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Analysis

Preferences for Energy Efficiency vs. Renewables: What Is the Willingness to Pay to Reduce CO_2 Emissions?

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ABSTRACT

Concerns about climate change are growing, and so is the demand for information about the costs and benefits of mitigating greenhouse gas emissions. This paper seeks to estimate the benefits of climate change mitigation, as measured by the public's willingness to pay for such policies. We investigate the preferences of Italian and Czech households towards climate change mitigation policy options directly related to residential energy use. We use discrete choice experiments, which are administered in a standardized fashion to representative samples in the two countries through computer-assisted web interviews. Our preferred estimates of the willingness to pay per ton of CO_2 emissions avoided is €133 for the Italians and €94 Euro for the Czech respondents (at 2014 purchasing power parity). We find evidence of considerable heterogeneity in WTP driven by income. The two samples differ in their within-sample income elasticities of WTP, but comparison across the two countries suggests an income elasticity of WTP of one—or even greater than one for certain mixed logit specifications.

1. Introduction

Growing concerns about climate change (IPCC, 2007; IPCC, 2014) have spurred efforts to estimate the benefits of greenhouse gas emissions mitigation strategies (e.g., Nordhaus, 1994, 2007; Tol, 2005; Stern, 2007; Agrawala et al., 2011). One approach to estimating such benefits is to list all of the possible physical and economy-wide effects of climate change, attach a monetary value to each of them, discount them to the present, and then compute the sum of such values (Nordhaus, 1994). Alternatively, one may use variation in temperatures across locales and over time and use regression analyses to infer losses or gains to society (Mendelsohn et al., 2000).[1] Finally, one could simply ask the beneficiaries of the mitigation policies to state their willingness to pay for them.

Any one of these three approaches can be summarized into a figure known as the social cost of carbon (SCC), i.e. the dollar value of reduced climate change damages associated with a one-metric-ton reduction in carbon dioxide (CO_2) emissions (Pizer et al., 2014). When the first or second of the approaches listed above are used, computing the SCC generally requires integrated assessment models that make assumptions about future population growth, economic activity and technology, and link the associated greenhouse gas emissions with their effects on climate (Greenstone et al., 2013).

Tol (2013) provides an exhaustive survey of the literature on the damages of climate change. Tol's meta-analysis spans over 588 estimates from 75 published studies, finding that "The mean estimate in these studies is a marginal cost of carbon of $196 per metric ton of carbon (tC), but the modal estimate is only $49/tC. Of course, this divergence suggests that the mean estimate is driven by some very large estimates." Converting these figures from carbon to CO_2 yields a modal value of 13.36$/t$CO_2$, while the mean is 53.45$/t$CO_2$ (1995 US$).

Studies that have used stated preference methods to elicit the public's willingness to pay for mitigation policies include Berk and Fovel (1999), Roe et al. (2001), Berrens et al. (2004), Li et al. (2004), Li et al. (2005), Nomura and Akai (2004), Viscusi and Zeckhauser (2006), Löschel et al. (2010), Löschel et al. (2013), and Diederich and Goeschl (2014). Tol (2013) reviews many of these and other studies, and concludes that the amount of money that people appear to be prepared to pay for carbon taxes is in line with its estimates based on the other approaches: The WTP per metric ton of CO_2 emissions reductions from

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[1] Tol (2013) terms the latter the "statistical" approach, and the former the "enumerative" approach.

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stated preference studies ranges from a few to a few thousand dollars (or euro) per ton.

In this paper, we follow the stated preference approach based on choice experiments to estimate the WTP per ton of CO_2 emissions reduced. We ask three research questions. First, how much would people say that they would be prepared to pay for each ton of CO_2 emissions reductions? Second, are the responses to hypothetical questions, and the WTP per ton that they imply, reasonable, and how do they compare with their counterparts from earlier stated-preference studies or from damage-function based approaches? Third, how does such WTP per ton vary with income?

We use discrete choice experiments, which we administer in a standardized fashion to two samples of respondents—one in Italy and one in the Czech Republic. Unlike earlier studies that elicited the additional price one would be prepared to pay to reduce emissions from a given product traded in the market (e.g., airline travel, see Brouwer et al., 2008, or MacKerron et al., 2009, or cars, see Achtnicht, 2012), we focus on public policies. Our context is energy use in buildings, and more specifically dwellings, and, unlike Longo et al. (2008) and Longo et al. (2012), we clearly specify the baseline annual emissions that the average household can expect to generate through the use of electricity, gas and other fuels at home.

Based on the discrete choice responses, our preferred estimates of the willingness to pay per ton of CO_2 emissions avoided are €133 for the Italians and €94 for the Czech respondents (2014 PPS euro). These figures are reasonable when compared with the WTP per ton from other stated preference surveys (which vary between €6 and thousands of euro per ton) and with other approaches to estimating the social cost of carbon. (See Appendix A for a summary of the WTP per ton of CO2 reduced from these stated preference studies.)

Moreover, our respondents appeared to trade off the attributes of the alternative policies they were to choose from in ways that are consistent with economic theory, and indicated that developing energy from renewables is more desirable than improving energy efficiency, and that carbon taxes are undesirable. This result is in contrast with a recent survey in the US, which indicated that at least 57% of the respondents were willing to pay a $1 fee on top of their utility bill to support a carbon tax policy (Greenstone, 2016).

In addition, we examine how WTP per ton of CO_2 emissions varies with the respondent's income. We specify models that let the marginal utility of emissions reductions (and hence the WTP and the income elasticity of the WTP for each ton of CO_2) depend on income.[2] We find that there is significant heterogeneity in the WTP per ton of CO_2 emissions reductions and in the income elasticity of WTP, this heterogeneity being driven by income. The mean income elasticity in each sample is less than one, and the Czech Republic exhibits low income elasticities (on average 0.35–0.42, depending on the model). This low within-sample income elasticity is in sharp contrast with the income elasticity of WTP implied by the comparison of the two countries' WTP, which is one. Some mixed logit specifications suggest that the across-sample income elasticities may be even greater than one.

These results can be placed in the context of benefit transfer, namely the practice followed in many studies, policy analyses and some integrated assessment models, which assumes a constant income elasticity of WTP of one (Pearce, 2006; Ready and Navrud, 2006; Lindhjem and Navrud, 2015). This means that if information about WTP is available at location A but not at location B, B's WTP can be predicted as A's WTP times the ratio of B's and A's income. Several recent empirical studies argue that this relatively simple approach based on adjusting for income performs better than "transfer functions" that include covariates and may rely on restrictive functional form assumptions (Barton, 2002; Muthke and Holm-Mueller, 2004; Johnston and Duke, 2010; Czajkowski et al., 2017; Baumgärtner et al., 2017).

In stated preference studies about environmental quality and health improvements, however, the income elasticity of WTP is often less than one (Kriström and Riera, 1996; Jacobsen and Hanley, 2009; Czajkowski and Ščasný, 2010; OECD, 2012). Our findings suggest that an income elasticity of one may be acceptable for benefit transfer purposes even though the income elasticity within locale A or locale B is less than one.

The remainder of this paper is organized as follows. Section 2 describes our choice experiments, the questionnaire and the administration of the survey. Section 3 lays out the statistical model of the responses to the choice questions. Section 4 presents the data and Section 5 the estimation results. Concluding remarks are offered in Section 6.

2. Choice Experiments, Structure of the Questionnaire and Survey Administration

2.1. Choice Experiments to Understand Preferences for Policies

We study the public's preferences for policies seeking to reduce CO_2 emissions using a survey-based approach, namely stated-preference choice experiments. In discrete choice experiments, study participants are asked to indicate which they prefer out of a set of K alternatives, usually goods or policy packages, where $K \geq 2$. The alternatives are defined by a finite set of attributes whose levels differ across alternatives. Respondents are usually asked to engage in several such choice tasks within one survey instrument in hopes of collecting more information about preferences for any given number of completed questionnaires.

In our choice experiments, the alternatives are policy packages described by four attributes: i) the goal of the policy, i.e., addressing energy efficiency or promoting renewable energy; ii) the policy mechanism(s) (which may entail one or more of the following: incentives, taxes on fossil fuels, standards, or information); iii) the reduction in CO_2 emissions per household, expressed both in tons and as percentage of the current emissions, and iv) the cost of the policy to the respondent's household. Items iii) and iv) are expressed as per year for each of 10 years.

We included attribute iii) and iv) because they are essential for computing the WTP per ton of CO_2, our key research question. Unlike Longo et al. (2012), who focus on percentage reductions in greenhouse gas emissions with respect to national levels, we focus on household-level emissions associated with residential energy use, and specify the reductions in both tons and as a percentage of the baseline.

We included attributes i) and ii) because we are interested in assessing whether people care about *how* emissions reductions are delivered, and earlier research on this issue is limited. Some studies have found that people generally tend to prefer policy instruments resulting in lower prices of environmentally friendly products and services (e.g. subsidies for renewable energy sources) over instruments that increase the prices of environmentally harmful goods (see Schade and Schlag, 2003; Eriksson et al., 2006). A policy instruments labelled as "tax" is found to be significantly less acceptable than an unlabelled policy instrument, even when they have the same characteristics (Brännlund and Persson, 2012; Cole and Brännlund, 2009; Kallbekken and Aasen, 2010; Kallbekken et al., 2011). Respondents that are opposed to taxes may, however, be mollified by policies that propose to recycle the revenue from those taxes into environmentally-oriented measures, such as support for public transport and alternative means of transportation, development of clean technologies, etc. (Sælen and Kallbekken, 2011).

In each choice question, respondents were asked to choose between two hypothetical policies and the status quo, and so in our survey $K = 3$. Attributes and attribute levels are summarized in Table 1. We told respondents that the CO_2 emissions associated with home electricity and heating fuel usage come to a total of 5 tons a year for the average Italian (or Czech) household. Our hypothetical policies would

[2] Our models, which allow for the income elasticity to depend on income, are consistent with Czajkowski and Ščasný (2010) and Barbier et al. (2016), who show that the income elasticity of the WTP for a marginal reduction in pollution is constant only under very restrictive assumptions and is most likely increasing in income.