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Consumers' willingness to pay for green electricity: A meta-analysis of the literature

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ABSTRACT

At present, electricity generated from power plants using renewable sources costs more than electricity generated from power plants using conventional fuels. Consumers bear these expenses directly or indirectly through higher prices for renewable energy or taxes. The number of studies published over the last few years focusing on people's preferences for renewables has increased steadily, making it more and more difficult to identify key explanatory factors that determine people's willingness-to-pay (WTP) for renewables. We present results of a meta-regression on valuation of consumer preferences for a larger share of renewable energy in their electricity mix. Our meta-regression results reveal a number of important factors that explain the differences in WTP values for renewable energy. Different valuation methods show widely different values, with choice experiments producing the highest estimates. Our results further indicate that consumers' WTP for green electricity differs by source, with hydropower being the least valued. Variables that are often omitted from primary valuation studies are important in explaining differences in values. These variables describe individual and household characteristics as well as information on the type of power plant that will be replaced by renewables. Further, the marginal effect of a survey conducted in the US is pronounced. We also assess the potential for using the results for out-of-sample value transfer and find a median error of 21%.

1. Introduction

Many industrialized countries have ambitious renewable energy targets to mitigate climate change and/or to gain independence of fossil fuel imports. At present, electricity generated from power plants using renewables is more costly compared with those using conventional fuels. The difference is paid for by the consumers either directly through a higher price for renewable energy or indirectly through taxes. As a response to this, a number of studies have investigated consumer preference and willingness to pay (WTP) for larger shares of green electricity (most recently, Kim et al., 2013). The number of such studies published over the last few years focusing on people's preferences for renewables has increased steadily, thus resulting in a flood of data, which has made it increasingly more difficult to identify key explanatory factors that determine people's WTP for renewables. Studies vary widely in the energy-related characteristics they analyse (such as energy mix, siting of new power plants, infrastructure investments, etc.), the geographical location and the valuation technique employed.

Meta-analysis is a quantitative analysis of summary indicators reported in a series of similar empirical studies (Stanley, 2001). A quantitative meta-analysis ensures global comparability of WTP for renewable energy and provides evidence for common preferences. In our meta-analysis, we investigate the mean WTP per household per month and per kilowatt-hour to determine global preferences for renewable energy. Based on a meta-regression, we analyse whether differences in WTP exist by country, whether results on explanatory variables for WTP differ and the extent to which survey design influences WTP estimates. Because costs associated with performing a study that assesses WTP for green electricity are considerable, we explore the use of "value transfer" to non-valued sites/countries as an alternative to primary valuation.

Previous meta-analyses on preferences for renewable energy focus primarily on public acceptance of wind power (e.g., Aitken, 2010) and on the corresponding "not in my backyard" (NIMBY) phenomenon (van der Horst, 2007). While meta-analysis in combination with meta-regression is often used in ecosystem valuations (e.g., coral reefs: Brander et al., 2007), to our knowledge, there does not exist a meta-regression analysis on WTP for renewable energy.

The structure of our paper is as follows. Section 2 reviews the literature regarding consumer WTP for renewable energy in the electricity mix and outlines the type of studies used in our analysis—those focusing

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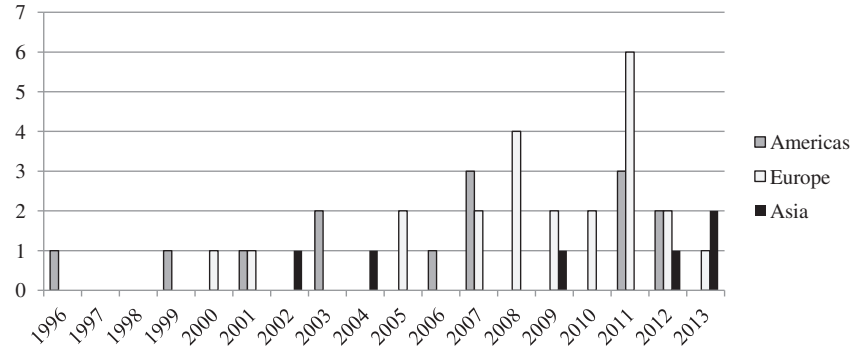

Source: Own presentation.

Fig. 1. Number of published studies by year and continent.

on green electricity. Section 3 presents our data and describes results of individual studies as well as summary statistics of WTP estimates. Section 4 presents the specification of the meta-regression, and the methods used to judge quality of the value transfer. Section 5 discusses the results of the meta-regression, and explores the validity, efficiency and robustness of our results when transferring values. Section 6 concludes the paper.

2. Overview of the willingness-to-pay for renewable energy literature

An extensive search for publish and unpublished (working papers and reports) studies relating to WTP for renewable energy was conducted on Web of Science, EconBiz, and Google Scholar and following references of relevant studies. The search spanned from end-December 2013 to end-January 2014 using the phrase "willingness to pay" in combination with each of the following renewable energy related words: (1) renewable, (2) green, (3) energy, (4) electricity, (5) power, (6) biomass, (7) wind, (8) solar, and (9) photovoltaic, (10) hydro; this implies that search output are likely to omit non-English related studies. Using this search algorithm we collected 101 studies based on stated preference surveys that estimated respondents' WTP for renewable energy. Out of the 101 studies 43 studies provides estimates of WTP for a higher share of renewable energy in the electricity mix. These studies are more readily comparable in a meta-analysis than a larger set of studies characterized by other key aspects, including studies that, for example, focus on the siting of wind farms.

The earliest study we found in the category 'electricity mix' was published by Farhar and Houston (1996). They measured the WTP for electricity from renewables in the United States (US). Between 1996 and 2006, only one or two studies per year were published. After 2006, the number of publications increased, with an average of 4.4 studies per year being published between 2007 and 2013, most of them with a focus on European countries or regions.

Fig. 1 shows that over space and time, studies are very unevenly distributed. Overall, we count 23 studies for Europe, twelve for the Americas and six for Asia. At the country level, most of the surveys were conducted in the US (twelve publications), followed by Germany (seven publications) and the United Kingdom (UK, four publications). While studies using data for the US or the UK are relatively evenly distributed over time, the first studies using German survey data were published in 2005 (Gossling et al., 2005; Menges et al., 2005).

Over time, researchers considered that more factors were involved in determining people's WTP, and the information they used provided increasingly more insight. For instance, several authors reviewed the influence of payment arrangements on the WTP for renewable energy, e.g., Menges and Traub (2008), Solino et al. (2009) and Solino et al. (2012). Other authors compared the current electricity mixes with stated consumer preferences, e.g., Grösche and Schröder (2011) and Kaenzig et al. (2013).

3. Description of data

Among the 43 studies, we exclude 25 from the meta-regression because of sample selection bias (e.g., Gossling et al., 2005) or unsuitable units of WTP estimates; that is, inconvertible. For instance, some authors express WTP as a percentage of the current electricity bill (e.g., Liu et al., 2013) or as the probability to be willing to pay anything at all (e.g., Batley et al., 2001). Further, we exclude one survey conducted in India (Chakrabarti and Chakrabarti, 2002). This study focused on rural electrification and, to a much lesser extent, on India's electricity mix.

Our final meta-regression consists of 85 WTP values that are ascertained from 18 studies (see Table 1). This corresponds to an average of 4.72 WTP values per study. We abstract the largest data sample (19 observations) from the study by Borchers et al. (2007), a choice experiment eliciting preferences for electricity for different renewable energy sources that was conducted in Newcastle County, Delaware, USA. As the number of observations (WTP estimates) per study varies, we use sampling weights to give studies contributing fewer observations, correspondingly, greater weight.

The 18 studies were published in 2004, 2007 or between 2009 and 2013. The corresponding surveys were conducted in nine developed countries and one developing country (China) on three continents (Europe, the Americas and Asia) either in 2000 or between 2006 and 2011. Multiple surveys were conducted in the US (3), Spain (3), Italy (3) and South Korea (2). One-half of the surveys were national, one-quarter were local and another quarter were regional. Each study in our sample used either contingent valuation techniques (twelve studies) or choice modelling approaches (six studies) to determine WTP. Two of the 18 studies are working papers (Bigerna and Polinori, 2011; Kosenius and Ollikainen, 2012). Of our 85 WTP values, 41 are gained by contingent valuation analyses and 44 by choice modelling.

Our dependent variable is the WTP for an increase in renewable energy in the current electricity mix. While results of contingent valuation studies are most often expressed as mean WTP, results of choice experiments are expressed as marginal WTP. If the "status quo" option belongs to the selectable alternatives of the choice experiment and the marginal WTP is based on the "status quo", we treat the marginal WTP as the mean WTP. Further, we use only WTP values in the meta-regression that can be interpreted as "WTP for a higher renewable energy share in the current electricity mix" and measure in fixed units of currency per time frame and household. Next, we approximate the WTP per kilowatt-hour to adjust the WTP to average electricity usage per capita.[1] A remarkable fact is the relatively high electricity

[1] For this, we used information on total residential energy consumption and total population (OECD/IEA, 2014a,b), as well as information on average household size (Eurostat, 2013; National Bureau of Statistics of China, 2010; OECD, 2012; Statistics Japan, 2013; U.S. Census Bureau, 2013).