Consumers' willingness to pay for biodiesel in Spain

AZUCENA GRACIA*, JESÚS BARREIRO-HURLÉ, LUIS PÉREZ Y PÉREZ***

(*) Unidad de Economía Agroalimentaria y de los Recursos Naturales
(Agro-Food Economics and Natural Resources Unit)
Centro de Investigación y Tecnología Agroalimentaria de Aragón (CITA)
(Agro-Food Research and Technology Centre of Aragón)
Avda. Montañana, 930 - 50059 Zaragoza, Spain
Phone: +34-976-716350, Fax: +34-976-716335
(**) Agricultural Development Economics Division
FAO-UN
Via delle Terme di Caracalla - 00153 Roma, Italy
Phone: +39-06-57053923

Corresponding author: Azucena Gracia, e-mail: agracia@aragon.es
Phone: +34-976-716350, Fax: +34-976-716335

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1. INTRODUCTION

Climate change is currently considered one of the most important threats that could have very serious impacts on growth and development (Stern, 2007). To avoid the impact of climate change, reducing greenhouse gas (GHG) emissions, particularly carbon dioxide, has become a key policy objective and among other measures, countries are adopting strategies of energy diversification in many sectors including transport. The EU, in its recent Directive on the promotion of the use of energy from renewable sources (EC, 2009), agreed to establish mandatory targets for an overall 20% share of renewable energy and 10% share of renewable (primary biofuels) in transport in the European Union's consumption in 2020. This 10% share for renewables in transport has been set for three reasons; *i)* the transport sector, which is currently responsible for about one-fourth of European energy-related GHG emissions, shows a rapid increase in GHG emission; *ii)* it tackles the oil dependency in the transport sector; *iii)* abatement costs in transport are currently more expensive to produce than in other sectors, which mean that they would hardly be developed without a specific requirement.

Biofuels in addition show an added benefit to other renewable energy sources in transport, they promote economic development in rural areas through a positive impact on productive activity and employment generation. However, depending on the oil price, production costs of biofuels might be higher than the fossil fuels and they will have to be marketed at higher prices. Therefore, the development of the market for biofuels has been closely linked to government intervention. This intervention can be applied to the supply side providing incentives to production or, conversely, to the demand, promoting the use of biofuels. Both options have been used in the EU, Directive 2003/96/EC allows Member Stares to apply a total or partial exemption of taxation for biofuels and the Biofuel Directive (2003/30/EC) urged Member States to set indicative targets for a minimum proportion of biofuels place on the market. However, direct market support could also be achieved if consumers value the benefits provided by biofuels.

Thus, understanding whether consumers will be willing to pay these higher prices and why, is a key issue that should be taken into account when designing policies to increase biofuel use. This study focus on biodiesel as Europe is the world leader in biodiesel production and this fuel represents about ¾ of the European biofuels market (EuropaBio, 2007) and Spain is the third biodiesel producing country (EEB, 2011). However, biodiesel consumption in Spain is still low accounting for 1,011 thousand tons in 2009 albeit its tremendous increase in the last few years (63 thousand tons in 2006, 293 in 2007 and 585 in 2008) and the biodiesel market share in relation to conventional diesel is very low accounting for 3.6% (APPA, 2010). Thus, the aim of this paper is to assess Spaniards' willingness to pay for biodiesel and the factors that explain their willingness to pay.

Although several empirical works have been conducted to assess consumers' willingness to pay for renewable energy electricity, as far as we know, only the work by Jeanty and Hitzhusen (2007), Jeanty *et al.,* (2007), Savvanidou *et al.,* (2010) and Giraldo *et al.,* (2010) have estimated the willingness to pay for biofuels. In particular, Jeanty and Hitzhusen (2007) and Jeanty *et al.,* (2007) have estimated the willingness to pay for air pollution reduction arising from using biodiesel fuel in diesel engines in Ohio (US) using a contingent valuation (CV) approach. The recent paper by Savvanidou *et al.,* (2010) also used CV to calculate the willingness to pay for biofuels in Greece and determine the factors that influence Greek car owners' willingness to pay for biofuels. Last, Giraldo *et al.,* (2010) assess willingness to pay for biodiesel in Spain using a choice experiment approach. Findings indicate that Spanish consumers are willing to pay 5% extra to fill up with biodiesel compared to fossil fuel diesel.

This paper also uses choice experiments (CE) to assess consumers' WTP for biodiesel for a number of reasons. CE is capable of valuing multiple attributes simultaneously, its framework is consistent with random utility theory, and the hypothetical choices presented are similar to real market decisions (Adamowicz *et al.,* 1998; Lusk *et al.,* 2003). The choice experiment was delivered to a representative sample of car owners in the city of Zaragoza (Spain) during September 2010. The paper is structured as follows. Section 2 presents the methodology and section 3 the survey and the choice experiment design. Section 4 describes the data collection and in section 5 the results and main economic implications are presented. Section 6 provides some conclusions.

2. STATED PREFERENCE THEORY AND CHOICE EXPERIMENT

The theoretical model is based on the Lancastrian consumer theory of utility maximization (Lancaster, 1966), and consumers' preferences for attributes are modeled within a random utility framework (McFadden, 1974). Lancaster (1966) proposes that the total utility associated with the provision of a good can be decomposed into separate utilities for their component characteristics or attributes. However, this utility is known to the individual but not to the researcher. The researcher observes some attributes of the alternatives but some components of the individual utility are unobservable and are treated as stochastic (Random Utility Theory). Thus, the utility is taken as a random variable where the utility from the n^{th} individual facing a choice among j alternatives within choice set J in each of t choice occasions can be represented as,

$$U_{njt} = \beta'_n x_{njt} + \varepsilon_{njt} \qquad (1)$$

where β_n is the vector of parameters which deviates from the population mean β by the deviation parameters η_n, x_{njt} is a vector of explanatory variables that are observed by the analyst in choice occasion t and and ε_{njt} is an unobserved random term that is distributed following an extreme value type I (Gumbel) distribution, i.i.d. over alternatives and independent of $\beta_n^{'} x_{njt}$, that is known by the individual but unobserved and random from the researcher's perspective.

Instead of assuming homogenous preferences, leading to a conditional *logit* model, we assume that preferences are heterogeneous, in other words, individuals differ from each other in terms of taste intensity (η_n). Then, we developed a Random Parameters Logit Model (RPL) considering a panel structure to take into account the fact that seven choices were made by each individual (Train, 2003). However additional modeling issues have been taken into account to assure that results are robust. In particular correlations across taste parameters are investigated.

In the standard RPL taste parameters are assumed to be random but independently distributed from each other. However, depending on the attributes under study, we can expect that some attributes may be inter-dependent. To take this into account, the correlation structure of β_n is assumed to follow a multivariate normal distribution (normal with vector mean μ and variance-covariance matrix Ω). If at least some of the estimates for elements of the Cholesky matrix C (where C'C= Ω) show statistical significance, then the data are supportive of dependence across tastes (Scarpa and Del Giudice, 2004).

For the estimation of the RPL, Halton draws rather than random draws are used since they provide a more efficient simulation for the RPL. Mean random parameters are derived as the average of the parameters over the *R* replications. The derived standard deviation which represents the amount of spread or dispersion around the sample population is calculated over each of the *R* draws. In addition to these estimated parameters, the RPL model provides also estimates parameters for each individual in the sample, reflecting that consumers present heterogeneous preferences.

Sources of heterogeneity in preferences can be identified including the assumed factors that induce the heterogeneity (i.e. socio-demographic characteristics, knowledge, etc.) in the estimation stage or using some *ex-post* analysis. The former approach involves the estimation of additional parameters in the utility function where interactions of attributes with the different consumers' characteristics are the new variables in the model specification. Because of the large number of consumers' characteristics to be included, the new model estimation is difficult to achieve because of lack of convergence. Then, we use an *ex-post* approach to identify the consumers' characteristics that explain heterogeneity in consumers' preferences.

Parameter estimates have little interpretative value in RPL models (Tonsor *et al.,* 2009). Then, we calculated mean WTP for each attribute by taking the *ratio* of the mean parameter estimated for the non-monetary attribute to the mean price parameter multiplied by minus one. Second, we derive WTP estimates for each of the individuals in the sample by using the Bayes Theorem to derive the expected value of the ratio between the non-monetary attribute and the price parameter (Scarpa *et al.,* 2007). These WTP that represent the estimates of the conditional expectation of WTP are used to explain heterogeneity in consumers' preferences for biodiesel by regressing these values on a number of explanatory variables which are the possible factors determining consumers preferences heterogeneity. The reported choice model has been estimated using NLOGIT 4.0 (Greene, 2007).

3. SURVEY DESIGN

3.1 Questionnaire design

The questionnaire used in the study was developed based on a previous pilot study (Giraldo *et al.,* 2010) and was designed with the main objective to identify consumer attitudes, knowledge and preferences for different aspects of biodiesel market development. Respondents were first asked a screening question on whether they were owners or users of motor engine vehicles. The interview was only conducted if a positive answer was provided to this question. Then, participants were asked questions related to fuel purchase habits (where and why), knowledge about biodiesel, attitudes towards biodiesel, biodiesel consumption (actual use of biodiesel, intention to purchase, place of purchase, etc.), and attitudes towards biodiesel and its purchase. The questionnaire also contained questions on socio-demographic characteristics and environmentally related lifestyles. Last, the questionnaire also included questions to implement the choice experiment.

Before the final questionnaire was administrated, a pilot survey was undertaken to identify consumer believes and knowledge with regards to biodiesel and to approximate their willingness to pay for this fuel. This pre-test survey, conducted to a small sample of respondents (N=20), allowed to select the most relevant diesel attributes to be included in the choice experiment design.

3.2 Experimental design

The first step to implement a choice experiment is to choose the attributes and levels to be used. The selected attributes should be relevant to the problem under analysis, realistic, believable and easy to understand by the average respondent (Bateman *et al.,* 2002). To meet these requirements, results from the previous pilot study and the pre-test of the current questionnaire were very relevant to select some of the attributes.

Two attributes were straightforward, price, because it allows the calculation of the willingness to pay, and the type of diesel[1], because it is the main objective of the paper. The third attribute, availability of the diesel in the petrol station close to their usual route, was selected as availability attribute is highly value by consumers (Giraldo *et al*., 2010). Finally, the place of production of the diesel was selected because of the ongoing debate in the European Union on whether biofuels should be produced in Member States or imported from third countries, such as Brazil, where their production is more efficient (Biopact, 2008). Moreover, it is interesting to know to what extent consumers prefer to use biodiesel produced in Europe as Spanish biodiesel production capacity is highly underused with significant imports from the USA (APPA, 2008). Table 1 shows the attributes and the levels used.

Table 1. - Attributes and levels used in the choice design

Attributes	**Levels**	***Status quo***
Price (€ per litre)	1.05; 1.1; 1.15 and 1.20	1.1
Type of **diesel**	Biodiesel Biodiesel with a sustainable label	Conventional Diesel
Availability in a petrol station close to the everyday router	Yes No	Yes
Place of production	Europe Outside Europe	Outside Europe

[1] When we say diesel we refer to diesel in general, including conventional and biodiesel.

For the price attribute four levels were defined. The lowest level correspond to the minimum price for diesel that could be found in the Spanish market at the time of the survey (1.05 €/litre). The next level was set at the average price of diesel (1.10 €/litre) and the other two levels were set at 1.15 €/litre and 1.20 €/litre, respectively. Because our objective is to assess willingness to pay for biodiesel, the first level for the type of diesel attribute is biodiesel. In addition certified biodiesel is also considered. During 2010 the European Commission (EC) has set up a voluntary system for certifying sustainable biofuels (IP/10/711 and MEMO10/247). With this, the EC guarantee that all the biofuels sold under the label are sustainable and produced under the criteria set by the Renewable Energy Directive. Biofuels are sustainable if ensures substantial reductions in greenhouse gas emissions and are not produced from raw materials from forests, wetlands and nature protection areas. The third and the four attributes have two levels. For the availability attribute, the two levels are: the diesel is available in a petrol station close to the individual's every day route or he has to go to another petrol station. For the place of production attribute, the diesel is produced in Europe or outside Europe.

A description of the experiment was presented to participants, indicating the selected attributes and levels for each of the diesel options. Choice sets included three alternatives: two unlabeled alternatives consisting of the different designed diesel options and the *status quo* corresponding to the actual average diesel price per litre, the conventional diesel, the availability in the petrol station close to the usual route and produced outside Europe origin. The choice sets were presented using graphical aids.

The choice set design was created following Street and Burgess (2007). We started from a full factorial design with 32 profiles. The second option in the choice sets is then created using one of the generators deriving from the suggested difference vector (1, 1, 1, 1) by Street and Burgess (2007) for 4 attributes with 2, 2, 2 and 4 levels, respectively, and two alternatives. We obtained 80 pairs being this design is 97.8% D-efficient. To avoid fatigue effects associated with multiple scenario valuation tasks, respondents were asked to make six choices and the total number of choice sets were randomly split into different blocks.

4. DATA COLLECTION

Data was collected from a survey conducted in Zaragoza, a medium-sized town located in northwest Spain, during September 2010. Target respondents were adults who own or use a motor engine vehicle and the interviews were carried out face-to-face. A stratified random sample of consumers was made on the basis of district and age. Sample size was set at 400, resulting in a sampling error of ±5%, and a confidence level of 95.5% when estimating proportions (p=q=0.5; k=2). Interviewers selected and approached individuals randomly, asking them one screening question: whether they own or use a motor engine vehicle. In the case of a negative response, interviewers randomly selected another customer belonging to a given age group, until they obtained a positive response. Summary statistics for the characteristics of the sample are presented in table 2.

Table 2. Sample characteristics (%, unless stated) and exogenous variables definition.

Variable definition	*Name (type)*	*Value*
Individual characteristics		
Gender		
Male	FEMALE (dummy: 1=female)	51.2
Female		48.8
Age (Average from total sample)	AGE (continuous)	44.0
Education of respondent	UNIVERSITY (dummy: 1=university)	
Elementary School		12.2
High School		30.0
University		57.8
Average monthly household income[a]		
Less than 1,500 €		13.8
Between 1,501 and 2,500 €	HIGH_INCOME (dummy: 1=higher than 3,500 €)	31.2
Between 2,501 and 3,500 €		29.5
Between 3,501 and 4,500 €		14.0
More than 4,500 €		11.5
Household Size (Average from total sample)	HSIZE (continuous)	3.2
Household with kids less than 6 years old (1=Yes)	KIDS6 (dummy:1=yes)	13.2
Household with adults more than 65 years old (1=Yes)	ELDERLY (dummy: 1=yes)	16.0
Consumers' knowledge on biodiesel		
Consumer objective knowledge of biodiesel	KNOW (dummy: 1=yes)	19.2
Consumers attitudes towards biodiesel (agreement with statements)		
The cost of production of biodiesel is higher than the cost of producing conventional diesel	COST (5-point scale)	3.46
Biodiesel use contributes the increase of farmers income	INCOMES (5-point scale)	4.00
Biodiesel use diminishes greenhouse gas (GHG) emissions	GHG (5-point scale)	3.99
Biodiesel use reduces oil import dependence	DEPENDENCE (5-point scale)	4.01
Buying biodiesel is good	GOOD (5-point scale)	3.84

About half of respondents were male (51%) with an average age of 44 years and living in households of 3 people. Around 30% of respondents stated that their household monthly net income was between € 1,500 and € 2,500 and between € 2,500 and €3,500. More than half of participants had university studies. Finally, 13% of households had children less than six years old, and 16% of households included elderly individuals.

5. RESULTS

5.1 Estimated utility parameters and willingness to pay

The vector of explanatory variables in equation (1) includes the price and the other non-monetary attributes. The price variable is defined as the price levels given to respondents for each diesel option. Because the diesel attribute has two designed levels plus the *status quo* level, two effect code variables are created, BIO for the biodiesel and BIOLABEL for the biodiesel with a sustainable label. The availability attribute and the place of production are also effect coded variables (AVAILABLE and PLACE). All coefficients except for the price are allowed to be random following a normal distribution. Price is expected to have a negative impact on utility while the effects of the other variables are the focus of interest. Table 3 presents the estimated parameters for the final model specification. Prior to this model, several specifications were considered and the Likelihood Ratio tests have rejected the hypothesis of homogenous preferences (conditional model) or uncorrelated taste parameters. Moreover, most values of the Cholesky matrix are statistically significant different from zero.

Table 3. Results for the RPL model: parameters and WTPs

	Coefficients	***t-values***	***Mean WTP***	***t-values***
Mean values				
PRICE	-5.2261	-20.39		
BIO	0.3574	4.80	0.068	4.79
BIOLABEL	0.4338	5.66	0.083	5.67
AVAILABILITY	0.6014	8.21	0.115	8.31
PLACE	0.0553	1.13	0.011	1.12
Standard deviation for parameter distribution				
BIO	0.7423	7.98		
BIOLABEL	0.7913	9.15		
AVAILABILITY	0.9238	3.78		
PLACE	0.4822	3.41		
Sample size	8,400			
Log-likelyhood	-2,187			
χ^2	1,016			
Pseudo R^2	0.19			

With respect to the overall fit, the model is statistically significant with a χ^2 of 1,016 which is higher that the critical value, suggesting that the considered diesel characteristics are jointly significant, affecting consumers' utility. As expected, the non-random parameter (PRICE) is negative and statistically significant different from zero at the 1% of significance level. Therefore, price increments decrease the associated utility level provided by the choice of each diesel products. The mean of the random parameters are statistically significant explaining consumers' utility except for the place of production (PLACE). Then, whether the diesel is produced in Europe does not increase consumers' utility. As the model does not include an alternative specific constant, the positive value of the mean parameter estimates for the biodiesel (BIO) and the biodiesel with a sustainable label (BIOLABEL) can be understood as the preference for the systematic difference between the *status quo* and the other options. As the only systematic difference is the conventional or bio origin of diesel the positive coefficients indicates that utility associated to the biodiesel and biodiesel with a sustainable label is higher than for the conventional diesel. Finally, the positive value for the parameter estimate for the AVAILABILITY variable indicates that consumers gain utility when the diesel is available in the petrol station close to their daily route. Looking to heterogeneity in preference, the Wald statistics for the derived standard deviation parameters indicates that the dispersion around the mean estimate is statistically different from zero for the analyzed characteristics of diesel. In other words, the effect of these attributes on the utility function differs across individuals.

Of particular interest are estimates of consumer WTP presented in Table 3. Estimates WTP are positive and statistically different from zero, except for the place of production. Then, consumers are not willing to pay a premium to use a diesel produced in Europe in relation to one produced outside Europe. However, they are willing to pay an extra price of 0.07 € per litre and 0.08 € per litre to use biodiesel or biodiesel with a sustainable label in relation to the conventional diesel, respectively. Taking the average price of the diesel (1.1 € per litre), consumers are willing to pay, on average, a 6% premium for the biodiesel *versus* a conventional diesel and a 7% premium for the biodiesel with a sustainable label *versus* the conventional diesel. It means that consumers are only willing to pay a 1% premium for the sustainable label in the biodiesel. Finally, availability of the biodiesel is important because it is the most valued attribute. Data show that consumers would need, on average, at least a 10% discount to tank in a petrol station which implies a detour in the daily route.

5.2 Explaining heterogeneous preferences

Table 3 shows that consumer preferences are not homogenous. To explain the factors which determine heterogeneity, we use individual-specific WTPs for each attribute as dependent variables to fit a value function for each diesel characteristics using as explanatory variables different individual characteristics. For the objectives of this paper we would be interested in knowing only those factors explaining WTP for biodiesel and biodiesel with a sustainable label *versus* the conventional diesel. It is assumed that determinants of WTP heterogeneity are not only respondents' socio-demographic characteristics (Table 2) but also knowledge on biodiesel, attitudes towards the biodiesel and its purchase and environmental related lifestyles. Definitions of the exogenous variables explaining WTP heterogeneity can be found in table 1.

As far as product knowledge is concerned, respondents were asked three questions on biodiesel: biodiesel is produced from vegetable or animal oils; biodiesel is a renewable energy; and biodiesel can be used in any diesel engine without specific modifications. Respondents answering correctly to the three questions were considered to have an objective knowledge about biodiesel (KNOW). Using this definition, less than 20% of respondents know what biodiesel is. Attitudes towards biodiesel were measured asking respondents to rate their degree of agreement in a five-point scale with different statements related to biodiesel: biodiesel production cost is higher than the cost of conventional one (COST); biodiesel production may help the increase of farm incomes (INCOMES); the use of biodiesel decreases the greenhouse gas emissions (GHG); and the use of biodiesel may diminish import oil dependence (DEPENDENCE). Attitudes to biodiesel purchase were measured asking consumers their degree of agreement in a 5-point increasing scale to the sentence "*I believe that buying biodiesel is good*" (GOOD).

Table 4 presents the value function estimates for the two biodiesel options. Each equation is estimated by Ordinary Least Square (OLS), as the two endogenous variables are continuous. As far as the interpretation of the results, first it should be pointed out that both models are overall statistically significant (F values reject the null hypothesis that all estimated parameters are equal to zero at the 5% significance level) and that they explain a reasonable part of the WTP heterogeneity (adjusted R^2 values are 0.24 and 0.29, respectively). Robust *t*-ratios are reported for individual parameter significance to correct for heteroscedasticity (Greene, 2008).

Table 5. Factors affecting individual willingness to pay for different biodiesel options.

Variables	BIO		BIOLABEL	
	Estimates	***t-ratios***	***Estimates***	***t-ratios***
Constant	-0.1885	-4.83**	-0.2987	-6.54
Socio-demographics				
AGE	-0.0007	-2.00**	-0.0004	-1.07
UNIVERSITY	0.0182	1.73*	0.0294	2.31**
HIGH_INCOME	0.0356	3.51**	0.0450	3.73**
Consumers' knowledge on biodiesel				
KNOW	0.0182	1.66*	0.0227	1.91*
Consumers attitudes towards biodiesel				
COST	0.0161	3.04**	0.0125	2.1**
INCOMES	0.0109	1.91*	0.0133	1.81*
GHG	0.0158	2.62**	0.0286	3.45**
GOOD	0.0261	3.83**	0.0406	4.48**
F VALUE	18.95		26.01	
Adjusted R^2	0.24		0.30	

Number of observations=400 / Robust White (1980) t-ratios are reported
* and ** statistically significant at 10% and 5%, respectively

Factors explaining the value attached to both biodiesel options are very similar. Both biodiesel WTPs depend on only three respondents' socio-demographic characteristics, although AGE has not been found statistically significant for the biodiesel with a sustainable label. Higher WTPs for both biodiesel are associated with individuals which have university degree (UNIVER) and higher income level (HIGH_INCOME). On the other hand, older respondents are less willing to pay for biodiesel. As far as knowledge is concerned, respondents who know about biodiesel are more willing to pay for both types of biodiesel.

Attitudes towards the biodiesel and its purchase are positive and statistically significant different from zero indicating that are significant determinants of biodiesel WTPs. Respondents who highly believe that the cost of production of biodiesel is higher than producing conventional diesel (COST), that the use of biodiesel may help to increase farms incomes (INCOMES) and that may diminish the greenhouse gas emissions (GHG) are more willing to pay for both types of biodiesel. However, agreement with the statement regarding reduction of oil dependence has not been statistically significant (DEPENDENCE), a result in line with the previous lack of significance of the place of production attribute in the RPL estimations. It seems that respondents do not care much about the geographical origin of the diesel. Finally, attitudes towards biodiesel purchase have been positive and statistically significant explaining both biodiesel WTPs (GOOD), respondents who believe that buying biodiesel is good are more willing to pay both types of biodiesel.

6. CONCLUSIONS AND DISCUSSION

Consumers' preferences for biodiesel have been explored using a choice experiment approach. Preliminary findings show that consumers are willing to pay a premium for biodiesel of 6% of the current price for conventional diesel and 7% for a biodiesel with a sustainable label. This premium is slightly lower than the extra-price they are willing to pay for fill diesel up in their usual petrol station (10%). This means that both convenience and environmental aspects of diesel have similar value to consumers. A first conclusion is that biodiesel will only be successful if made available in a larger number of petrol stations. When consumers need to change their petrol station to tank biodiesel, the disutility associated with changing the route is higher than the additional utility attached to biodiesel. Results show that in these circumstances biodiesel could be marketed with a premium price of 6% respect to the conventional diesel price and thus could gain market share, even in the absence of public support policies. However, this needs to be confirmed with a supply side analysis of the extra-cost biodiesel must face when entering the market, as if it were higher public support would still be needed.

If that were the case, still some people would be willing to pay higher premiums, which would correspond with young, educated and higher income consumers. However, other factors beyond socio-demographics explain higher WTP. Those who consider that the cost of production of biodiesel is higher than producing conventional diesel; that the use of biodiesel may help to increase farms incomes and that greenhouse gas emissions are indeed reduced by using biodiesel are also more willing to pay for both types of biodiesel. Thus, public policy can also increase the potential level of market support for biodiesel. Increasing consumer awareness about biodiesel would provide a double benefit in this sense, as increased knowledge on biodiesel and knowledge of the positive characteristics of biodiesel would both increase WTP.

Additional analysis is needed to better understand the difference between certified and non-certified diesel and the potential impact it will have in the market. The EC has put forward a complex system of certification and consumers seem to value biodiesel even in the absence of the certification system.

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