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# Willingness to pay for climate policy: a review of estimates

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**Abstract:**
One explanation for the modest pace of efforts to mitigate climate change, both federally and internationally, is that constituents do not ascribe much beneficial value to new laws that change the way we produce and consume energy. We surveyed estimates of consumer willingness to pay (WTP) for climate policy to: (1) assess the validity of this explanation, (2) compare elicitation techniques, and (3) explore factors that might explain variation in WTP estimates. We recalculated WTP estimates on an equivalent basis across 27 studies and found a range for WTP of $22-$437/household annually, with a median of $135. We also discuss outliers not included in this range. Discrepancies among estimates drawn from American, Asian, and European samples enable some preliminary inferences about the effects of nationality on WTP for climate stability. Environmental attitudes and beliefs are common explanatory elements in WTP surveys. Others include income, education, and political views. While valuation methods and survey types vary, the great majority of existing work in this area has relied on contingent valuation.

## 1. Introduction

Among the many difficulties inherent in designing policy to address climate change, the combination of near-term and local costs with longer term and globally dispersed benefits must rank among the most severe. Unsurprisingly policy discussions have focused on the former. Debates about *how*, and *how much,* to address climate change, have almost exclusively focused on minimizing the costs of achieving prescribed emission reduction targets. But the motivation for adopting reductions and bearing some costs must ultimately originate from some conception that there are societal benefits to reducing emissions. Even if these perceived benefits derive

from diverse elements. These benefits obviously vary based on the situation of the individual. They are also uncertain; they spillover national boundaries. They reflect diverse perspectives on risk aversion, risk perception, time preferences, inter-generational responsibility, and ethical motivations. They even force some implied expectation of the magnitude and characteristics of avoidable future damages.

Integrated assessment models, which combine a physical climate model with an economic growth model, estimate the avoided future climate damages from climate change policies. These models have been widely used to determine the benefits of climate policy and—by comparing marginal benefits with marginal costs—socially optimal levels of expenditure on climate stabilizing measures. An alternative method for estimating benefits is to elicit individuals' assessments of these benefits. Determining benefits in this way is challenging, given the complex nature of global climate change as both a physical and psychosocial phenomenon. Economists, political scientists, and policy analysts have begun to address this challenge by using a variety of methods to estimate consumer willingness to pay (WTP) for enhanced climate stability. However, the results of these studies, and the conditions under which researchers gather them, vary. This heterogeneity detracts from the clarity of any policy guidance these analyses seek to provide. This paper attempts to survey the explanatory power of existing literature on WTP for climate policy. It does this by identifying common variables across a varied set of WTP studies in order to establish a basis for comparison. It also provides an analytical structure for future studies to evaluate the effects of variation in key comparative elements upon WTP. Preliminary observations illustrate potentially fertile ground for meta-analysis of the combined effects of existing studies. Future research and meta-analyses can employ several observations contained in this analysis.

In this paper, the rest of Section 1 describes the characteristics of WTP as a tool to value climate stability. Section 2 reviews recent work on how individuals value climate policy, focusing on social and behavioral aspects that may explain some variation. In section 3 we explain our calculations and provide the results of our comparison of existing studies. Section 4 discusses a research agenda for improving identification of factors explaining variation in WTP and a conclusion follows in Section 5.

### 1.1. What is Willingness to Pay for Climate Stability and Why Study it?

Conventional economic thinking tells us that climate policies, such as emissions targets, should reflect a simple measure of the costs and benefits associated with the good that the policy seeks to provide. Climate strategies typically define this good as increased stability in or avoided damages from temperature, precipitation, weather patterns, and other climatic phenomena affected by atmospheric GHG concentrations. While approachable in theory, measuring the value of this good is enormously difficult given the complexity of the climate change issue. Nonetheless, policymakers must strive to convey the benefits of climate stabilization if they are to create a unified response to anthropogenic climate change (Jacoby, 2004). Estimates of willingness to pay for climate stabilization provide one means of conveying these benefits.

Economists define the benefits of an environmental policy as the collective willingness to pay to preserve some environmental good (Stavins, 2007)[1]. Researchers typically gather data on

[1] Economists also employ the concept of willingness to accept (WTA) compensation for environmental damages to quantify the benefits of environmental policy. The decision of whether to use WTP or WTA has become increasingly controversial, as the two measures often produce very different estimates of value (Fischer, McClelland, and Schulze, 1988). Others have found this discrepancy to be minimal under certain conditions (Willig, 1976). The magnitude of differences in these two parallel measures depends upon the precise nature of the environmental good, as well as the level of income and substitution effects (Mantymaa, 1999). This analysis forgoes

WTP for environmental goods using one or more of the following methods: 1) garnering a dollar estimate on the basis of what others actually pay to access environmental goods (*travel cost method*); 2) determining price differences across otherwise similar assets that vary only in their access to environmental goods (*hedonic pricing*); and contingent valuation methods (*CVM*), which use surveys to elicit willingness to pay associated with hypothetical scenarios (O'Conner and Spash, 1999). Studies of WTP for climate stability almost always rely on the assessment of hypothetical scenarios, and are therefore suited to the CV method[2]. Further, this method is particularly appropriate for our purposes because it captures both use and non-use value[3] (Stavins, 2007). This is important, as the benefits of climate stability to voters in developed countries are predominantly of a theoretical, indirect, or aesthetic nature[4].

The shortcomings of using WTP for environmental valuation are significant and tend to reflect larger issues facing the application of cost-benefit analysis to environmental policy. For one, the vast uncertainty, long timescales, and social conflicts that characterize climate change make monetization of climate impacts extremely difficult (Conner, 1999). Further, because climate impacts transcend international boundaries, comprehensive valuation must occur on a global scale. True valuation of climate stability also depends heavily on discount rates, or how we value impacts in the distant future as climate change unfolds over long time horizons (Hulme,

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any formal consideration of this debate and focuses on WTP for the sole reason that it dominates existing studies of valuation of climate stabilizing policies and programs.

[2] All but one of the twenty-seven studies examined in this paper make use of hypothetical scenarios. The remaining study simply polls participants outright regarding their WTP for a climate stabilizing policy. This study is not representative of existing literature and was selected as a foil for the relatively comparable CVM exercises that populate the remaining twenty-six studies.

[3] Use-value refers to direct benefits people receive through protection of their health or the use of a natural resource while non-use value refers to passive benefits that are not directly experienced (Stavins, 2007).

[4] Typical non-use values associated with climate stability might include the rights of distant and impoverished populations, the survival of endangered species, and the wellbeing of future generations.

2009). As a result, we should not expect accurate estimates of WTP for climate stability in anything but relatively constrained scenarios with limited geographic, social and temporal boundaries[5].

### 1.2. Possible Determinants of WTP

This paper focuses on WTP as a means of capturing public preferences for climate strategies in relatively localized settings. Associating WTP measures with the unique characteristics of each study provides a means of comparing estimates across a number of empirical categories. Motivating the need for this form of comparison are insights from psychological and socio-cultural literature on the drivers of climate-related behaviors and attitudes. Indeed, as subsequent sections point out, many studies seek to associate attitudinal and behavioral variables with WTP measures. Identifying theoretical explanations for these variables helps establish an empirical basis for studying WTP.

Research on the social and behavioral aspects of energy use indicates that higher income and pro-environmental lifestyles are related to higher levels of WTP for energy conservation equipment (Lutzenhiser, 1993). Feedback studies on household electricity use have found a significant negative effect of environmental awareness on energy consumption (Brandon and Lewis, 1999). This effect was even greater for households with positive environmental attitudes. A comprehensive review of literature on the determinants of energy-related behaviors is beyond the scope of this analysis. These studies are helpful, however, in uncovering the empirical basis for studying WTP for climate stability across certain attitudinal and socio-economic categories.

[5] The studies examined in this paper were chosen partly on the basis of these constraints.

Further research also highlights the importance of contextual differences in geography and local opportunities in explaining environmental behavior (Poortinga, 2004). Demographic and generational transitions have been shown to explain variance in residential energy consumption (O'Neill and Chen, 2002). Also driving household energy consumption are the varying psychological needs and dispositions associated with different generations, ethnicities, and socio-economic groups (Ai He and Greenberg, 2009). In addition, the American Psychological Association has recently identified a number of mental models that affect individuals' understanding of and reactions to climate change (APA, 2009). For instance, framing a climate stabilizing measure in terms of its impact on weather may trigger a "weather" model that conjures a sense of chaos, helplessness, and resignation with regard to the proposed good.

These insights provide a starting point for identifying probable explanations for variance in WTP estimates. The next section will explore apparent themes across a body of studies on WTP for climate stability conducted in recent years. This section will give a general sense of the types of studies, surveys, and explanatory variables used to estimate WTP in the climate policy arena. It will also identify some of the primary distinctions across studies that hinder attempts at detailed quantitative comparison.

## 2. Climate change and values

Existing research on the valuation of climate stability is both limited and diverse. Responses to critical questions regarding public willingness to pay for climate-protecting measures are often relegated to "sound-bytes" garnered from popular media and dialogue among climate actors[6].

[6] For example, see former President George W. Bush's June, 2001 White House Press Release explaining his opposition to the Kyoto Protocol, in which he stated that compliance with the mandate would "have a negative

Climate scientist and anthropologist Mike Hulme explains the conflict among competing measures of value for climate stability in the following way:

> "We disagree about climate change because we view our responsibilities to future generations differently, because we value humans and nature in different ways, and because we have different attitudes to climate risks" (2009).

WTP estimates represent an effort to reconcile this disagreement with the need for accurate and effective emissions reduction goals in climate policy.

The great majority of studies on WTP for climate stability have been conducted within the past decade, and each of the twenty-seven surveys covered in this analysis was conducted after 1998. The nascence of WTP methods of climate valuation and recent prominence of the climate change issue over the past decade allows for some uniformity in our sample of estimates. It also precludes the possibility of extensive time-series analysis. Further hindering identification of temporal trends, researchers have only very recently begun to explore the influence of certain key explanatory variables such as uncertainty of climate outcomes (Cameron, 2005; Viscusi and Zeckhauser, 2006) and travel frequency (Brouwer et al., 2008) on WTP.

The policy objects, or environmental goods, under valuation in WTP estimates vary extensively, ranging from climate stabilizing policy in general (Cameron, 2005), green energy investments (Diaz-Rainey, 2007; Wiser, 2007; Hoyos and Longo, 2009), decreased temperature changes and food shortages through increases in gas prices (Viscusi and Zeckhauser, 2006; Solomon and Johnson, 2009), down to specific carbon sequestration mechanisms (Brouwer et al,

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economic impact, with layoffs for workers and price increases for consumers…when you evaluate all these flaws, most reasonable people will understand that it's not sound public policy."

2008). Common payment vehicles used to estimate WTP are taxes on income (Bohringer, 2004) and gasoline (Viscusi and Zeckhauser, 2006), increased energy prices (Berrens et al., 2004), and higher household costs generally (Akter and Bennett, 2009). The vast majority of surveys use the contingent valuation (CV) model of valuation. Other methods include an ordered probit model targeting discrete ordinal responses to valuation scenarios[7] (Diaz-Rainey and Ashton, 2007), and extrapolation from public opinion polls (Bohringer, 2004). Researchers employ a number of question types within the CV framework. Open-ended questions simply ask respondents to "name their price" for a particular climate stabilizing measure[8]. Such questions often include payment cards, listing a range of possible prices (Solomon and Johnson, 2009). More often, questions take the form of single, or multiple-bounded dichotomous choice variables that capture yes/no responses to a randomly selected WTP bid[9].

Significant explanatory variables in estimates of WTP for climate stability include gender (Viscusi and Zeckhauser, 2006), education (Berk and Fovell, 1999), level of perceived responsibility (Brouwer et al., 2008), temperature increases (Berk and Fovell, 1999), payment vehicle type (Wiser, 2007), awareness of climate change impacts (Nomura and Akai, 2004), respondent effort (Berrens et al., 2004), and uncertainty of climate outcomes (Akter and Bennett, 2009; Cameron, 2005). Each of these variables appears in one or more of the studies examined

[7] The primary difference between this model and contingent valuation is the inability of the former to produce a continuous measure of WTP. Instead, the ordered probit model measures a discrete (1-5) response to a single WTP bid question. CV studies may also employ discrete, ordinal question types, but such models generate responses to multiple bid amounts to provide continuous WTP measures (Viscusi and Zeckhauser, 2006).

[8] Without specifying bid amounts, such surveys are particularly vulnerable to grossly inaccurate WTP estimates, in the form of "feel-good" and "protest" votes (Berk and Fovell, 1999). For these reasons none of the studies featured here employs the open-ended method.

[9] Double-bounded dichotomous WTP questions often follow with a second bid that is higher if the respondent answered yes to the first question, and lower if he or she answered no.

in this analysis. The frequency and statistical significance of these variables will be key considerations in comparing WTP estimates across studies.

As the next section illustrates, most studies produce estimates that translate into annual household[10] dollar amounts[11]. Such estimates range from as little as $21.77 (Wiser, 2007) to $3623.32 per year (Cameron, 2002)[12]. The magnitude of this range further illustrates the need for projects like this one, which seek to identify common explanatory elements across a diverse body of WTP estimates. Other important differences across existing WTP studies appear in the size and nature of the survey sample, as well as in the proximity of the survey date to focusing events that may skew estimates in certain settings. It is difficult to make meaningful comparisons among estimates of WTP between a sample of Harvard policy students (Viscusi and Zeckhauser, 2006), and another of relatively conservative and rural Mid-western voters (Solomon and Johnson, 2009). Further, it is reasonable to assume that surveys conducted shortly after climate-related focusing events will be higher (or lower) than they would under normal circumstances[13]. Finally, challenges in comparison arise from heterogeneity of featured summary statistics for WTP measures. Many studies offer several different measures based on

[10] In cases where household data was not provided, individual expenditures were converted using country-specific multipliers (The Economist, 2010).

[11] The key exception appears to be estimates WTP unit-specific taxes on items such as gasoline (Viscusi and Zeckhauser, 2006; Petrolia et al., 2010). In these cases, annual WTP estimates are calculated on the basis of average annual consumption of the taxed item.

[12] All estimates are converted to 2008 U.S. dollars using online calculators for currency conversion and inflation adjustment (www.xe.com, 2010; HBrothers, 2010).

[13] An example appears in David Kaczan et al.'s finding of an unusually high estimate directly following the release of both Al Gore's provocative film, An Inconvenient Truth and the Stern Review on the Economics of Climate Change (forthcoming).

different models, making it difficult to select an overall estimate[14]. It is also impossible to identify a single type of WTP measure across available studies. Existing estimates tend to provide means, medians, mean ranges, sample percentage accepting bid, or some combination of the above. But none of these measures appears in every study, making clear comparison difficult. Studies also vary in their proposed duration of expenditure on a policy or good. While most surveys generate average annual measures of WTP, others cap the duration of payment at a few years (Wiser, 2007) while still others fail to identify any timeframe, presenting a total one-time measure of WTP (Achtnicht, 2009)[15].

This section has identified some of the major trends and differences across existing literature on WTP for climate stability. It has also discussed some of the difficulties these trends pose for comparison across WTP estimates. A quick glance at the variance across WTP estimates illustrates the need for comparative analysis to determine the causes of such fluctuations. The next section establishes an analytical framework for such comparison, highlighting promising explanatory elements across a group of twenty-seven recent studies.

## 3. Existing estimates of willingness to pay for climate policy

How can researchers and policy analysts best compare WTP studies to make meaningful inferences about climate policies? To answer this question, we must first survey the range of

[14] See Hoyos and Longo (2009). The last section of this report recommends that where the use of multiple models generates varied estimates without apparent differences in quality, these estimates should be treated as independent observations in a meta-analysis that uses others' WTP estimates as the dependent variable.

[15] One-time measurements of climate-focused WTP are not uncommon and are often the only logical choice, e.g. in estimating WTP for energy efficiency equipment or solar panels. Further research along the lines of this report could extrapolate annual estimates from one-time measures by amortizing the expenditure over the individual's lifespan.

estimates in existing literature and identify key differences in the methods by which researchers have obtained them.

### 3.1. WTP results from previous work

Section 2 mentioned the vast intervals that appear in extant studies of WTP for climate stability. Figure 1 displays this range across twenty-seven key studies. Figure 2 removes outliers on the high end, revealing that the majority of estimates fall between $50 and $300 annually[16]. Table 1 shows the summary statistics for the 27 studies with outliers removed. The mean value was $167 with a range of $22-$437.

**Table 1 Summary of WTP estimates**

| | Mean | Median | Minimum | Maximum |
|---|---|---|---|---|
| $2008/household/year | $167 | $135 | $22 | $437 |

[16] As mentioned in section 2, presenting variance in average WTP across studies is difficult given the heterogeneity of statistics and payment vehicles presented in the literature. This resulted in the crude juxtaposition of medians, means, and derived averages that the author calculated on the basis of average levels of expenditure and consumption.

**Figure 1 Average household WTP ($2008)**

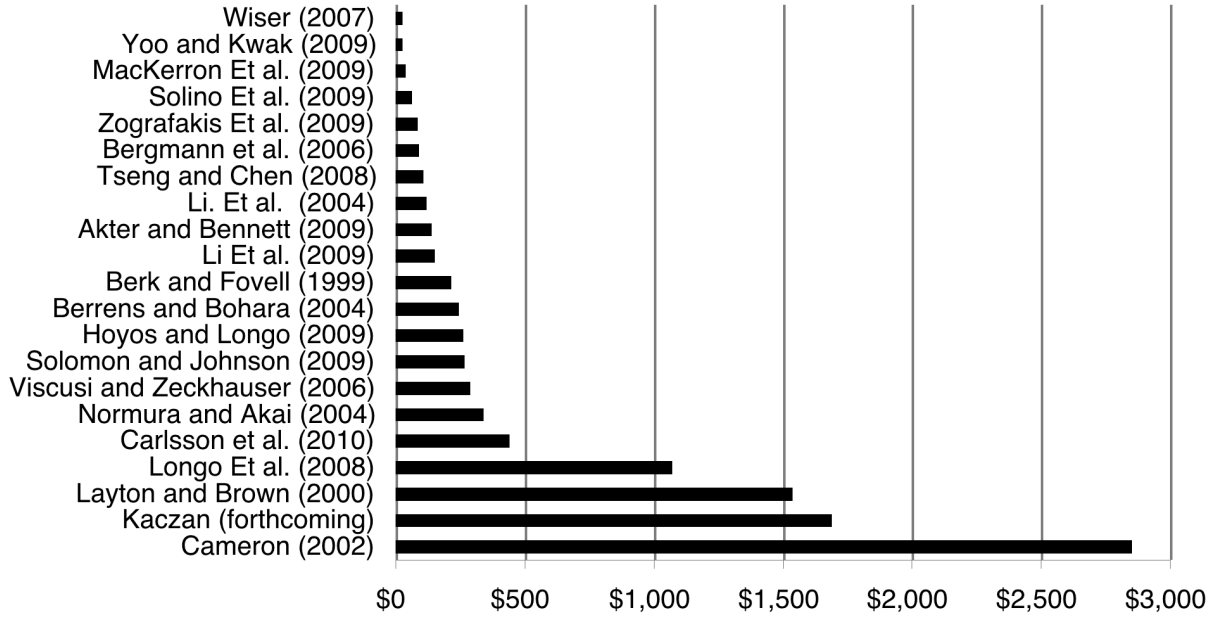
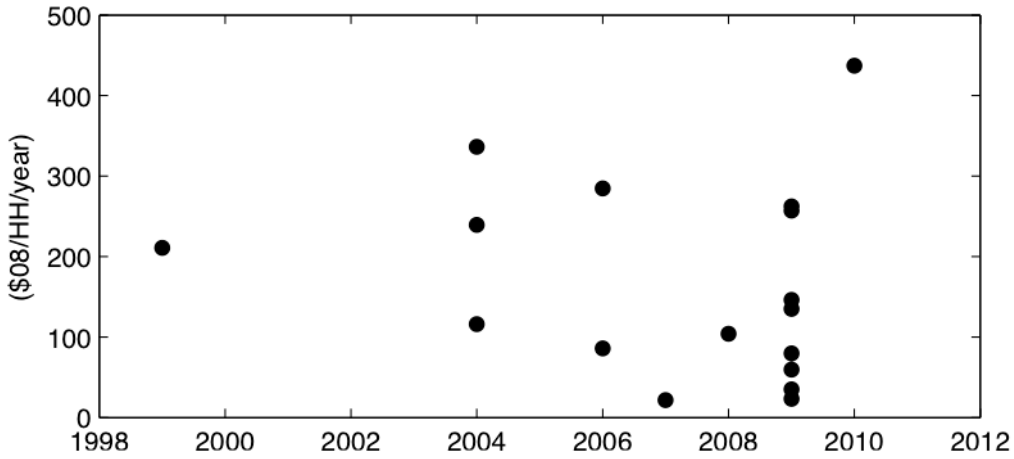



**Figure 2 Average annual household WTP (outliers removed)**

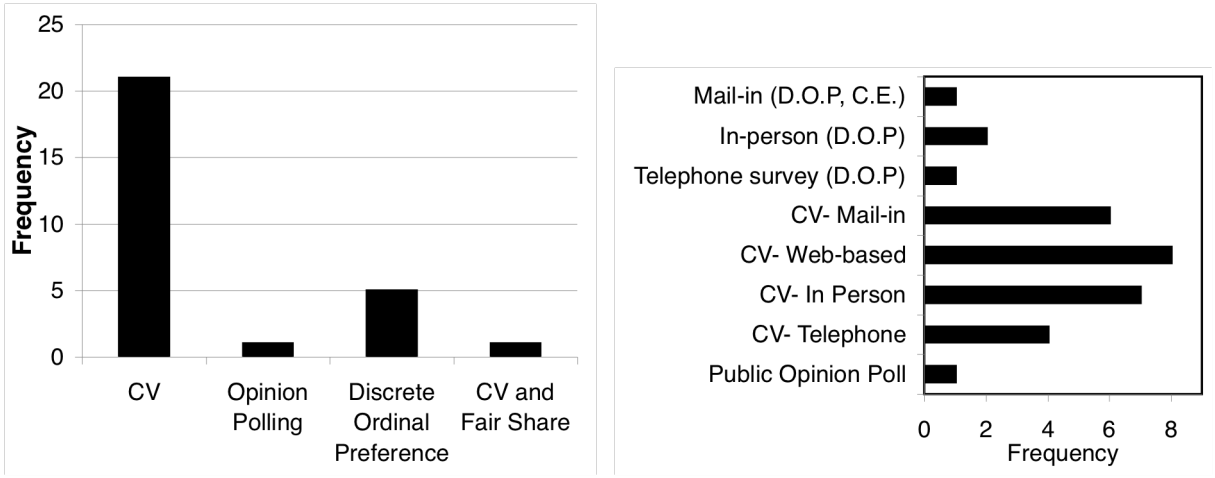



This section considers these issues through an examination of twenty-seven recent WTP studies selected on the basis of certain criteria for meeting the objectives of this paper: 1) Direct *relevance* to climate or energy policy geared toward climate stability; 2) *reliability* as captured by sufficient peer-review, publication, and repeated citation across studies; 3) prospective

*comparability* as evidenced by relative overlap of at least some explanatory variables; and 4) sufficient *breadth* of survey features and conditions to provide for effective differentiation.

Figure 3 offers a snapshot of the studies featured in this analysis. The panel on left illustrates the dominance of the CVM survey method while the right panel shows the breadth of survey format types appearing in recent studies. D.O.P refers to discrete ordinal preference. C.E. refers to choice experiment.

**Figure 3 Valuation method (left) and survey format (right)**




When we consider the physical complexity of climate change the countless proposals for dealing with its impacts, "climate stability" becomes a rather amorphous term. Under certain broad conceptions, we may consider any effort or policy that ultimately reduces pressure on atmospheric greenhouse gas concentrations a "climate-stabilizing measure." Taken to extremes, an overly broad approach might include estimates of WTP for economic or transportation policies designed for specifically non-climate purposes, but which nonetheless result in "climate stabilization[17]." A more ambiguous example is the case of certain energy policy studies. This

[17] Examples might include trade policies that reduce the distance traveled to deliver exports or vehicle emission mandates to lower toxic emissions that happen to result in CO2 emission reductions.

analysis specifically excludes studies of WTP for renewable energy increases if those increases were proposed as primary solutions to energy security issues. Instead, it only includes studies in which the policy change or strategy is directly related to climate stabilization, *e.g.* renewable energy for the sake of decreased carbon intensity[18].

This report also selected studies that tended toward a common analytical purpose of uncovering the psychological and socio-cultural determinants of WTP for climate stability. Thus there is considerable overlap among explanatory variables and their underlying theoretical objectives across studies. Table 2 lists common explanatory variables of interest that appeared in several of the twenty-seven studies. A complete list of studies featured in this report, along with their dates, payment vehicles, proposed policies/goods, and key explanatory variables is included in Table 3 in the Appendix. These variables, along with the analytical differences conveyed in Figure 3 above, form the beginnings of a framework in which to compare measures of WTP for climate stability.

[18] A similar analysis to this one that studies estimates of WTP for strategies with indirect climate benefits is warranted and would undoubtedly be useful to analysts and climate policy designers. These studies are not directly relevant, however, in an analysis of WTP *for* climate stability.

**Table 2 Common explanatory variables across 27 WTP studies**

| Variable | Number of Studies |
|---|---|
| Environmental Engagement | *18* |
| Environmental Attitudes/Beliefs | *17* |
| Education level | *16* |
| Perceived Efficacy of Policy/Strategy | *10* |
| Political Views | *10* |
| Level of Certainty on Climate Change and Policy Outcomes | *8* |
| Expected Future Temperature/Precipitation Levels | *5* |
| Perceptions of Others' Efforts | *3* |

Also important to our comparative framework are basic differences in demographic, geographic, and temporal dimensions. The following section on anomalies among WTP studies will zero in on key temporal conditions, such as proximity to major public relations and weather events, which threaten the reliability of estimates. Age and other demographic variables play a key role in distinguishing the character of survey samples across studies. The samples used in these studies range from student populations (Cameron, 2002; Viscusi and Zeckhauser, 2006), to older populations with conservative (Solomon and Johnson, 2009) or "yuppie" (Berk and Fovell, 1999) characteristics. Several studies feature samples that are generally representative of national populations (Bohringer, 2004; Wiser, 2007). Such stark differences in samples hinder application of the WTP estimates they produce. Fortunately, they also help establish a basis for comparative examination to determine sources of variance in WTP.

Further strengthening the comparative framework are geographic differences in the samples used, as well as in the scope of the CV scenario depicted. Thirteen of twenty-seven studies were conducted in the United States with scope of the proposed policies varying from the national (Li et al., 2004) to the coastal (Berk and Fovell, 1999), state (Solomon and Johnson, 1999), and local levels (Viscusi and Zeckhauser, 2006). The other studies reflect WTP in

various European and Asian countries[19]. Carlsson et al. simultaneously conducted the same survey on three continents to identify substantial differences in WTP for CO2 reductions among American, Asian, and European residents (2010). Thus geographic differences in survey samples and variance in the scope of proposed climate policies (e.g. local, national, global) provide useful metrics for explaining variance in WTP across studies.

While the overlap of certain explanatory variables reveals promising common ground for comparison, the details of the survey questions will ultimately shape deeper analysis of WTP across studies. As discussed later, we may be able to measure the effects of the mere existence of certain types of variables on WTP across an aggregated sample of studies. However, categories such as environmental attitudes, uncertainty, and even political beliefs do not produce homogeneous measurements such as those found in age or income variables. We cannot, for example, pool measurements of the effect of cultural identity in BAC Spain (Hoyos and Longo, 2009) with levels of membership in Midwest American conservative organizations (Solomon and Johnson, 2009). In addition, many studies employ several models that produce different, but equally interesting WTP estimates (Berrens et al., 2004; Solomon and Johnson, 2009). It is often difficult and seemingly arbitrary to favor certain estimates over others when establishing an overall measure of WTP for each study. Finally, how should researchers treat WTP studies that simply do not offer specific monetary estimates? Certain credible studies measure the effects of various parameters on dichotomous choice or discrete ordinal preference responses to the question, "would you be willing to pay more for X?" (Bohringer, 2004; Diaz-Rainey, 2007). Section five of this paper will offer suggestions for disentangling some of these issues. For now,

[19] See Appendix.

it is sufficient to acknowledge the limitations facing more a more detailed framework for comparing WTP estimates.

### 3.2. Outliers in WTP studies

As previous sections document, the existing body literature is far from establishing a meaningful and coherent range of climate-focused WTP estimates. While the majority of estimates covered here fall within $100-$300 annually, conspicuous outliers persist on both the high (Cameron, 2002; Kaczan, forthcoming) and low (Wiser, 2007; Yoo and Kwak, 2009) ends of the distribution. It is important for our comparative framework to uncover possible empirical explanations for these departures from more moderate estimates. Such outliers may provide key insights into the underlying determinants of WTP across studies.

High-end estimates differ from the remaining studies in important ways. David Kaczan conducted his surveys in close proximity to two provocative climate media events: the release of Al Gore's *An Inconvenient Truth* and the publication of the *Stern Review of the Economics of Climate Change* (Kaczan, forthcoming). Further, Kaczan admits that the average income of his sample was significantly higher than the Australian national mean. Finally, Kaczan compares his methodology to Berrens et al.'s 2004 study, which produced similarly high estimates[20] (between $1290 and $1760 annually) until the important removal of uncertain respondents from the latter's sample. Each of these factors undoubtedly played a role in producing such an unusually high estimate of average annual WTP.

[20] After recoding responses to include only those who were relatively certain of their WTP, Berrens et al. produced the much more conservative estimate displayed in Figure 1 and Figure 2 above (Berrens et al., 2004). An important motivation behind this tactic was the inherently uncertain nature of the policy good featured in Berrens: U.S. ratification of the Kyoto Protocol.

Perhaps the most obvious explanation for Cameron's (2002) exceptionally high estimate of over $2800 per year is the unique character of his sample. Far from representative, the subjects of this survey consisted of a small convenience sample of undergraduate economics students with a mean age around 19 and whose expected incomes greatly exceeded national averages. While Cameron did not design his study to be representative, such grave departure from the general population presents enormous difficulty in comparing his results to those of other studies.

On the opposite end of the distribution, both Wiser (2007), and Yoo and Kwak (2009) produced exceptionally low estimates of around $20 per year. In the former case, the nature of the good and payment vehicle (voluntary versus government-mandated renewable energy premiums) allowed only a narrow range of WTP bids to begin with[21]. This result speaks to the difficulty of comparing WTP estimates across a diverse range of policy tools and goods designed to promote climate stability. The low result in Yoo and Kwak (2009) is likely due in large part to the extremely uneducated nature of the sample. Only 19.5% had any understanding of the good in question (renewable energy) and only 7% were aware of the Korean government's policy to increase use of that good. Researchers will need to somehow control for such distortions in the pool of samples in order to make valid inferences across existing WTP studies. Accurate comparison will also require appropriate categorization of estimates according to the type of policy (e.g. local renewable energy premiums versus passage of national emissions targets) under valuation.

[21] Bid amounts were $.50, $3, and $8 per month, providing for a narrow and modest annual WTP range of $6 - $96 (Wiser, 2007).

## 4. Identifying the determinants of WTP

We have so far analyzed key differences and identified promising similarities across a substantial share of existing climate-based WTP estimates, creating a framework for more sophisticated comparison. This final section offers some specific suggestions for using this information to develop a meta-analysis. Such an analysis would combine the results of existing WTP studies to produce more powerful estimates than what is possible under a single set of conditions. These suggestions will stop short of providing actual regression models[22], focusing instead on the following two issues: controlling for relevant study characteristics and selection of appropriate dependent variables. The previous sections have gone a long way in responding to the first issue, but some additional suggestions are helpful in light of further analysis of the twenty-seven studies. The second issue is much thornier given the lack of uniformity among popular measurements of climate-based WTP. The section concludes with some general remarks about the difficulty of climate change valuation and its implications for this sort of analysis.

Table 2 above gave a general sense of the overlap among explanatory variables in existing WTP studies. Table 4 in the Appendix adds some detail to the discussion of promising independent variables in a meta-analysis of climate-based WTP estimates. As the table illustrates, certain variables such as age, gender, income, and political views appear in nearly all of the studies. These variables are key starting points for characterizing observations in a meta-analysis. Other types of variables and their underlying empirical conditions vary across studies. For instance, several studies measure the effects of uncertainty and perceived fairness on WTP. Meta-analysis could measure the combined effects of these variables for those studies that

[22] Though this would certainly be possible through application of a more sophisticated quantitative background than that which this author can provide. Applying more detailed statistical knowledge to this report's findings could

include them. Alternatively, researchers could code observations in a meta-study based on the existence of these and other explanatory elements or conditions. In this way, certain explanatory conditions, such as political conservatism or environmental engagement, become predictors of variance in the overall pool of WTP estimates.

Determining which explanatory variables to include in a climate-based WTP meta-analysis is a daunting project in and of itself. The tables and observations in this report provide some promising avenues for initial exploration. For instance, a glance at these twenty-seven studies reveals the apparent sensitivity of WTP estimates to survey sample characteristics such as age, nationality, and education level (Cameron, 2002; Yoo and Kwak, 2009; Carlsson et al., 2010). A more obvious means of selecting explanatory elements is to identify common and statistically significant variables among existing studies. The twenty-seven estimates featured here reveal some such variables and Table 4 lists them according the studies in which they were found to be significant[23].

We have seen that determining a uniform measure of average annual WTP can be extremely difficult. Studies present different information on mean and median WTP, as well as duration of expenditure on the proposed good. With this in mind, it is prudent to consider alternative options for dependent variables in a meta-analysis of variation in existing WTP estimates. Commonalities among the twenty-seven studies featured in this report reveal good

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produce valuable suggestions for promising regression models. Such models should be a prominent focus of any further work on this topic.

[23] The table lists all variables that were statistically significant at 10% or lower in at least one model. The list is not exhaustive by any means. These twenty-seven studies offer dozens of potential explanatory variables that this report does not cover due to limitations on space and project scope. See the notes in the Appendix for more detail about these variables.

candidates for dependent variables in both the range of WTP estimates (Figure 4) and the percentage of the sample who accept their proposed bid (Figure 5).

**Figure 4 Range of estimates of WTP across and within studies. Studies are ordered in sequence with earliest at left.**

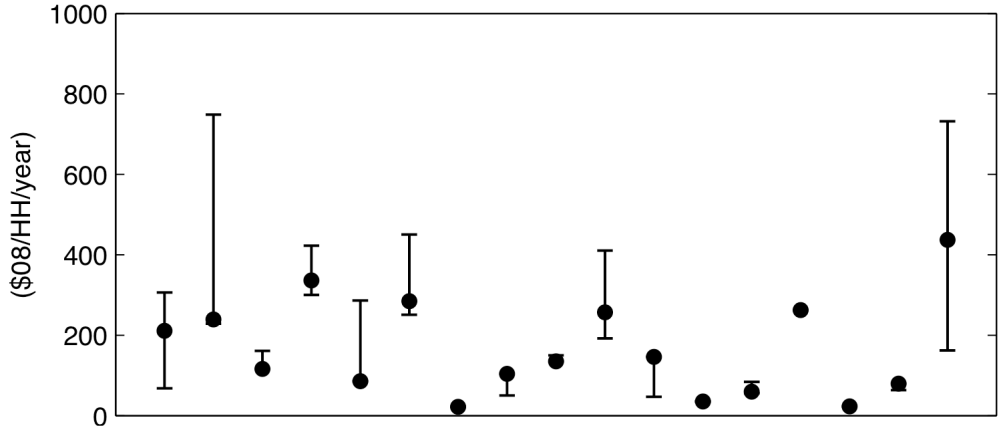
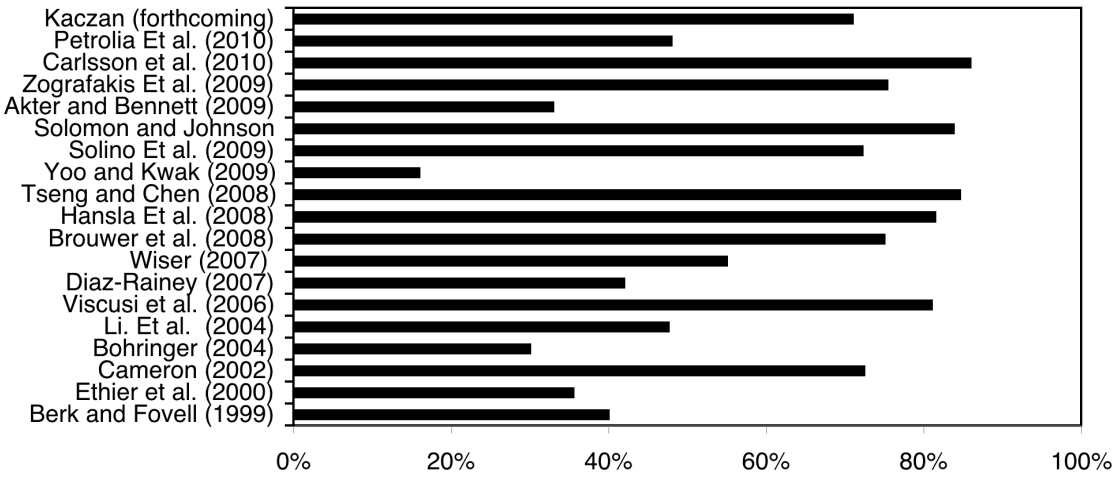



**Figure 5 Percent of sample who accept some WTP bid**




By using ranges of WTP estimates, researchers have the option of measuring variation in lower and upper bounds independently. Alternatively, they could measure variation in the range of estimates within studies. This is particularly useful for studies that produce multiple estimates of seemingly equal quality from different models (Berrens et al., 2004; Solomon and Johnson,

2009). Another way to handle the problem of multiple models is to count each model's WTP estimate as its own distinct observation, yielding multiple observations per study.

Defining the dependent variable as a percentage is one way to deal with studies that do not present monetary estimates (Bohringer, 2004; Diaz-Rainey, 2007). In these cases, meta-analysis would simply estimate variation in the percentage of positive responses to dichotomous or discrete ordinal choice questions. In the latter case it may also be helpful to present the dependent variable as an average ordinal measure on various scales of agreement or certainty regarding WTP questions.

## 5. Conclusion

This analysis has provided a survey of existing estimates of WTP for climate stability and established a basis for comparing them across relevant empirical categories. Behavioral, psychological, and socio-cultural variables are critical to understanding fluctuations in WTP. Existing studies have begun to explore the nature and effects of these variables by measuring the relationships between WTP and numerous attitudes, behaviors, beliefs, and cultural values. These effects and their underlying causes are difficult to determine and even more difficult to combine across studies. Nonetheless, it is imperative that researchers include them in future WTP analysis for climate stability—a good that is notoriously undervalued in market-based analyses.

Climate change affects numerous sources of human welfare for which there are no markets, including ecological diversity, aesthetic beauty, social justice, and multiple sources of natural capital (Hulme, 2009). Second, the slow and long-term nature of climate change impacts requires effective valuation mechanisms to incorporate beliefs and attitudes about the future.

Standard economic tools such as cost-benefit analysis fail to capture these important sources of value. Consequently, the carbon prices and emissions targets developed on the basis of these market tools offer, at best, an incomplete account of constituents' willingness to pay for those measures. At worst, they reflect the high-handed decisions of certain actors based on crude and selective measures of particular economic values.

This analysis has offered a preliminary step toward informing existing climate policies with more robust measures of WTP. It has identified common explanatory ground across a number of existing studies and provided explanations for stark differences among them. It has also pointed out the most glaring difficulties in normalizing WTP estimates to make macro-level assertions about their implications for public valuation of climate policy. Finally, the project defines a detailed analytical framework with suggestions for both dependent and independent variables, with which researchers can begin to aggregate WTP estimates. Successful application of this framework will maximize the explanatory power of current research and produce more authoritative estimates of value for climate stability across jurisdictions.

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## Appendix

**Table 3 General description of selection of 27 studies of WTP for climate policy**

| | *Study* | *Key Explanatory Variable (s)* | *Geographic/Policy Jurisdiction* | *Policy/Good to be Valued* | *Payment Vehicle* | *Date of Survey* |
|---|---|---|---|---|---|---|
| **1** | Berk and Fovell (1999) | Expected temperature | West Coast United States Communities | Prevention of Harmful Weather | None Specified | N/A |
| **2** | Ethier et al. (2000) | Survey technique | United States | Green Electricity | Voluntary Electricity Bill Surcharge | N/A |
| **3** | Layton and Brown (2000) | Impacts on future generations | United States (Colorado)a | Forest Preservation | Higher monthly Household Expenses | 1998 |
| **4** | Cameron (2002) | Expected temperature; Uncertainty | United States | Average regional temperature control | Increased prices of goods and services | 1997-1998 |
| **5** | Berrens et al. (2004) | Uncertainty; Respondent effort | United States | U.S. Ratification of Kyoto Protocol | Increased energy and gasoline prices | 2000 |
| **6** | Bohringer (2004) | N/A (No statistical analysis) | United States | "Environmental Protection" | Various eco-taxes, income losses | 2000 |
| **7** | Li. Et al. (2004) | Limits on developing countries | United States | U.S. Ratification of Kyoto Protocol | Increased energy and gasoline prices | 2000 |
| **8** | Normura and Akai (2004) | Renewable energy type, climate change awareness | Japan | Increased Renewable Energy | Monthly Premium for Renewable energy | Feb., 2000 |
| **9** | Bergmann et al. (2006) | Urban/Rural differences, landscape changes, air quality, job creation | Scotland | Increased proportion of energy from renewable sources | Electricity prices | Oct., 2003 |
| **10** | Viscusi and Zeckhauser (2006) | Risk perception, uncertainty | United States (Boston Area) | Decreases in various environmental risks | Gasoline tax | Oct.-Nov, 2004 |

| | *Study* | *Key Explanatory Variable (s)* | *Geographic/Policy Jurisdiction* | *Policy/Good to be Valued* | *Payment Vehicle* | *Date of Survey* |
|---|---|---|---|---|---|---|
| **11** | Diaz-Rainey (2007) | Environmental beliefs and attitudes | United Kingdom | Increased renewable energy | Increased energy prices | May-June, 2003 |
| **12** | Wiser (2007) | Payment vehicle type; Expected WTP of others | United States | Increased renewable energy | Mandatory versus voluntary increase in electricity bill | N/A |
| **13** | Brouwer et al. (2008) | Nationality, travel frequency | Global (Mostly European travelers) | Emissions offsets | Carbon travel tax | Nov., 2006 |
| **14** | Hansla et al. (2008) | Values, environmental beliefs/concerns | Sweden | Renewable energy | Electricity prices | N/A |
| **15** | Longo et al. (2008) | Energy security, Job creation | Bath, England | Climate change mitigation, employment increase, energy security | Electricity prices | Jul.-Aug., 2005 |
| **16** | Tseng and Chen (2008) | Effects on endangered species, payment vehicle | Taiwan | Preservation of Taiwan trout population | Tax or donation | Sep.-Oct. 2006 |
| **17** | Akter and Bennett (2009) | Perceived effectiveness | Australia | Temperature stability | Higher monthly household costs | Nov.-Dec., 2008 |
| **18** | Hoyos and Longo (2009) | Mention of ancillary benefits | Spain (BAC) | Increased renewable energy | Unspecified tax | June-July, 2008 |
| **19** | Li et al. (2009) | Perceptions of nuclear energy and biofuels, views on foreign oil use | United States | Increased energy research and development | Electricity and gasoline prices | Mar.-Jun. 2006 |
| **20** | MacKerron et al. (2009) | Co-benefits to health and technology, charitable giving | United Kingdom | Carbon offset certifications for aviation enterprises | Increased air travel costs | Feb.-Mar. 2007 |

| | *Study* | *Key Explanatory Variable (s)* | *Geographic/Policy Jurisdiction* | *Policy/Good to be Valued* | *Payment Vehicle* | *Date of Survey* |
|---|---|---|---|---|---|---|
| **21** | Solino et al. (2009) | Question format, periodicity of payment vehicle | Galacia, Spain | Increased renewable energy | Electricity prices | Jan.-Feb. 2006 |
| **22** | Solomon and Johnson (2009) | Renewable energy type, uncertainty, perceived fairness | Midwestern United States (MN, WI, MI) | Lower emissions, fewer food shortages through increased use of cellulosic bio-fuels | Higher gasoline prices | Nov, 2007-Jan, 2008 |
| **23** | Yoo and Kwak (2009) | Environmental engagement | South Korea | Increased renewable energy | Increased Electricity Bills through gov. mandate | April-May, 2006 |
| **24** | Zografakis et al. (2009) | Residential size and characteristics | Crete, Greece | Increased renewable energy | Electricity prices | Sep., 2006-Feb., 2007 |
| **25** | Carlsson et al. (2010) | Climate change attitudes, country of residence | United States, Sweden, and China | 30, 60, 85% reductions in CO2 emissions by 2050 | Higher monthly household costs | Nov.-Dec. 2009 |
| **26** | Petrolia et al. (2010) | Political and environmental beliefs | United States | Increased use of ethanol fuel blends | Gasoline prices | Apr., 2007 |
| **27** | Kaczan (forthcoming) | Confidence, behavioral and attitudinal variables | Australia | Temperature stability | Increased electricity prices | Nov, 2006 |

**Table 4 Prevalence of explanatory variable across studies**

| | *Study* | *Income* | *Age* | *Gender* | *Political Views* | *Edu.* | *Environmental Engagement* | *Environmental Attitudes/Beliefs* | *Perceived Efficacy of Policy* | *Perceived Fairness of Policy* | *Perceived Efforts of Others* | Uncertainty of Climate Outcomes | *Other Key Predictors* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Berk and Fovell (1999) | X | X | | | X | | X | | | | | Precipitation, Expected Temperature |
| 2 | Ethier et al. (2000) | X | X | X | | X | X | X | | | | | Survey method |
| 3 | Layton and Brown (2000) | | | | | | | X | | | | | Time horizon, impacts on future generations |
| 4 | Cameron (2002) | X | X | X | X | | X | | | | | | Expected Temperature |
| 5 | Berrens et al. (2004) | X | X | X | | X | X | X | | X | | X | Respondent Effort |
| 6 | Bohringer (2004) | | | | | | | | | | | | |
| 7 | Li. Et al. (2004) | X | X | X | X | X | X | X | X | X | X | X | Treatment (Developing Countries face emissions targets) |
| 8 | Normura and Akai (2004) | | | | | | X | | | | | X | Wind versus PV Solar energy |
| 9 | Bergmann et al. (2006) | X | X | X | | | | | | | | | Urban versus rural residence, landscape changes, air quality |
| 10 | Viscusi and Zeckhauser (2006) | X | X | X | X | X | X | | X | | | X | Payment vehicle type, Expected Temperature; Environmental risk perception |
| 11 | Diaz-Rainey (2007) | X | X | X | | X | X | X | X | | X | | |
| 12 | Wiser (2007) | X | X | X | X | X | X | X | | X | X | | Payment vehicle type, distrust of government and others |

| | *Study* | *Income* | *Age* | *Gender* | *Political Views* | *Edu.* | *Environmental Engagement* | *Environmental Attitudes/Beliefs* | *Perceived Efficacy of Policy* | *Perceived Fairness of Policy* | *Perceived Efforts of Others* | Uncertainty of Climate Outcomes | *Other Key Predictors* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | Brouwer et al. (2008) | | | | | X | X | X | | | | | Nationality, travel frequency, price paid for airline tickets |
| 14 | Hansla et al. (2008) | X | X | X | | X | X | X | | | | | General values and beliefs about the world |
| 15 | Longo et al. (2008) | X | X | X | | X | X | X | X | | | | Importance of jobs, views on nuclear and renewables, energy security |
| 16 | Tseng and Chen (2008) | X | X | X | | | | | | | | | Climate change knowledge, children, endangered species, payment vehicle type |
| 17 | Akter and Bennett (2009) | X | X | | | | X | | X | | | X | Expected Temperature |
| 18 | Hoyos and Longo (2009) | X | X | X | X | | X | X | | | | | Ancillary, local benefits considered |
| 19 | Li et al. (2009) | X | X | X | X | | | X | X | | | | Concern over energy security and shortages, nuclear attitudes |
| 20 | MacKerron et al. (2009) | X | X | X | | X | X | X | | | | | Co-benefits to health and technology, charitable giving |
| 21 | Solino et al. (2009) | X | X | X | | X | X | | X | | | | Survey question format, periodicity of payment vehicle |
| 22 | Solomon and Johnson (2009) | X | X | X | X | X | X | X | X | X | | X | |
| 23 | Yoo and Kwak (2009) | X | X | X | | | X | | | | | | |

| | *Study* | *Income* | *Age* | *Gender* | *Political Views* | *Edu.* | *Environmental Engagement* | *Environmental Attitudes/Beliefs* | *Perceived Efficacy of Policy* | *Perceived Fairness of Policy* | *Perceived Efforts of Others* | Uncertainty of Climate Outcomes | *Other Key Predictors* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 | Zografakis et al. (2009) | X | | | | | | X | X | | | | Residential size and characteristics, climate awareness, energy information, energy shortages |
| 25 | Carlsson et al. (2010) | X | X | X | X | X | | X | | | | X | Country of residence |
| 26 | Petrolia et al. (2010) | X | X | X | X | X | | | X | | | | Policy preferences, personal satisfaction from ethanol use |
| 27 | Kaczan (forthcoming) | X | X | X | X | X | X | X | | | | X | Expected Temperature |

Notes:

* Political Views- May be membership or association with a particular party; culturally conservative/liberal leaning (Hoyos and Longo, 2009); traditionally conservative or liberal values such as favoring development over the environment (Kaczan, forthcoming).

* Environmental Engagement/Education- May be membership in an environmental group (Berrens et al., 2004), current purchases of green electricity or carbon offsets (Akter and Bennett, 2009), awareness of climate change impacts (Nomura and Akai, 2004), or familiarity with policy options (Li et al., 2004; Yoo and Kwak, 2009).

Environmental Attitudes/Beliefs- e.g. Human beings caused and are responsible for CC (Akter and Bennett, 2009); Concerns about climate change (Berk and Fovell, 1999).

* Note that some studies did not provide detailed surveys in their published reports, leaving open the possibility of more variables included that this table shows.