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Abstract

This paper uses a large OECD web survey to shed light on preferences for renewable energy in the residential sector in six OECD countries. The key contributions are as follows. First, the authors propose to elicit willingness-to-pay (WTP) in a way that solves a consistency problem when a price, such as the price of green energy, is used as a payment vehicle in a survey. Given that the paper is only interested in the value of "green" energy per se, it is needed to take into account the fact that an increased electricity price implies lower consumption (and a utility loss). The authors thus elicit the value of "green electricity" as the maximum percentage of the current electricity bill the person is willing to pay to "re-mix" electricity supply such that it is based only on renewable energy. Second, using a multi-country survey, we find WTP to be in the order of a few percentages in each of the countries surveyed, buttressing the idea that it is difficult to extract a sizable price-premium in the market quite independently of where this strategy is tried (in the OECD, at least). Third, environmental concern/attitude consistently drives the decision to enter the (hypothetical) market for "green electricity", while membership in environmental organizations typically affects how much a person wants to pay, given entry. Economic variables are less important.

Keywords: multi-country survey, renewable energy, survival analysis, willingness-to-pay.
JEL Classification: Q42, Q51.

Introduction

Substantial investments in renewable energy program are currently underway in many countries. These investments are driven by an array of different motivations, most often including climate concerns and energy security. To effectively shape energy policy that aims at sustainable solutions for the future, detailed information about the demand and supply is useful. In particular, how much does the public want to pay for a switch to a system based on renewables? This paper adds to an already substantial literature on "green energy" demand in the residential sector. Our review of this literature below identifies a number of gaps that we seek to fill.

First, rather than study one particular country, we use a large OECD web-survey to scrutinize willingness-to-pay (WTP) for "green energy" in Australia, Canada, Czech Republic, France, Norway, and South Korea (interviewing about 1K households in each country). We have chosen OECD countries that differ in several pertinent dimensions; for example, the countries display several climes, have followed different paths when developing their energy-environmental policies and show significant income-variation. The variation between the countries allows us to disentangle similarities as well as dissimilarities in a way that has not been possible before in this literature.

Second, we propose an alternative way to elicit WTP for "green energy" in a survey in a way that solves a consistency problem, when a price is used as a payment vehicle. This choice of payment vehicle is not uncommon and has certain advantages, not the least regarding familiarity. However, Johansson (1996) demonstrated that there are several problems from a theoretical point of view. For example, if one uses a gasoline price premium for reducing a certain environmental problem related to fuelling a vehicle at a gas station, we inadvertently include the utility lost due to a higher gasoline price. Intuitively, the price increase implies a utility loss that becomes intermingled with the utility gain from the implied increase in environmental quality. In our application, the respondent can buy into an (hypothetical) energy system based 100% on renewables, a quite common scenario in the literature on green energy. Typically, the electricity price is used as a payment vehicle (as a price premium) without conditioning on the quantity electricity demanded. We thus propose to condition on the current consumption of electricity; the price premium can then directly be interpreted as the value of re-mixing the energy supply to a system with only renewable sources. In addition, the problem of handling currency conversion is addressed by asking about the price premium in terms of a percentage increase of the cost relative to the cost of current electricity consumption.

Third, we derive a kind of demand curve for "green energy" including potential shifters of this curve. In particular we split the consumer decision about the price-premium in two parts: the entry and level-decision. This analysis is seldom undertaken in the literature on green energy premiums.

The rest of the paper is structured as follows. We begin with a compact survey of the literature in section 1; section 2 develops our economic model and section 3 details corresponding econometric models and our data. The final section concludes. An Appendix provides additional details about a variable we have constructed as a proxy for energy consumption, called heating/cooling degree days.

1. Literature survey

There is a substantial literature on the demand for "green" energy in the residential sector, both on empirical and conceptual issues. A bulk of this literature uses surveys to estimate the value consumers, hypothetically, place on such energy (see Table 1 below). Because many companies offer "green" energy options via a price premium, one can sometimes observe such valuation in the marketplace. An important paper in the empirical analysis of price premiums across payment institutions is Cameron, Poe et al. (2002). The authors combine a telephone survey with six mail surveys in cooperation with a power company in New York State. Respondents were offered, in a real or hypothetical setting, a price premium for the company to plant trees and/or provide energy from renewable sources. The results support the notion that there is often a difference between real and hypothetical behavior, a point buttressed by several other papers in this genre (e.g., Roe, Teisl et al., 2001; Rose, Clark et al. 2002; Kotchen and Moore, 2007; Wiser, Fowlie et al., 2001; Ek and Söderholm, 2008). However, power companies seem to have difficulties extracting the substantial premiums sometimes reported in surveys[1]. Pichert and Katsikopoulos (2008, p. 63) assert that "... although green electricity is available in many markets, people do not generally buy it."

Costly switching is one reason why consumers "do not generally buy" green electricity. Pichert and Katsikopoulos (2008) give the interesting example of Schönau, a small German town where virtually everybody uses "green" electricity, following a referendum decision on whether or not (the use of) nuclear power should be abolished. According to the authors, a Schönau citizen will need to exercise some effort in finding "grey" electricity; indeed, eight years after the referendum decision, very few customers have made the switch. The authors also present analysis of results from another German town, Wustenhagen. In a survey, 150 000 customers of Energidienst GmbH were asked to make a choice between slightly cheaper "grey" electricity, substantially more expensive "super-green" electricity, and the status quo (a default "green" alternative). Two months after the request to make a choice, 94% preferred the status quo. Two small laboratory experiments are also offered to further drive the point home.

In general, the relevant literature focuses either on the decision to enter the green energy market or on WTP (but not the two decisions in tandem, as is the case here). Table 1 summarizes a number of recent studies. A review of earlier studies in this genre appears in OECD (2011).

Table 1. Literature review

Author	Country	Method	Dependent variable	Demographics	Economics	Attitudes	Others
(Bang, Ellinger et al., 2000)	USA	T test	7-point scale willingness-to-pay for renewable energy			Concern for environment (+) Beliefs about positive consequences (+) Knowledge about renewable energy (+)	
(Batley, Colbourne et al., 2001)[1]	UK	Correlation analysis	Whether willing-to-pay extra for renewable electricity	Social status (+)	Income (+)	Energy efficiency (+) Willing to invest efficient appliances (+)	
(Zarnikau, 2003)	USA	Tobit model	Willingness-to-pay a premium for utility investment in renewable energy	Age (-) Education (+) White race (+) House owner (-)	Salary (+)		
(Clark, Kotchen et al., 2003)	USA	Logit model	Participation in a green electricity program	Number of individuals in the household (-)	Income (+)	Altruistic attitude (+) Environmental attitude (+)	
(Rowlands, Scott et al., 2003)	Canada	Correlation analysis	Willingness-to-pay extra for green electricity	Education (+) Age (-) Participation in community groups (+)	Income (+)	Ecological concern (+) Liberalism (+) Altruism (+) Perceived consumer effectiveness (+)	
(Ek, 2005)	Sweden	Binomial logit model	5-scaled attitude towards wind power	Age (-)	Income (-)	Environmental interest (+) Express public preferences (+)	

[1] The Australian Green Power program is a government accreditation program for renewable energy. According to http://bit.ly/c64yRo there were about 800000 households subscribing to the program by June 30, 2010. Increasing costs for electricity seems to partly explain why about 15% of the subscribers left the program over the year. The cost of the program is "a few cents extra" per Kwh, see http://www.greenpower.gov.au.

Table 1 (cont.). Literature review

Author	Country	Method	Dependent variable	Demographics	Economics	Attitudes	Others
(Arkesteijn and Oerlemans, 2005)	Netherlands	Binary logistic regression	Adoption of green electricity	Knowledge of renewable energy (+)	Willingness-to-pay (+) Perception of "green" price (+)	Environmental attitude (+)	Displayed behavior (+) Ease of switching and use (+)
(Kotchen and Moore, 2007)[2]	USA	Tobit, Negative binomial, Probit, and Truncated regression	Contribute to a green electricity program	Male (-) Household size (-)	Income (+)	Environmental concern (+) Altruistic attitudes (+)	
(Wiser, 2007)[3]	USA	Logit	Whether willing-to-pay a bid for renewable energy	Age (-) Education (+)	Bid (-)	Participation expectations (+) Family support (+) All should pay (+) Direct benefits (-) First mover (+)	
(Ek and Söderholm, 2008)	Sweden	Choice experiment: random effects binary probit model	Choose "green" alternative	Age (-)	Electricity price (-)	Personal responsibility (+) Perceived consumer effectiveness (+) Environmental attitudes (+) People close expect "green" (+)	Electric heating (-)
(Yoo and Kwak, 2009)	Korea	Spike model	Whether willing to pay for green electricity policy		Bid (-) Income (+)		
(Gerpott and Mahmudova, 2010)	Germany	Partial least squares analysis	5-scale agreement to willing to adopt green electricity			Social endorsement (+) Environmental protection attitude (+)	Switching difficulty (-)
(Gerpott and Mahmudova, 2010)	Germany	Logistic regression Ordinal regression	6-rank willing to pay a mark-up for green electricity	Household size (+) Age (-)	Electricity bill (-)	Attitude towards environment and current supplier (+) Social reference group (+)	Ecological conservation behavior (+)
(Diaz-Rainey and Ashton, 2011)	UK	Ordered probit model	5-scaled agreement to be willing to pay 5% to 10% more for green electricity	Membership of environmental group (+)	Income (+)	Knowledge (+) Perceived consumer effectiveness (+) Environmental information and action (+)	
(Ozaki, 2011)	UK	Correlation analysis	5-scale agreement to adoption intention			Attitude towards green electricity (+) Social influence (+) Normative beliefs (+) Controllability (+) Information (+)	
(Oliver, Volschenk et al., 2011)	South Africa	Logistic regression	Willing to pay a premium for green electricity		Income (+)	Reliable attitude (+) Everyone should contribute (+)	Recycle behavior (+)
(Hansla, 2011)	Sweden	OLS	5-scale likelihood to pay a surcharge for eco- labeled electricity		Surcharge (-)	Biospheric framing (+) Self-transcendence value (+)	
(Abdullah and Jeanty, 2011) [4]	Kenya	Double bounded model	Whether willing to pay for PV electricity	House ownership (+) Age (-)	Income (+) Bid (-)	Interested in business (+)	
(Zorić and Hrovatin, 2012) [5]	Slovenia	Tobit and Double hurdle model	Willingness to pay for green electricity	Age (-)	Income (+) Electricity bill (+)	Environmental awareness (+)	
(Strazzera, Mura et al., 2012)	Italy	Double bound model	Whether willing to pay a bid for solar energy	Urban (+) In energy sector (+) Home green tech (+)	Bill (+)	Health risk perception (+) Photovoltaic pollution perception (-) Invest heavy industry (+)	Coal information (+) Contact Energy Agency (+)
(Liu, Wang et al., 2013)	China	Logit model	Positive willingness to pay for renewable energy	Age (-)	Income (+)	Belief about the cost (+) Knowledge (+)	

Table 1 (cont.). Literature review

Author	Country	Method	Dependent variable	Demographics	Economics	Attitudes	Others
(Ertör-Akyazı, Adaman et al., 2012)	Turkey	Logit model	Endorsement of renewable energy	Education (+)		Knowledge of climate change (+) Environmental optimism (-) Environmental concern (+) Economy-oriented (-)	
(Zhai and Williams, 2012)	USA	Fuzzy logit model	Adoption of photovoltaic			Environmental concern (+) Perceived cost of solar panels (-) Perceived maintenance requirement (-)	

Notes: [1]The results here are for the "random" of the two samples they study. [2]The results presented here are for a decision about whether to contribution to voluntary contribution mechanism program, while the decision of how much to contribute to it is only influenced by income. [3]Here are the results of scenario 3 (voluntary payment and private provision). [4]The result is for photovoltaic of monthly payment. [5]These factors influence the amount of WTP. The decision of participation is determined by age, education, and environmental awareness.

Oliver, Volschenk et al. (2011) is one of the new studies that bring in developing country perspectives. Employing a random sample of 543 households in the Cape Peninsula (SA), they use correlation and logit analysis to test a number of hypotheses. A key finding is that income correlates positively with WTP. Abdullah and Jeanty (2011) considers the value Kenyans (in the Kisimu district) place on electricity connection in rural areas. They find that respondents place a higher value on grid connection services compared to a Photovoltaic alternative, leading the authors to propose – inter alia – subsidies for electricity connections. Zorić and Hrovatin (2012) employ a final sample of 450 Slovenian households and use econometric methods similar to ours, to find that income is a significant driver of WTP. They find an average WTP of about 9% increase of the monthly bill. Note that there is subsidized electricity in Slovenia (Zorić and Hrovatin, 2012, p. 184). Interestingly, they find that income is positively related to the level of WTP, but not significant for the participation decision, a result we can compare directly below. Ertör-Akyazı, Adaman et al. (2012) look at preferences for nuclear and renewable energy in Turkey, using a sample of 2248 urban Turks. The logit model used shows that endorsement of renewable energy is positively related to education and environmental concern, while "economy-oriented" individuals were less likely to endorse renewable energy. Liu, Wang et al. (2013) use a survey of respondents in Shandong and confirm several other studies in that income is positively related to WTP, as is knowledge, but age has a negative impact.

Turning now to a few examples of recent studies from developed countries, we begin with a study by Gerpott and Mahmudova (2010), who use a survey of 238 German households to find that roughly half (53.5%) are "in-the-market" for "green energy", while 26.1% support a price premium in the range 5-10%. Ozaki (2011) asks a somewhat different question in her survey of 103 UK respondents; she looks at the switching, or adoption, decision from a sociology standpoint. She reports at least one surprising result, given that the sample had (according to the author) a "green bias".

"… we found great hesitation among them (the respondents) about adopting a green electricity tariff, and even those with high adoption intentions are indecisive. Positive green attitudes towards pro-environmental behaviors do not necessarily translate into the performance of the behaviors" (p. 13).

The reasons why "green" consumers do not switch to "green" electric include, according to Ozaki (2011), switching costs (in general terms), uncertainty about the quality of green energy and the lack of strong social norms. The switching inconvenience Ozaki's (2011) respondents refer to, appears directly related to the "hidden costs" economists apply to explain tardiness in energy saving technology.

Hansla (2011) presents a study based on psychological theories, employing a sample of 1800 Swedes (with a 26.5% response rate). Respondents were shown five different price premiums and asked how likely they would make the switch for each premium. Hansla (2011) uses different "treatments" for subsamples. The study gives some support for the idea that altruism positively affects the probability of paying the premium. Zhai and Williams (2012) scrutinizes adoption of photovoltaics (PV, "solar panels"), using a 201 survey of 487 homeowners in Phoenix (of which 21 had already installed a grid connected PV). They claim that it is not only the direct economic consequences that are important determinants of adoption, but maintenance and environmental awareness also play a role. As a final example of recent research in this area, Strazzera, Mura et al. (2012) splits a sample of 358 individuals in the province of Oristano, Italy, such that one subsample is asked about coal and solar, the other subsample is asked about the same energy sources but in the reverse order. The contingent valuation study attempted to find out (a) the (negative) value of coal; (b) the value of renewables. In the case of coal, the respondents were offered a price that would save on their utility bill, should they switch to coal. In the case of renewables, the respondent was given a price-premium to accept or reject that would entail receiving all electricity from solar energy. The average discount accepted is 64% of the annual bill for the switch to only coal, while the switch to only solar is valued at 40% surcharge on the existing bill.

We now turn to the empirical study, beginning with the economic model that underpins our analysis. After detailing what we want to measure we turn to the econometrics and then the results.

2. Economic model

Let z denote environmental quality, q the consumption of electricity, p the price of electricity and m the individual income. For simplicity, we suppress indices on individuals. Let $V(p, m, z)$ be a conventional indirect utility function, decreasing in p and increasing in m and z. We set the price of a private good composite to 1. Suppose that a switch to "green" electricity induces an improvement in the sense that $z^1 > z^0$, where z^0 is the status quo environmental quality. More generally, z can be thought of as a bundle of positive externalities available from the switch to renewables[1].

We use percentage increases of the electricity bill as our payment vehicle. In the status quo, the electricity bill is pq^0 and we define α to be the maximum percentage increase of the bill that the individual can accept to pay for the implied improvement $z^0 \rightarrow z^1$. Thus, we define our money measure, assuming $\alpha > 0$, in percentage terms as follows:

$$V\left(m - pq^0\left(1+\alpha\right), z^1\right) = V(m - pq^0, z^0). \quad (1)$$

As discussed above, we keep electricity consumption constant at q^0 to isolate the value of the environmental improvement. We thus ask the respondents about their valuation of a "re-mixing" of how the current electricity consumption is generated. Let d denote the marginal utility of money ($[(\partial V)/(\partial m)]$) and c the marginal utility of environmental improvements ($[(\partial V)/(\partial z)]$). Approximating V linearly and choosing units such that $z^1 - z^0 = 1$ we obtain:

$$\alpha = \frac{c}{d}\frac{1}{pq^0}. \quad (2)$$

α is, to the first order, inversely proportional to the existing electricity bill. The higher the bill, the lower is α. Observe that the marginal WTP ($[c/d]$) is just αpq^0; the level is just the percentage revealed in the valuation question times the current expenditures.

It is important to note that α does not depend on income in this simple linear model. Thus, income should really not be included in a regression model (the "income effect" is already included in the parameter d). Furthermore, our dataset does not include information about pq^0. As a simple remedy, we use heating degree days (HDD) and cooling degree days (CDD) as a proxy for the amount of energy consumed (q^0) by the households. HDD and CDD are derived from daily temperature observations as explained in the Appendix. Observe that p varies in complex ways between households and therefore our proxy for pq^0 is far from perfect. For example, energy tax rates vary within countries (as in e.g. Sweden) and households can choose between different price schedules (i.e. fixed contract of some duration versus spot price contracts).

3. Econometric models

In the web survey, intervals that include α are collected in the form of brackets. Specifically, the households provide information about α by choosing one out of five given brackets. The suggested brackets were [0%, 0^+–5%, 5^+–15%, 16^+–30%, 30^+%–]. Importantly, we assume that α is *censored at random*. Thus α is assumed independent of the particular censoring mechanism we have chosen. If the individual behaves according to the utility theoretic model, α is independent of the elicitation mechanism[2].

Survival analysis techniques are used to estimate the distribution of α and we employ a parametric and a non-parametric model. Let R_i and L_i be the upper and lower bounds of the interval that includes the WTP of individual i ($i = 1...N$), and $F(\cdot)$ denote the c.d.f of WTP. We can then write the log likelihood function (for those with $WTP > 0$) as

$$\alpha = \sum_{i=1}^{N} \ln\left(F\left(R_i\right) - F\left(L_i\right)\right). \quad (3)$$

Turnbull (1974) and Turnbull (1976) have studied non-parametric maximum likelihood estimators for general types of censoring. We use an implementation of the EM algorithm in R to implement a non-parametric estimator and for the parametric version of F we use the Weibull distribution. The parametric model is specified as follows:

$$\Pr\left(\alpha \geq a\right) = \exp\left(-\exp\left(\frac{\log\left(a\right) - X\beta}{\sigma}\right)\right), \quad (4)$$

[1] It is not the quantity of money charged from an individual can improve the environmental quality from z^0 to z^1, but the aggregated quantity from the population can be used to make it possible (in our case, to offer "green" electricity).

[2] There is an extensive literature in economic psychology on anchoring that challenge the censored at random assumption, see Winter (2002). The pros and cons of using brackets as an elicitation method are discussed in Belyaev and Kriström (2012).

where σ is the scale and X denotes a matrix of explanatory variables (see Table 3 below).

We can account for the zeroes by implementing variations of the Tobit model, but we use a simpler approach here. Thus, we analyze the entry decision ($WTP > 0$ or $WTP = 0$) using a logit model and then survival analysis for those who submitted a positive valuation. This amounts to assuming independence between entry and level decisions (see, Wooldridge (2010, ch.16) for details on alternative assumptions).

3.1. Data. The 2007 OECD 10-country household web survey aims to shed light on the design of environmental policies[1]. Ten member countries took part in the survey: Australia, Canada, Czech Republic, France, Italy, Mexico, Norway, the Netherlands, South Korea, and Sweden. The questionnaire includes seven parts: the first two parts intend to collect the socio-demographic and attitudinal characteristics of respondents; the other five parts relate to household behavior in five key environmental areas: energy, waste, transport, food and water. As explained in the introduction, we selected Australia, Canada, Czech Republic, France, Norway, and South Korea, because these countries cover several climes, provide examples of different energy policy choices and display interesting within and between disparities regarding disposable income and preferences.

The valuation question (#69 in the questionnaire) is formulated in the following manner:

What is the maximum percentage increase on your annual bill you are willing to pay to use only renewable energy? Please assume that your energy consumption remains constant.

The question was preceded by the OECD definition of renewable energy. It is to be stressed that the valuation part of the OECD study is not intended to be a rigorous contingent valuation study. Rather, we consider the question sufficiently detailed to provide information about preferences, since a closely related good is typically available to the respondent at a price premium. Observe that the scenario is silent on how much other consumers are supposed to buy of the good offered in the scenario. Such aspects must necessarily be included in a rigorous contingent valuation study; here we simply make an atomistic assumption. Consequently, we cannot control what assumptions the respondent makes about how much others are buying of the good.

3.2. The demand curve: a first look. The "don't know" answers are deleted in our empirical analysis and we first focus on positive WTP, i.e. those who are "in-the-market". If we connect the percentage choosing each particular interval by a line, we can interpret the resulting curve as a kind of demand curve (this rationale for this intuition is explained in Johansson (1993). Briefly, as the price increases, we expect to find fewer respondents accepting to pay the implied price. Table 2 has a summary of the results.

Table 2. Proportion of respondents willing to pay for renewable energy

Country regions		Zero	< 5%	5-15%	16-30%	> 30%	Don't know
Australia	Eastern	0.36	0.27	0.18	0.03	0.01	0.15
	Western	0.37	0.30	0.15	0.01	0.02	0.15
	SouthNT	0.47	0.23	0.17	0.00	0.00	0.13
Canada	Western	0.31	0.20	0.18	0.03	0.00	0.28
	Central	0.34	0.24	0.16	0.03	0.01	0.22
	Atlantic	0.36	0.27	0.11	0.03	0.01	0.21
Czech Republic	NW	0.30	0.26	0.19	0.03	0.01	0.21
	Severovychod	0.33	0.30	0.11	0.03	0.00	0.23
	South	0.28	0.27	0.20	0.01	0.01	0.22
France	NW	0.41	0.28	0.11	0.01	0.01	0.18
	SW	0.49	0.21	0.15	0.03	0.03	0.09
	Eastern	0.44	0.25	0.11	0.02	0.01	0.17
Norway	Vestland	0.40	0.15	0.22	0.04	0.01	0.19
	OstlandMiddle	0.43	0.18	0.18	0.03	0.02	0.15
	Nordland	0.49	0.20	0.15	0.03	0.00	0.14
South Korea	North	0.31	0.31	0.18	0.03	0.01	0.15
	South	0.26	0.39	0.16	0.02	0.02	0.15
	Jeju	0.23	0.32	0.16	0.04	0.00	0.26

[1] A description of the study can be downloaded from http://www.oecd.org/dataoecd/19/22/42183878.pdf.

Table 2 makes clear that the proportion of respondents who want to pay for renewable energy (as defined in the questionnaire), typically falls as the price increases. Some "within-country" variations are unmasked by a closer scrutiny of the data:

- In Australia, almost half of respondents (47%) in South Northern Territory (SouthNT) are not willing to pay anything to use only green energy, compared with 36% and 37% in the Eastern and the Western regions. Correspondingly, no respondent in SouthNT is willing to pay more than 15%, while 1% and 2% of the households are willing to pay more than 30% in other two regions.
- In Canada, about one third of respondents report a zero *WTP*; there is no substantial difference of *WTP* between the regions in any bracket. (Rowlands, Scott et al., 2003), in a survey conducted in Waterloo Region in Ontario, asked how much extra respondents would be willing to pay on the electricity bill each month to ensure that all of the electricity they use comes from green sources. 6% answered that they did not want green electricity, a substantially lower proportion compared to the results of this survey.
- The Czech Republic displays a rather similar pattern to Canada.
- The regions in France display the highest proportions of zero *WTP* (41%, 49% and 44%, respectively).
- In Norway, nearly half of respondents in Nordland indicate a zero *WTP* (49%), and no one is willing to pay more than 30%. The proportion of respondents who are willing to pay nothing in OstlandMiddle is 43%, while 2% of the respondents will pay more than 30%. We can find a similar pattern in Vestland.
- The number of South Korean respondents willing to pay less than 5% is not fewer than those who want to pay nothing in three regions.

Overall, Table 2 suggests that WTP is rather modest. We can compare our findings with the February 2008 Financial Times/Harris Poll[1], an online survey of 6,448 adults 16-64 years old in France, Germany, Great Britain, Spain and the United States, and adults aged 18 to 64 in Italy. The question asked was similar to the one used here:

How much of an increase would you be willing to pay at the most for energy if it were from renewable sources?

The Harris Poll reports 43% zero WTP for the French respondents and we obtain very similar numbers for three French regions (41%, 49% and 44%). It is somewhat more difficult to compare the other brackets, because the Harris poll uses another bracket-construction, i.e. "5% more", "10% more" and so on.

We turn now to a more formal econometric modeling of the demand curve and begin by tabulating the variables we used in our econometric analysis.

3.3. Estimating the demand curve: Weibull model. Table 3 presents the explanatory variables used in the econometric analysis. Heating degree days (HDD) and cooling degree days (CDD) are, as noted, proxies for the amount of energy consumed by the households. More information about HDD/CDD is presented in the Appendix.

Table 3. Explanatory variables

Socio economics	Age Employment status Gender Level of education Marital status
Household	Household composition Household income Top earner in the household (yes/no)
Residence variables	Age of residence Area of residence (town, village etc.) Duration of living in Residence owner Type of residence
Attitudes	Attitudinal characteristics (various) Environmental attitudes (secretariats computation, based on Q28) Environmental concerns
Other	CDD HDD Member of environmental organization Taking energy costs into account when buying/renting current residence Voluntary organization work

Mean WTP is the area bounded by the survival function and for our Weibull specification without covariates and with x_0 the intercept, we have:

$$E\left(WTP\right) = \exp(x_0)\Gamma(1+\sigma). \quad (5)$$

Figure 1 shows the contribution of renewable to domestic energy supply[2] of 2007 paired with mean α for green electricity (estimated with the Weibull model) for each country. The contribution of renewable energy to total energy supply (CRES) varies substantially across the countries. The renewable energy share of the total primary supply in Norway is 48.3%, while it is only 1.4% in South Korea (according to OECD (2010). Interestingly, the Norwegian respondents report the highest conditional mean (8.3%) and the French display the lowest (5.5%).

[1] The Harris Poll, #21, February 26, 2008, http://www.harrisinteractive.com/.

[2] % of total primary energy supply, data from OECD Factbook 2010.

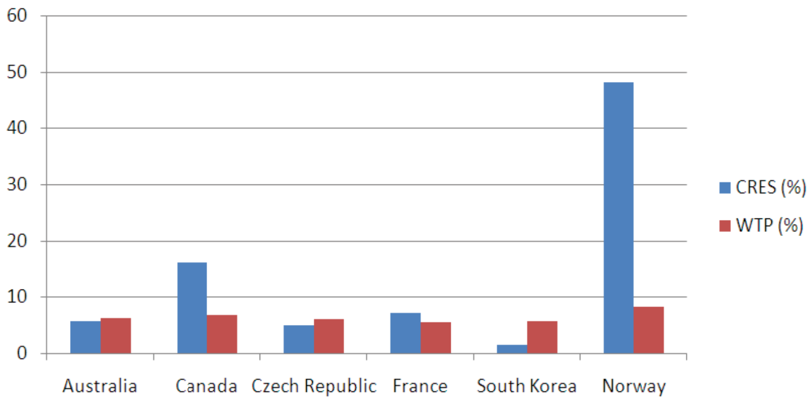
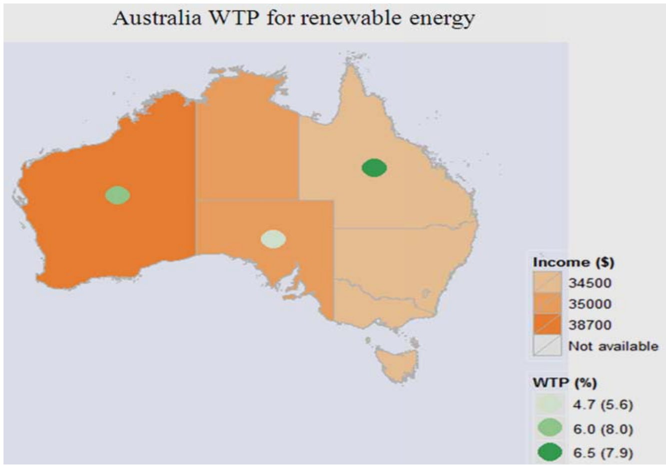
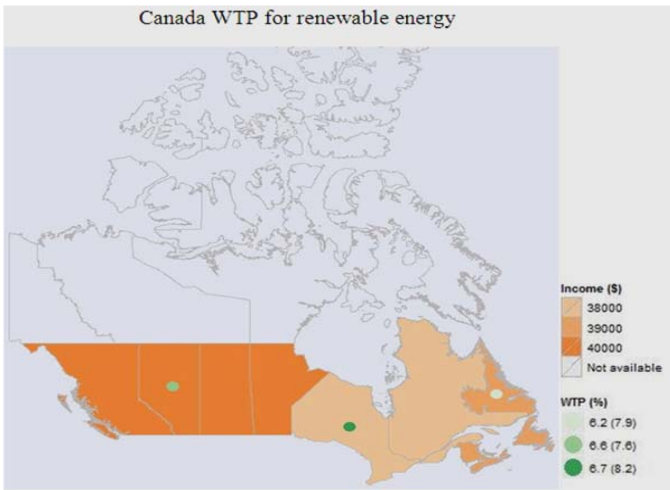


Fig. 1. Contribution of renewable to energy supply (CRES) and conditional (> 0) WTP

We fexplored within-country variation of WTP by using choropleth maps adding income as a layer. Figure 2 presents such maps using the Turnbull's (1976) estimator to obtain the means (in brackets)[1].





[1] We assume an upper bound for WTP at 100% and interpolate linearly.

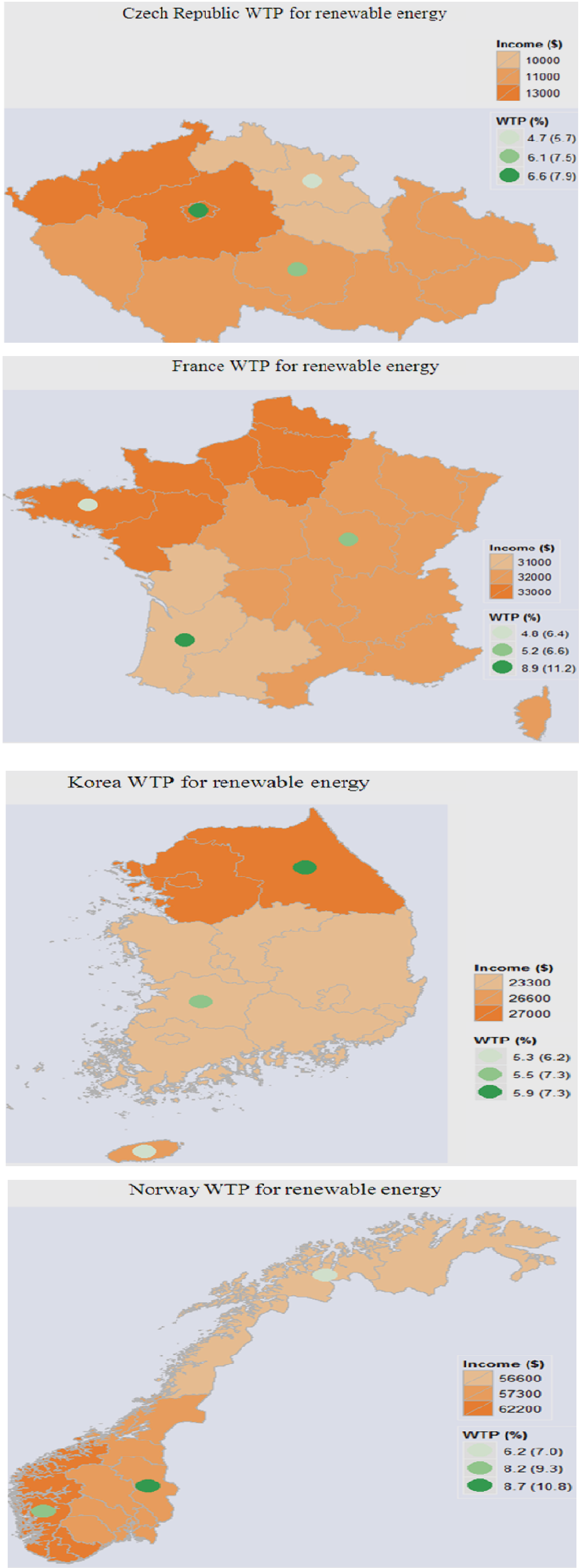


Fig. 2. Regional mean WTP for green electricity (percentage)

We find the largest within-country variation in France. The respondents who are willing to pay the most (as a percentage of the bill) are in the Southwest (8.9%), which is nearly twice of that in Northwest (4.8%).

We now turn to our full econometric model and Table 4 summarizes the results of the estimations. Model selection is based on including significant variables at the 10% level. To save space, we present the signs of significant parameters instead (the full results are downloadable at this page www-sekon.slu.se\~bkr\leikristromzhou\webresult.pdf).

Table 4. Determinants of WTP, according to Weilbull survival analysis model

	A	C	Z	F	K	N
Intercept	+			+	+	
Female		-		-		-
Age = young (18-24)	-		-			
Education = high school graduate	-				+	
Education = some post-secondary education	-	+			+	
Education = Bachelor's degree (BA)		+			+	
Education = Post Graduate Degree (Master of Ph.D.)		+			+	
Employment status = employed	-	+	+			
Earning most in household = no	-	+	+			
Earning most in household = don't know	-					
Residence owner = no				-		
Residence status = living alone		+				
Residence status = living with parents or other relatives				+		
Residence status = sharing a house/flat with non-family members				+		
Living area = rural	+			-		-
Living area = suburban (fringes of a major town/city)				-		
Living area = urban				-		
Residence type = a detached house	-	-			+	
Residence type = a semi-detached/terraced house		-				
Residence type = an apartment in a building with more than 12 apartments			-			-
Residence type = other (specify)		-				
Residence construction = between 16 and 50 years ago				+		
Energy cost consideration = no					+	
Energy cost consideration = not sure	+				+	
HDD (heating degree days)					-	
CDD (cooling degree days)					-	
Environmental attitude index	+		+		-	+
Environmental concern index		+				
Environmental organization member = no	-	-	-	-	-	

Notes: Australia (A), Canada (C), Czech Republic (Z), France (F), South Korea (K), and Norway (N). Sign indicates direction of marginal effect on WTP, and that the coefficient is significant at the 10% level.

Our linear utility model results in a WTP expression that does not include income. If income is nevertheless included, it is generally insignificant and does not change the results to any significant degree. Overall, we see that membership in an environmental organization is most consistently associated with WTP; non-members have a lower average WTP, ceteris paribus. In contrast to other papers in the literature, women have a lower WTP. An index that proxies environmental attitudes has the expected sign (+) in three cases, but it is, somewhat curiously, negative in the model for Korea. Turning to our proxies for energy consumption, we see that HDD has a negative impact on WTP in Norway. A HDD means that the colder the weather is, the more energy the household consumes to warm the house.

3.4. Determinants of the entry decision. The decision to enter the hypothetical market seems to be driven by a slightly different set of parameters. To save space we omit detailed results from the logit models employed and provide a compact summary in Table 5 (full results are available at this page www-sekon.slu.se\~bkr\leikristromzhou\webresult.pdf).

Parameters reflecting attitudinals (environmental concern and environmental attitudes) are generally significantly positive for the entry decision. For 4 out of 6 countries, we find that the younger persons are more likely to enter the market. However, given entry, the young are willing to pay less compared to the other age groups (see Table 4). There is some indication that women are less willing to enter the market. If she does, we find that her WTP is significantly less compared to a man in 3 countries.

Table 5. Determinants of entry decision, according to logit model

	A	C	Z	F	K	N
Intercept				-		
Female			-	-	+	
Age = young (18-24)	+	+			+	+
Education = high school graduate						+
Education = some post-secondary education		+				
Education = Bachelor's degree (BA)	+	+				+
Education = Post Graduate Degree (Master or PhD)	+	+			+	+
Income	+		+	+		
Earn most in household = no			+	+		
Residence type = other (specify)				-		
Residence constriction time = between 5 and 15 years ago		+				
Residence constriction time = between 51 and 80 years ago			-			
Residence status = living alone		-		+		
Residence status = living with parents or other relatives						+
Energy cost consideration = no				+	-	
Environmental concern index	+	+		+		+
Environmental attitude index	+	+	+	+		+
Environmental organization time	+					

Table 5 (cont.). Determinants of entry decision, according to logit model

	A	C	Z	F	K	N
HDD						-
CDD						-

Notes: Australia (A), Canada (C), Czech Republic (Z), France (F), South Korea (K), and Norway (N). Signs indicate direction of marginal effect on entry decision, and coefficients are significant at 10% level.

Conclusions

We use an OECD household web survey to examine the mean willingness to pay for green electricity and the determinants of residential WTP in six countries. Survival analysis indicates that people are not willing to pay much in any of the country regions, and the regional WTPs can be quite different from the national one. Entry into the hypothetical market is driven by other parameters than the level of WTP, given positive valuations. An index of environmental concern/attitude is consistently positively related to the entry decision, while membership in an environmental organization is (conditionally) positively linked to the level of WTP. Consistent with our theoretical model, income is generally not significant in the econometric models.

These results are robust across countries. For other variables, the econometric results vary. For example, the female dummy is significantly negative in Canada, France, and Norway, while it is not significant in other three countries. "Detached house" affects WTP negatively in Canada and Australia, but positively in South Korea.

Our results suggest that WTP for a significant expansion of renewable energy is in the order of a few percent of the current electricity bill. This result is fully consistent with what is known from comparable market data; it is not easy for private companies to extract a significant price premium for renewable energy. The WTP for significant renewable energy expansion in a cross-section of major OECD-countries does not seem higher than previously believed.

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Appendix

Heating degree days (HDD) is a quantitative index designed to reflect the demand for energy needed to heat a house. This index is derived from daily temperature observations, and the heating requirements for a given structure at a specific location are considered to be directly proportional to the HDD at that location. A similar index, cooling degree days (CDD), reflects the amount of energy used to cool a house. HDD/CDD can be added over periods of time to provide a rough estimate of seasonal or annual heating or cooling requirements.

For each day, the heating and cooling degree days are calculated using the following formulae:

$HDD = \text{MAX}\ (18-T, 0)$,

$CDD = \text{MAX}\ (T-18, 0)$,

where 18 is base temperature; T is daily average temperature in degree centigrade.

In this study, the HDD and CDD data were collected for Canada and Australia on http://apps1.eere.energy.gov/buildings/energyplus/cfm/weather_data.cfm. The data of South Korea were collected from the Heating and Cooling Degree-Days by City 2000. For the HDD of the rest countries, we used actual heating degree-days from 1998 to 2009 on Eurostat website, while annual CDD data were calculated with mean monthly temperatures from http://www.tutiempo.net/en/Climate/Cannes/02-2002/76840.htm.