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How much are wood-based cellulosic biofuels worth in the Pacific Northwest? Ex-ante and ex-post analysis of local people's willingness to pay

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ABSTRACT

The National Institute of Food and Agriculture (NIFA) provided a grant to establish a wood-based cellulosic biofuels industry in the US Pacific Northwest. Whether the industry will be sustainable depends largely on social acceptability in general and market acceptability of the biofuels among the public in particular. We conducted contingent valuation surveys of general public in the US states of Oregon and Washington to determine people's willingness to pay (WTP) for wood-based cellulosic biofuels and the factors that influence their WTP decisions. Oregon has an existing cellulosic biorefinery, while Washington's biorefineries are only being planned, allowing us to conduct an ex-ante (Washington) versus ex-post (Oregon) WTP comparison. We sent out mail surveys to 2828 valid mailing addresses between May and July of 2015 and received 757 completed surveys. We used the distribution-free Turnbull estimator to estimate the expected WTP and logistic regression to determine the relative strength of predictors on WTP. About one fifth (18.8%) of the respondents were willing to pay some premium for wood-based cellulosic biofuels. The mean WTP amount was $0.19 ± $0.03/gal. (95% confidence interval: $0.17 to $0.21), which equates to a 6.4% price premium on top of the market price for gasoline. Logistic regression results showed that the offered bid price, knowledge on biofuels, age and religious affiliation of respondents were statistically significant predictors of WTP decisions. No significant differences in ex-ante versus ex-post WTP were observed. We also discussed the policy implications of these results for sustainable management of the wood-based cellulosic biofuels industry.

1. Introduction

What is it that makes people willing to buy fuel which uses wood-based cellulosic biofuels, and how does this key motivation differ between consumer segments? The answer to this question is critical to make a smooth transition from a pilot phase to a commercial scale of production of wood-based cellulosic biofuels in the US Pacific Northwest. The National Institute of Food and Agriculture (NIFA), a US federal agency, provided a $40 million grant in 2011 to establish a wood-based cellulosic biofuels industry in the Pacific Northwest to address dual challenges of energy security and climate change. The federal Renewable Fuel Standard stipulated that at least 15 billion gallons of biofuels (of 36 billion gallons target to be met by 2020) should come from renewable woody materials (US EPA, 2009; Dixon et al., 2010; Janssen et al., 2013). In response to this policy imperative, a regional level initiative led to the first pilot project focusing on producing advanced cellulosic biofuels from woody energy row crops as a dedicated feedstock. As such, hybrid poplar (which can be thought of as energy row crops) plantations are expected to provide 70% of the feedstock required for the advanced biofuels industry. The Renewable Fuel Standard stipulates the threshold levels of greenhouse gas emission reductions that the fuel types must meet in order to qualify as renewable fuels to prevent undesirable land conversions. Because proposed biomass production meets the land conversion prohibitions, cellulosic biofuels made from hybrid poplar energy row crops can make a sizeable contribution to decrease carbon emissions if done properly. Also, Brent and Rabotyagov (2013) find that the potential development of cellulosic biofuels industry in Washington is likely to have land use change effects consistent with decreased carbon emissions. A cellulosic biorefinery is already established in Boardman, Oregon to process hybrid poplar biomass with the NIFA grant support, and at least one similar biorefinery is expected to be established in Washington. The Boardman biorefinery has been producing cellulosic biofuels from hybrid poplar energy row crops, but the biofuels are not in the market yet for consumer use. So advanced cellulosic biofuels made from hybrid poplar energy row crops are either a real good or a realistic good for prospective consumers in the region, and the presence of cellulosic biorefineries is either already a reality for Oregon residents or is very

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plausible for many Washington residents. However, whether the actual presence of a biorefinery positively influences social and market acceptability of cellulosic biofuels (e.g., due to perceived beneficial environmental or local economic development impacts) or has a negative acceptability impact (e.g., due to perceived environmental problems or local land use or transportation impacts) is an empirical question which we address by comparing the ex-post (Oregon) sample with the ex-ante (Washington) sample.

A key motivation for the establishment of the wood-based cellulosic biofuels industry is to overcome the problems associated with the first generation biofuels such as corn or sugarcane ethanol (Bang, 2010; Brennan and Owende, 2010; Clarens et al., 2010). Particularly, bioethanols derived from corn or sugarcane have been criticized for their poor environmental performance due to increased carbon emissions, undesirable change in land use, and increased water use (Searchinger et al., 2008; Fargione et al., 2008; Gutterson and Zhang, 2009; Dixon et al., 2010). Furthermore, corn or sugarcane based ethanols have been implicated for raising food prices, leading to diminished access of poor people to food, especially in the developing world (Brennan and Owende, 2010; Nigam and Singh, 2011). There appear to be several perceived benefits of cellulosic ethanols compared to first generation ethanols, which might serve as motivations for people to buy cellulosic biofuels. For example, the net monetary benefit of biofuels made from yellow poplar in terms of better environmental and health outcomes is estimated to be $0.06/gal. (Winden et al., 2014). No matter how environmentally friendly the cellulosic biofuels are, the biofuels industry cannot survive if consumers do not want to buy their product. Thus, the sustainability of the cellulosic biofuels industry largely depends upon social acceptability of the biofuels among the public. One form of social acceptance is the market acceptance – people's willingness to buy to generate the demand – of the cellulosic biofuels among the consumers (Wustenhagen et al., 2007).

There appears to be some support for clean energy among Americans as expressed by their willingness to accept increased utility bills if the electricity comes from cleaner sources (Aldy et al., 2012). Empirical research has shown that a majority of Americans (78%) consider the use of biofuels as a good idea (Wegener and Kelly, 2008). The real issue is whether Americans would like to contribute to materialize the ideas they consider as good. Cellulosic biofuels tend to be more expensive to produce than conventional fossil fuels or first generation biofuels. The higher production costs mean that consumers must pay a higher price for cellulosic biofuels in the market. An unfavorable direct cost comparison of cellulosic biofuels with others, of course, ignores their potential benefits. Thus a critical question is whether people really value the potential benefits of cellulosic biofuels over other fuels. It is therefore critical to assess whether there would be the demand for cellulosic biofuels when these will be produced at a commercial scale and whether the demand differs across demographic groups.

Because cellulosic biofuels are not yet traded in the market, it is not possible to estimate their economic value based on market transactions. In such a situation, we can rely on non-market valuation techniques to estimate the economic value of cellulosic biofuels. One such technique is the contingent valuation method in which a hypothetical market is created and people are asked to state their preferences in the form of willingness to pay (or accept) to obtain (or forgo) goods and services (Carson, 2000; Venkatachalam, 2004). The market acceptability of cellulosic biofuels' higher costs per unit of gasoline can be determined by people's willingness to pay (WTP) a premium for cellulosic biofuels within the contingent valuation framework. The contingent valuation method has been used to estimate the economic value of biofuels elsewhere (Solomon and Johnson, 2009; Susaeta et al., 2010; Petrolia et al., 2010; Johnson et al., 2011).

The goal of the paper is to assess the market acceptance and demand for cellulosic biofuels made from energy row crops, particularly the hybrid poplar, in the Pacific Northwest. We accomplish this goal by posing a broader research question: what is the expected WTP for wood-based cellulosic biofuels within the population and how it varies with socio-demographic variables? We estimate the economic value people ascribe to cellulosic biofuels made primarily from hybrid poplar energy row crops and determine the factors that lead to heterogeneity in the demand for biofuels. By providing such information, we attempt to fill the knowledge gap in the published literature in the specific domain of advanced cellulosic biofuels. Furthermore, we hope to provide critical policy-relevant information for the sustainability of the wood-based biofuels industry in the Pacific Northwest by leading a research project on the economic value of advanced cellulosic biofuels.

2. Methods

2.1. Sampling and data collection

We focused on collecting data from a site where a cellulosic biorefinery already exists and from sites where the sitting of biorefinery is likely in the near future with an aim of conducting ex-ante and ex-post analyses (Boardman et al., 2006). ZeaChem Inc. established a 250,000 gal per year cellulosic ethanol biorefinery in 2012 as a demo plant in Boardman, Oregon to produce biofuels particularly from hybrid poplar energy row crops. The production capacity is equivalent to 2.5 million gallons of E10 blend. A 22 miles radius was drawn on the map taking the ZeaChem's biorefinery as the center for sampling with an expectation that people residing in the vicinity of the biorefinery are more likely to have seen or heard about it, and have formed opinions about it based on their own experience.

At least one cellulosic biorefinery is expected to be established in Washington State, but the exact location is not known yet. Optimal facility siting models have identified suitable sites for siting biorefineries in Washington. We got the list of top 22 potential sites from our research collaborators. Multiple suitable sites were present within counties, so we chose counties to be the primary units for sampling. We selected four counties — Snohomish, Grays Harbor, Skamania and Stevens — to maximize variation based on the following attributes: (1) whether a county has existing biorefineries (Stevens and Grays Harbor), (2) whether a county is primarily industrial (Snohomish and Grays Harbor), (3) whether a country lies on the coast or inland (Snohomish and Grays Harbor are coastal), and (4) whether a county is mainly dependent on forestry (Skamania and Stevens are dependent on forestry). As the result of study design, some attributes of the sampling sites were similar while others differed between Oregon and Washington.

After determining the sampling sites, we bought Address Based Samples from a reputed commercial survey vendor because they provide the most comprehensive sampling frame for mail surveys, covering 95% of the households on average in a selected area (Dillman et al., 2009). Systematic stratified sampling procedures generated random samples for the study. To control the geographic distribution at a very low level within a selected geography, the population of sampling units was stratified and sorted by ZIP + 4 digits. Once the universe of eligible units was determined, a sampling interval was calculated by dividing the total number of eligible sampling units by the sample size. After selecting a random starting point, the next sampling unit was selected one interval away and so on until the entire sample had been selected. By sampling in this manner, all social, economic and demographic attributes of the population should be well represented in the samples. We had 3500 random samples in total: 500 samples from each of four counties of Washington, and 1500 samples from the vicinity of ZeaChem in Oregon.

2.2. Contingent valuation scenario

Wood-based cellulosic biofuels are still not available at gas stations for consumers, which make them suitable for contingent valuation to