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Analysis

Valuing climate protection through willingness to pay for biomass ethanol

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ABSTRACT

This study uses a multi-part, split-sample contingent valuation method (CVM) and fair share (FS) survey to better understand the public's valuation of mitigating global climate change through its willingness to pay for biomass or "cellulosic" ethanol. In addition to a basic CVM question, a related scenario was developed that asked half of the survey respondents to state their fair share cost to lessen a potential food shortage in the next decade, also through the expanded use of cellulosic ethanol. Three alternative biomass feedstocks were assessed: farming residues, forestry residues and paper mill wastes, and municipal solid wastes. Overall a slightly larger proportion of respondents were WTP extra for cellulosic ethanol in the basic CVM scenario than in the FS scenario, though no significant differences were found in the WTP for the different feedstocks. Bid curve lognormal regression results for the two models were similar, supporting the idea that asking a FS rather than a conventional WTP question may be justifiable in some circumstances, such as in cases of a national emergency.

1. Introduction

There is little remaining doubt that global climate change and climate disruption are not only serious and enduring problems, but also extremely urgent ones. A countless stream of studies at the national and international level have underscored this consensus, and the environmental, economic and social perils facing humanity if it fails to act in time (e.g., McKibben, 1989; Houghton, 2004; Lovejoy and Hannah, 2006; Parry et al., 2007; Metz et al., 2007; Stern, 2007). Indeed, if the pronouncements of leading climate scientists such as James Hansen and Steve Schneider are correct, the world has under a decade to dramatically lower its carbon dioxide (CO_2) and other major greenhouse gas emissions in order to stave off the worst effects of global climate change (e.g. Sheppard, 2007). Unfortunately, it may be a cruel irony that this most urgent of problems also appears to be one of the most difficult ones to solve. As noted by Hempel (2006, p. 299), "the economic implications of that fledgling consensus is inimical to the interests of powerful stakeholders. Uncertain, potentially catastrophic, complex beyond human comprehension, and susceptible to costly overreaction and underreaction by partisan policymakers, climate issues offer a revealing glimpse of what happens when probabilistic science meets the crystallized objectives of interest group politics."

It is natural for most citizens of a democracy to expect their government to not only warn them of major social and environmental problems, but also to enact timely policy responses. At the international level this has taken the form of the Kyoto Protocol to the Framework Convention on Climate Change, which entered into force on February 16, 2005 without U.S. participation. While little real progress toward emissions targets has been made thus far among the signatories, follow-up international discussions are continuing, most recently at the UN Climate Change Conference in Poznan, Poland in December 2008 (Toleffson, 2008). Although the U.S. Congress has yet to pass meaningful climate legislation, 17 U.S. states have developed their own CO_2 emissions reduction plans, most noticeably in California (Rabe, 2007). Similarly, over 900 U.S. mayors have committed to, among other things, strive to meet or beat the Kyoto Protocol targets in their own communities (Selin and Van Deever, 2007, pp. 6–7). These state and local actions are encouraging, but they have yet to have an appreciable effect on U.S. carbon-based energy consumption patterns, the primary contributor to rising emissions.

Even with inaction of the U.S. federal government on greenhouse gas control, individual citizens can play a constructive role in CO_2 emissions reduction. These responses are well known, and include such options as the purchase of hybrid gasoline-electric and high mileage vehicles, energy efficiency, renewable energy, recycling, and tree planting (Metz et al., 2007; Heiman and Solomon, 2007, pp. 14–16). Unfortunately, many of these technical options are beset by a variety of market failures and "public failures" or institutional biases that slow the rate of greenhouse gas reduction, or at a minimum make them unnecessarily expensive (Brown et al., 2008). Examples of these include the under pricing of carbon, as well as fiscal, regulatory, statutory and intellectual property barriers. This further underscores the need for government policy reform to reduce carbon emissions, which could act in concert with such responses from the public.

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One of the most readily available consumer options for lowering greenhouse gas emissions may be using biofuels in motor vehicles, such as ethanol or biodiesel. Research has clearly shown that the only sustainable option among these must be based on cellulosic material from crops, trees, grasses or wastes (Heiman and Solomon, 2007). Cellulosic ethanol also has the largest potential to reduce CO_2 emissions, by 90% or more. Almost all of current ethanol production, however, is based on corn, wheat, sugarcane, or other food crops. Not only is the production of these foodstuffs for fuel supply constrained and unsustainable, but it also has been implicated in the 2008 global food shortage and price increases (World Bank, 2008).

The U.S. Congress recognized the great potential of cellulosic ethanol by passing the Energy Independence and Security Act in December 2007 (EISA). The EISA established a Renewable Fuel Standard (RFS) for U.S. transportation fuels of 36 billion gallons by 2022. No more than 15 billion gallons per year of this total will come from cornstarch, with the remaining 21 billion to come from advanced biofuels with greatly reduced greenhouse gas emissions (including biodiesel). Over three fourths of the advanced biofuels portion will eventually come from cellulosic materials, and this part of the mandate could be met with any combination of ethanol and other alcohols (Sissine, 2007). While as of early 2009 a commercial market for cellulosic biofuels in the U.S. had yet to develop, several demonstration plants were operating while a half dozen commercial plants were slated to open in 2009–10 (Solomon et al., 2008).

The purpose of this paper is to determine how the public values climate protection through the potential purchase and consumption of cellulosic ethanol. A case study of Michigan, Minnesota and Wisconsin residents will explore this issue in the U.S. context through a stated preference survey. In the next section of the paper we will review the pertinent previous research on this subject. This will be followed by an overview of our methodology. In particular, we will describe a willingness to pay contingent valuation method (CVM) survey and scenario, and a related "fair share" scenario of a food shortage emergency that was given to half of the survey recipients. The CVM and fair share scenarios are part of a larger survey to investigate the viability of large-scale development of cellulosic ethanol in the regional context. We will then present our main statistical results and analyses, and end the paper with a summary and some conclusions.

2. Previous research

Since a commercial cellulosic ethanol industry was not considered feasible until recently, no previous stated preference research has examined the willingness to pay for this motor vehicle fuel. Alternatively, since grain and sugarcane-based ethanol have been produced and marketed for decades, revealed preference data can be collected on these fuels. However, as noted earlier, ethanol production from these feedstocks is unsustainable and does not significantly reduce CO_2 emissions. There have been several studies of consumer preferences or support for climate change mitigation policies and related environmental values that are instructive for a market assessment of cellulosic ethanol. In addition, several other studies have examined consumer willingness to pay for renewable electricity generation, with biomass energy being among the fuel options. These studies will be reviewed in turn.

Dietz et al. (2007) used mail surveys to assess the preferences of Michigan and Virginia residents for policies designed to reduce the burning of fossil fuels and to mitigate climate change. Policies with the most direct economic impact on consumers received the least support, such as an increase in taxes on gasoline and large vehicles. In contrast the most support was expressed for shifting government subsidies away from fossil fuels and toward cleaner forms of energy, and to increase automobile fuel efficiency (which was finally enacted under the EISA in 2007). The authors found that political affiliation, age, income, and state of resident were significant determinants of policy support, while gender and education were insignificant.

More directly relevant to our own research is the CVM study of Berrens et al. (2004) and the related, follow-up study by Li et al. (2009). Berrens et al. (2004) used a split-sample treatment referendum design to examine willingness to pay (WTP) for greenhouse gas emissions reduction under the Kyoto Protocol. Three very large national internet-based samples were compared to a national telephone sample baseline. Li et al. (2009), in turn, used national telephone and internet-based samples to examine WTP to support energy research and development to reduce U.S. reliance on fossil fuels. Berrens et al. (2004) found a conservative mean estimator of $191.70 in annual WTP, and conditional on households having a positive value, WTP rose to $816 per year. Several models were assessed. Significant explanatory variables included political ideology, education, age, gender, respondent assessments of the effectiveness and fairness of the Kyoto Protocol, and belief in the greenhouse effect. The respondent region was insignificant. As for the split-sample effect, respondent use of enhanced information on global climate change was modest and highly variable, though some of this effort (objectively measured page count) positively and significantly influenced WTP. In the study by Li et al. (2009), WTP was significantly related to gender, political ideology, income, perceived importance of crop-based energy, and expressed importance of reducing U.S. reliance on foreign energy sources.

Hidano et al. (2005) conducted a CVM study of Japan's anti-global warming policies, focusing on the amount of effort needed to complete the survey. In particular, the authors split their sample into two groups to determine the effect of different levels of survey load (i.e. extensive additional attached information on global warming and policy) and fringe benefits (i.e., whether respondents believed the survey was a good cause and provided useful information), and used a payment card approach to determine respondents' WTP additional taxes to reduce CO_2 emissions. The findings were that participation rate was higher if the survey fringe benefit factor scored higher and, as expected, lower for the recipients of the survey with the heavier load.

Another study of indirect relevance to the cellulosic ethanol case was conducted by Lewandowski et al. (2006). The authors attempted to quantify value of the phytoremediation function (cleaning of the soil by plants, e.g. cadmium removal) among farmers in the Rhine Valley of Germany who faced the option of switching from vegetable or cereal production to willow (*Salix* spp.). Replacement cost and hedonic price analyses were conducted and compared to CVM results applied to the farmers. While the first two methods yielded similar results, the WTP results were much lower because the farmers considered remediation as the government's responsibility.

Several studies of consumer WTP for "green" electricity, including electricity generated from biomass energy sources, have been conducted since the late 1990s (e.g., Ethier et al., 2000; Zarnikau, 2003; Bergmann et al., 2006; Hansla et al., 2008; Longo et al., 2008). Byrnes et al. (1999) tested the criterion validity of CVM in this context by conducting telephone interviews of Colorado and Wisconsin ratepayers who previously expressed a willingness to make a voluntary premium payment on their utility bills to purchase electricity from renewable sources with actual payment commitments. Only the Colorado program included biomass energy as one of the fuel options (the Wisconsin program used photovoltaic solar cells). The authors concluded that while mean WTP across respondents varied greatly between the CVMs and market simulations, the CVM is capable of reliably estimating WTP of people who would make payments, though not of predicting who would actually pay. They also emphasized the importance of attributing zero valuations to non-respondents. Contrary findings were reported by Roe et al. (2001). These authors compared the results of a conjoint analysis of hypothetical WTP to actual price premiums for green electricity, and the latter were roughly half the former.