Will the residents choose to pay more for clean energy to meet the increasing power demand ? Empirical study using the double bound dichotomous choice method for Tianjin, China

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Jun 25th , Beihang University

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Introduction

- The excessive use of fossil fuels has caused serious greenhouse effects and air pollution.

- The power industry is the largest consumer of fossil fuels in China and is also the sector with the highest carbon emissions.

- **With the booming economy, the power demand in China is still increasing.**

  - During the “13th Five-Year Plan” period (2016-2020), the annual average growth rate for total electricity consumption is predicted to be 5.5%–7.5%, and is forecasted to reach 7.6 to 8.4 TWh in 2020

Introduction

- From a global perspective, fossil fuels are limited and non-renewable, alleviating society's dependence on fossil fuels is an urgent problem that needs to be solved.
- Countries are induced to look for alternatives to fossil fuels to meet the increasing power demand.
- **Developing clean energy is a critical issue**

- Clean energy contributes to reducing excessive dependence on fossil fuels and enhances energy supply security
- The application of green electricity can reduce pollutant emissions, improve air quality, and mitigate climate change.

Introduction

- Although the costs of clean energy have decreased considerably as the renewable energy technology industry has expanded, they are still higher than thermal power costs
- It is critical to investigate whether residents are willingness to pay (WTP) for clean energy and how much they are willingness to pay for it.

- An increasing number of people show a willingness to pay (WTP) for clean energy instead of suffering from air pollution.
- However, WTP for clean energy differs among different groups of residents.
- An increasing number of studies have evaluated the WTP for clean energy by different method.

Introduction

Aim

- Investigating whether residents in Tianjin are willing to pay for clean energy and calculate the WTP for it.
- Exploring the potential variables affecting residents' attitudes towards clean energy and their WTP.
- Comparing the results between double-bounded dichotomous choice and open-ended method.

Literature review

- CVM was considered to be one of the most valuable methods for estimating public goods and environmental products.
- The elicitation technique, which is the format of the questions given to respondents, is an important factor affecting the results of the WTP, including dichotomous choice, open-ended questions and payment card.

Table 1. Summary for different elicitation techniques.

Elicitation	References	Survey area	Advantage	Disadvantage
Dichotomous choice	Zografakis et al. (2010)	Cretan	Simple question with less confusion and higher statistical (Aldy et al., 2012; Hanemann et al., 1991)	Less convenient for statistics
	Yoo and Kwak (2009)	Korean		
Open-ended questions	Zorić and Hrovatin (2012)	Slovenia	Respondents can directly give the value(Kosenius and Ollikainen, 2013)	Uncertainty might be far from the real value
	Abdullah and Jeanty (2011)	Kenya		
Payment card	Bigerna and Polinori (2014)	Italian	Easy to give response (Zhang and Wu, 2012)	Affected by the bidding price
	(Zhang and Wu (2012))	China		

Yoo S H, Kwak S Y. Willingness to pay for green electricity in Korea: A contingent valuation study[J]. Energy Policy, 2009, 37(12):5408-5416.

Zhang L, Wu Y. Market segmentation and willingness to pay for green electricity among urban residents in China: The case of Jiangsu Province[J]. Energy Policy, 2012, 51(4):514-523.

Zografakis N, Sifaki E, Pagalou M, et al. Assessment of public acceptance and willingness to pay for renewable energy sources in Crete[J]. Renewable & Sustainable Energy Reviews, 2010, 14(3):1088-1095.

Methodology

- Double bound dichotomous choice (DBDC) method

$$F_{WTP}(B) = [1 + \exp(\alpha - \beta(B))]^{-1} \quad (1)$$

$$\begin{aligned} P[Yes/Yes] &= P_{YY} = 1 - F_{WTP}(B^U) \\ P[Yes/No] &= P_{YN} = F_{WTP}(B^U) - F_{WTP}(B) \\ P[No/Yes] &= P_{NY} = F_{WTP}(B) - F_{WTP}(B^L) \\ P[No/No] &= P_{NN} = F_{WTP}(B^L) \end{aligned} \quad (2)$$

$$Ln(L) = \sum_{i=1}^{n} [I_{YY} Ln(P_i^{YY}) + I_{YN} Ln(P_i^{YN}) + I_{NY} Ln(P_i^{NY}) + I_{NN} Ln(P_i^{NN})] \quad (3)$$

$$E(WTP) = \frac{1}{\beta} Ln[1 + \exp(\alpha)] \quad (4)$$

$$\alpha = \sum_{j=1}^{k} \gamma_j X_j \quad (5)$$

Kim J, Park J, Kim H, et al. Assessment of Korean customers' willingness to pay with RPS. Renewable and Sustainable Energy Reviews, 2012, 16(1): 695-703.

Results and discussions

➢ Variable definition and descriptive statistics

- In this survey, a total of 779 questionnaires were collected, of which 682 were valid, the effective response rate reaches 87.55%.

Table 2. Definitions and sample statistics of the variables.

Variables	Definition	Mean	Std. Dev.	Min	Max
Environment	Awareness of the environmental issues	3.686	0.786	1	5
Belief	Belief on the authority for environmental governance	3.169	0.935	1	5
Knowledge	Dummy variable, 1 = respondent knows about green electricity	0.755	0.430	0	1
Behavior	Previous behavior to energy conservation and emissions reduction	3.497	0.785	1	5
Gender	Dummy variable, 1 = male, 0 = female	0.547	0.498	0	1
Age	Age of respondents	2.116	1.071	1	6
Education	Dummy variable, 1 if the respondent have a bachelor degree.	0.677	0.467	0	1
Family size	Total number of household members	3.370	1.089	1	9
Income	Total monthly household income	2.548	1.168	1	5
Disease	Dummy variable, 1 = someone in the respondent's family suffers from respiratory disease	0.311	0.463	0	1
Bid	Initial bid	-	-	1 5	100

Results and discussions

➢Variable definition and descriptive statistics

Table 3. Reasons for the non-positive WTP responses.

Motives	Description	Number (%)
Genuine zero responses	The air quality is good enough and does not need to be improved.	0 (0.00)
	I am willing to pay, but the household income is not enough to bear the extra cost.	37 (15.10)
	The extra cost should be paid by the government and polluters.	120 (48.98)
Protest responses	I do not trust government and related departments.	42 (17.14)
	The cost has been included in the taxes and fees.	46 (18.78)
Total		245 (100.00)

Table 4. Number of questionnaires for different initial bids.

Initial bid	Higher bid	Lower bid	Number (%)
15	30	10	132 (19.35%)
30	50	15	130 (19.06%)
50	80	30	141 (20.67%)
80	100	50	144 (21.11%)
100	130	80	135 (19.79%)
Total			682 (100.00%)

Results and discussions

➢Variable definition and descriptive statistics

Table 5. Means of the variables by distribution of responses.

Variable	No-No	No-Yes	Yes-No	Yes-Yes
Environment	3.572	3.748	3.808	3.812
Belief	3.170	3.279	3.101	3.143
Knowledge	0.655	0.865	0.814	0.874
Behavior	3.494	3.452	3.576	3.459
Gender	0.506	0.529	0.558	0.664
Age	2.176	2.269	1.946	2.000
Education	0.515	0.798	0.853	0.832
Member	3.497	3.221	3.264	3.261
Income	2.127	2.644	2.798	3.361
Disease	0.300	0.327	0.295	0.345
Bid	66.742	56.875	37.984	42.941
Number	330	104	129	119

Results and discussions

➢Variable definition and descriptive statistics

Table 6. Regression results.

Variable	Logit model
Environment	0.028
Belief	0.062 ***
Knowledge	0.129 **
Behavior	-0.017
Gender	0.182 ***
Age	-0.024
Education	0.190 ***
Family size	-0.035 *
Income	0.178 ***
Disease	0.017
Bid	-0.006 ***
Constant	-1.476
Pseudo R^2	0.301
Total	682

Results and discussions

➢ Empirical results

Table 7. Grouping analysis results.

	Disease		Knowledge		Gender		Age	
	Disease	Healthy	Familiar	Unfamiliar	Male	Female	Old	Young
Environment	0.062	0.029	0.022	0.046	0.032	0.009	-0.019	0.057*
Belief	0.072*	0.067**	0.070**	0.075*	0.031	0.121***	0.000	0.091***
Knowledge	0.220**	0.079			0.131*	0.115	0.121*	0.135**
Behavior	-0.029	-0.017	0.005	-0.053	-0.002	-0.051	0.047	-0.046
Gender	0.207***	0.175***	0.197***	0.190**			0.203***	0.148***
Age	-0.053	-0.012	-0.024	-0.024	-0.002	-0.065*		
Education	0.276***	0.155**	0.185***	0.296***	0.140**	0.303***	0.109	0.193***
Family size	-0.035	-0.033	-0.035	-0.044	-0.015	-0.075**	-0.065**	-0.021
Income	0.128***	0.199***	0.210***	0.107***	0.178***	0.181***	0.185***	0.174***
Disease			0.063	-0.123	0.024	0.018	-0.041	0.073
Bid	-0.004***	-0.006***	-0.007***	-0.004***	-0.005***	-0.007***	-0.004***	-0.006***
Constant	-1.527	-1.511	-1.284	-2.124	-1.194	-1.568	-1.609	-1.538
Pseudo R^2	0.281	0.308	0.281	0.218	0.270	0.327	0.404	0.273
WTP	111.106	66.940	84.351	46.841	104.970	49.708	77.082	78.887
Number	212	470	515	167	373	309	63	19

Results and discussions

➢Results Comparison between the DBDC and OE methods

- The average WTP calculated was different, WTP get by DBDC and OE method are 76.21 and 32.63 yuan/month respectively, it was within a reasonable range because a large number of studies have shown that the DBDC method WTP values are 1 to 5 times higher than the OE method values.
- There are several reasons for this difference:

- The difference in the guidance method significantly affects the WTPs;
- The socioeconomic attributes of the research groups were not completely consistent;
- The sample size was different and not large enough to show differences between the estimated results and the overall actual situation.

Results and discussions

➢ Suggestions and concerns

Table 8. Suggestions or concerns of respondents.

Suggestions or concerns	Number	Suggestions or concerns	Number
Promoting clean energy	88	Increasing publicity	12
Governing polluting enterprises and projects	40	Introducing incentive policies to encourage the development of clean energy	6
Increasing efforts to improve air quality	32	Formulating reasonable price for household clean energy products	6
Effective implementation of policies	32	Strengthening scientific and technological innovation	6
The government should play a leading role	28	Investigating the project in advance	4
More investment into clean energy	22	New energy vehicles and other products	4
Green travel	20	Industrialization of clean energy	3
Strengthening government supervision	18	Media and educational institutions should bear certain responsibilities	2
Residents should engaged positively	16	Do not increase the burden on the people excessively	1
Energy conservation	14	Increasing environmental tax collection	1
Air pollution	14	Reducing clean energy costs	1

Conclusions

- Most respondents are willing to pay a certain amount to support the development of clean energy. The DBDC method produced a mean value for WTP of 76.21 yuan/ month.
- The main factors affecting WTP are belief, knowledge, gender, education, family size, income, and bid, which are related to consciousness and personal characteristics. And the variables of family size and bid are negative significant. The group analysis showed that the influencing factors varied greatly depending on gender and age.
- The DBDC method leads to a significantly higher WTP compared to the OE method. To some extent, the DBDC method may be closer to residents' real WTP. Our research results further confirm the previous conclusions that DBDC method results a higher WTP than open ended method and is 1-5 times higher generally. In terms of significant affecting variables, they were about the same for both methods.

Thank You!

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