oiaf/servicerpt/hr2454/pdf/sroiaf%282009%2905.pdf.

Vainio A, Paloniemi R and Varho V (2017) Weighing the risks of nuclear energy and climate change: Trust in different information sources, perceived risks, and willingness to pay for alternatives to nuclear power. *Risk Analysis* **37**, 557–569.

Venere E (2012) Indiana Electricity Rates Projected to Rise from New Clean-air Rules January 25, University News Service. Purdue University. Available at: http://www.purdue.edu/newsroom/research/2012/120125GothamCleanair.html

Zarnikau J (2003) Consumer demand for 'green power' and energy efficiency. *Energy Policy* **31**, 1661–1672.

Zografakis N, Sifaki E, Pagalou M, Nikitaki G, Psarakis V and Tsagarakis KP (2010) Assessment of public acceptance and willingness to pay for renewable energy sources in Crete. *Renewable and Sustainable Energy Reviews* **14**, 1088–1095.

Appendix A

Table A1. Correlation matrix of emotion variables

	Depression	Guilt	Worry	Interest	Disgust	Sadness	Anger	Hope	Helpless	Fear
Depression	1									
Guilt	0.70	1.00								
Worry	0.63	0.53	1.00							
Interest	0.75	0.67	0.62	1.00						
Disgust	0.79	0.71	0.65	0.79	1.00					
Sadness	0.22	0.18	0.45	0.20	0.21	1.00				
Anger	0.70	0.67	0.52	0.70	0.73	0.24	1.00			
Hope	0.71	0.64	0.57	0.67	0.71	0.26	0.68	1.00		
Helpless	0.72	0.65	0.59	0.83	0.76	0.17	0.66	0.64	1.00	
Fear	0.84	0.70	0.67	0.76	0.80	0.23	0.69	0.69	0.72	1.00

Table A2. Summary statistics for the subsample: knowing their energy sources ($N = 1157$)

Variable	Description	Mean	Std. Dev.	Min	Max
Demographics					
Female	Dummy for female gender	0.67	0.47	0	1
White	Dummy for race being white	0.69	0.46	0	1
Age	Age (years)	43.11	14.80	21	65
Income	Annual household income ($)	55,510	30,560	12,500	150,000
Education	Years in school (years)	13.69	1.61	10	17
Energy consumption					
Housesize	Area of house (square feet)	1661	1290	300	10,000
Elecexp	Monthly electricity bill ($)	137	156	0	1600

(*Continued*)

Table A2. (*Continued*)

Variable	Description	Mean	Std. Dev.	Min	Max
Winterexp	Winter month electricity ($)	174	204	0	1600
Summerexp	Summer month electricity ($)	166	190	0	1600
Sourcecoal	If major source is coal/oil	0.13	0.34	0	1
Sourcebiofuel	If major source is biofuel energy	0.02	0.12	0	1
Sourcegas	If major source is gas	0.71	0.45	0	1
Sourcenuclear	If major source is nuclear	0.04	0.18	0	1
Sourceother	If major source is other than the options	0.00	0.00	0	0
Sourcesolar	If major source is solar energy	0.06	0.23	0	1
Sourcewind	If major source is wind energy	0.01	0.12	0	1
Has_centAC	Has central air-conditioning	0.73	0.45	1	2
Emindex	Index created using the emotions toward global warming	0.19	2.24	−3.45	4.78
Consumers perceive positive or neutral environmental impact of energy sources					
Impactwind	Positive/neutral impact wind	0.92	0.27	0	1
Impactsolarshi	Positive/neutral impact solar shingle	0.92	0.27	0	1
Impactsolarpri	Positive/neutral impact solar private	0.93	0.26	0	1
Impactsolarfar	Positive/neutral impact solar farm	0.88	0.32	0	1
Impactcoal	Positive/neutral impact coal	0.84	0.37	0	1
Impactgas	Positive/neutral impact gas	0.93	0.26	0	1
Impactbiofuel	Positive/neutral impact biofuel	0.90	0.31	0	1
Consumers' belief that the future of energy should focus on the energy source					
Beliefgreen	Belief future renewable dummy	0.92	0.28	0	1
Beliefgas	Belief future gas dummy	0.77	0.42	0	1
Beliefsolarpri	Belief future solar private dummy	0.74	0.43	0	1
Beliefsolarshi	Belief future solar shingle dummy	0.84	0.37	0	1
Beliefbiomass	Belief future biomass dummy	0.70	0.46	0	1
Beliefbiofuel	Belief future biofuel dummy	0.52	0.50	0	1
Beliefwind	Belief future wind dummy	0.89	0.32	0	1
Democrat	If affiliated with democrat	0.20	0.40	0	1
Independent	If affiliated to independent.	0.13	0.34	0	1
Libertarian	If affiliated with libertarian.	0.004	0.066	0	1
Republicans	If affiliated with Republicans.	0.15	0.35	0	1

(*Continued*)

Table A2. (*Continued*)

Variable	Description	Mean	Std. Dev.	Min	Max
Other-party	If not affiliated with the above	0.52	0.50	0	1
Midwest	Midwest region dummy	0.20	0.40	0	1
Northeast	Northeast region dummy	0.13	0.34	0	1
West	West region dummy	0.24	0.43	0	1
South	South region dummy	0.32	0.47	0	1

Table A3. Marginal WTP for alternative energy of the subsample ($N = 1{,}157$)

			Covariance (nonrandom)		
	Mean	Std Dev	Solar	Wind	Biofuel
Solar	0.267***	1.087***			
	(0.066)	(0.085)			
Wind	−0.077	1.141***	−0.994***		
	(0.073)	(0.090)	(0.000)		
Biofuel	−0.775***	1.452***	−0.609	0.872***	
	(0.100)	(0.868)		(0.000)	
Traditional	−0.089***	0.154***	0.073***	−0.071***	0.016***
	(0.009)	(0.013)	(0.000)	(0.000)	(0.000)
LR	33420.41***				

***, **, *denote significance at 1%, 5%, and 10% levels, respectively, with standard errors in parentheses.

Table A4. Estimation results of factors affecting WTPs from the subsample ($N = 1{,}157$)

	(1)	(2)	(3)
Variables	Solar	Wind	Biofuel
Female	−0.0422	−0.0372	−0.0471
	(0.040)	(0.042)	(0.052)
White	0.0499	0.0935**	0.0665
	(0.044)	(0.046)	(0.056)
Age	−0.0089***	−0.0087***	−0.0072***
	(0.001)	(0.001)	(0.002)

(*Continued*)

Table A4. (*Continued*)

Variables	(1) Solar	(2) Wind	(3) Biofuel
Income	2.08e-06***	2.44e-06***	1.04e-06
	(6.71e-07)	(7.04e-07)	(8.88e-07)
Education	0.0065	0.0031	−0.0043
	(0.013)	(0.013)	(0.016)
House size	1.13e-05	1.14e-05	3.18e-05*
	(1.49e-05)	(1.61e-05)	(1.70e-05)
Elecexp	9.82e-05	0.000135	−4.91e-05
	(0.000135)	(0.000127)	(0.000125)
Winterexp	−0.000134	−0.000102	4.97e-05
	(0.000126)	(0.000116)	(0.000130)
Summerexp	−0.000116	−0.000171	−0.000105
	(0.000123)	(0.000123)	(0.000141)
Sourceoil	0.1692	0.0867	0.1120
	(0.121)	(0.122)	(0.151)
Sourcegas	0.0365	−0.0774	−0.0498
	(0.111)	(0.110)	(0.137)
Sourcenuclear	−0.0522	−0.1972	0.0383
	(0.122)	(0.126)	(0.165)
Sourcesolar	0.0659	−0.0696	0.0414
	(0.140)	(0.139)	(0.166)
Sourcewind	0.0157	−0.0981	−0.2804
	(0.212)	(0.205)	(0.230)
Has_centralAC	−0.0587	−0.0697	0.0016
	(0.044)	(0.047)	(0.054)
Emindex	0.0445***	0.0568***	0.0341***
	(0.009)	(0.010)	(0.012)
Impactwind	0.1024	0.0932	−0.0164
	(0.077)	(0.079)	(0.114)
Impactsolarshine	−0.0637	−0.0472	−0.0736
	(0.081)	(0.090)	(0.112)
Impactsolarprivate	0.2066***	0.1810**	0.0713
	(0.079)	(0.087)	(0.125)

(*Continued*)

Table A4. (*Continued*)

Variables	(1) Solar	(2) Wind	(3) Biofuel
Impactsolarfarm	−0.0106	−0.0197	0.0120
	(0.061)	(0.066)	(0.085)
Impactcoal	−0.2433***	−0.2387***	−0.1774**
	(0.050)	(0.055)	(0.076)
Impactgas	−0.0106	−0.0244	−0.1669*
	(0.080)	(0.084)	(0.097)
Impactbiofuel	−0.0281	0.0297	0.1309
	(0.063)	(0.067)	(0.084)
Beliefrenewable	0.1226*	0.1270*	−0.0760
	(0.066)	(0.069)	(0.088)
Beliefcoal	0.0513	0.0050	0.0440
	(0.043)	(0.045)	(0.054)
Beliefsolarprivate	0.0212	0.0006	−0.0022
	(0.044)	(0.045)	(0.055)
Beliefsolarshin	0.1117**	0.0857	0.0284
	(0.049)	(0.053)	(0.067)
Beliefbiomass	0.1065***	0.1186***	0.1236**
	(0.041)	(0.044)	(0.054)
Beliefbiofuel	−0.1478***	−0.1247***	0.0727
	(0.038)	(0.040)	(0.050)
Beliefwind	0.2229***	0.2231***	0.0550
	(0.058)	(0.059)	(0.069)
Democrat	0.0607	0.1206**	−0.0774
	(0.049)	(0.052)	(0.060)
Independent	0.0332	0.0516	−0.0895
	(0.058)	(0.060)	(0.067)
Libertarian	0.1927	0.1157	0.2389
	(0.316)	(0.304)	(0.423)
Republicans	0.0128	0.0084	−0.0807
	(0.053)	(0.056)	(0.070)
Midwest	−0.0276	−0.0364	−0.0183
	(0.050)	(0.054)	(0.064)

(*Continued*)

Table A4. (*Continued*)

Variables	(1) Solar	(2) Wind	(3) Biofuel
Northeast	−0.1617***	−0.1812***	−0.1402**
	(0.056)	(0.059)	(0.070)
West	−0.0773	−0.0810	−0.0645
	(0.050)	(0.053)	(0.064)
Constant	0.0429	−0.1692	−0.3828
	(0.230)	(0.236)	(0.283)
R-squared	0.212	0.210	0.077

***, **, *denote significance at 1%, 5%, and 10% levels, respectively, with standard errors in parentheses.

Cite this article: Katare, B., H. H. Wang, M. Wetzstein, Y. Jiang, and B. Weiland (2024). "Renewable energy prosocial behavior, is it source dependent?" *Agricultural and Resource Economics Review* **53**, 185–207. https://doi.org/10.1017/age.2023.36