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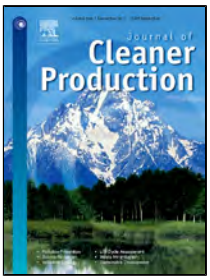

Overcoming the barriers for biodiesel use in Spain: an analysis of the role of convenience and price

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Highlights

- The aim of the paper is to analyse biodiesel active market acceptance in Spain
- We study the intention to use biodiesel and the factors explaining this intention
- We developed a model of the intention to use biodiesel
- The model was specified as an ordered probit and estimated with Spanish data
- The important factors are attitudes towards the use, knowledge and self-identity
- The effects of all the factors were different depending on price and availability

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1. INTRODUCTION

Reducing greenhouse gas (GHG) emissions, particularly carbon dioxide, has become a key policy objective to mitigate climate change. Climate change represents serious threats for the life conditions of people around the world – access to water, food production, health, and use of land and the environment (Stern, 2007). The high concentration of greenhouse gases is the main reason of global warming and, therefore, the climate change. Among these gases, the anthropogenic carbon dioxide emissions (CO2) are the main responsible of the greenhouse effect. Therefore, CO2 emissions are considered as the best available indicator of climate change (Alvarez-Diaz et al., 2011).

The European Union Directive on the promotion of the use of energy from renewable sources established mandatory targets for an overall 20-percent share of renewable energy and 10-percent share of renewable energy in transport in the European Union's consumption in 2020 (EC, 2009). Moreover, the Commission has increased the target for reduction in emissions to 40 percent by 2030 without establishing new targets for renewable energy or for greenhouse gas intensity of fuels that are used by the transport sector or any other sub-sector after 2020 (EC, 2014). Because the transport sector has become the second-largest carbon contributor, biofuels have been highlighted as one of the most promising alternatives to reach the carbon emissions target (Chin et al*.,* 2014). In addition, the use of biofuels also increases energy security.[1] Finally, biofuels are immediately available as an alternative, as they do not require changes in the car fleet, since they can be used blended (bioethanol) or unblended (biodiesel) (Loureiro et al*.,* 2013)[2].

[1] Other aspects of biofuels are more controversial, such as their impact on food security (HLPE, 2013) or their net greenhouse savings (Searchinger et al*.,* 2008).

[2] As mentioned by a reviewer, car manufacturers have started limiting the use of biodiesel in their engines for warranty purposes. However at the time of the survey there were not such concerns and only a minority of interviewees highlighted engine related aspects as barriers for using biodiesel (see Table 2). However, this has implications for the conclusions of this research as highlighted in the conclusions section.

Within this context, and supported via mandatory targets, the production of biofuels in the EU has experienced an exponential growth over the last ten years (Barisa et al., 2015). In less than a decade, the EU28 biofuel production has increased more than tenfold from approximately 1.2 million tonnes of oil equivalent (toe) in 2002 up to 13 million toe in 2013 (EU, 2015). However, biofuel use in transport in Europe seems to have reached a ceiling, and its consumption has stopped growing and has stabilised around 14 million toe in the last three years (EurObserv'ER, 2013; EurObserv'ER, 2015). This study focuses on biodiesel, a biofuel for which the EU is the world's largest producer, representing, on volume basis, about 80 percent of the biofuels market in the transport sector (USDA, 2015). In addition, within the EU, biodiesel amounted to 79.7 percent of biofuel consumption, bioethanol to 19.1 percent, biogas to 1 percent and other types of biofuels to 0.2 percent (EurObserv'ER, 2015). This is partly due to the high level of dieselification of the European car fleet, the possibility to use it directly unblended in current car engines and the compatibility with current fuelling infrastructures (Bomb et al., 2007)[3].

Spain, despite having the highest biodiesel production capacity in the EU (3.9 million tonnes in 2014), produced barely one million tonnes in 2014, ranking as the fourth-largest producer after Germany, France and the Netherlands (APPA, 2015; Infinita Renovables, 2015). Moreover, biodiesel consumption in Spain that same year was even lower (0.6 million tonnes), with a clear decreasing trend (minus 3 percent compared to 2013 and minus 59.5 percent compared to 2012). As a matter of fact, biodiesel consumption in Spain should have a threefold increase to meet the 20-percent renewable energy EU target, which would also avoid the closure of biodiesel production plants (in 2013, 15 of 53 plants were closed) (Infinita Renovables, 2015). With this in mind, our analysis focuses on Spain, a European country characterised by high production capacity and low relative consumption of biodiesel (Infinita Renovables, 2015). Spain faces the great challenge to expand the use of biodiesel in order to increase its consumption to meet the renewable energy in transport targets and to guarantee the subsistence of biodiesel production plants. One of the steps for this to happen is acceptance of biodiesel by society.

[3] Following the diesel-gate where emissions by diesel manufacturer had been underreported some countries are reconsidering the incentives for diesel use (mainly via the favourable taxation compared to petrol) and limiting the access of diesel cars to cities. While this might have an impact on total diesel consumption and the potential of GHG savings from biodiesel, the current bias in vehicle fleets towards diesel will remain for years to come and biodiesel can remain part of the mitigation strategy for the transport sector in the mid-term.

There are two levels of acceptance, passive consent and active involvement (Chin et al., 2014). In the case of biodiesel, passive consent would correspond with consumers using biodiesel that meets mandatory blending with fossil diesel, as already found in the market. In other words, diesel car drivers are using a percentage of biodiesel, because they fill conventional diesel, which is mandatorily blended with biodiesel. On the other hand, active involvement would occur when diesel car drivers are willing to use biodiesel (pure biodiesel).[4] This active acceptance is one of the dimensions of social acceptance, named as market or consumer acceptance. In our case, we are interested in the analysis of the latter; as Barisa et al. (2015) stated, promoting biofuel acceptance among end-users is critical for the biodiesel sector.

Against this framework, the objective of this paper is to investigate the active-market acceptance of biodiesel in Spain taking into consideration some of the barriers for adoption identified in the literature: availability and cost. In particular, we study the willingness/intention to use biodiesel by Spanish car drivers and the factors explaining this intention. Few empirical papers have been conducted to analyse the consumer preferences for biodiesel (Giraldo et al., 2010; Kallas and Gil, 2015) and only a limited number of papers address consumer acceptability of biofuels assessing perceptions and attitudes but without going into the study of consumers' behaviour (Chin et al., 2014; Mariasiu, 2013; Van de Velde et al., 2009). Findings from the latter studies indicated that consumers perceived biofuels to be better for the environment, the regional economy and for increasing energy security.

To achieve our aim, we developed a model of the intention to use biodiesel based on the Theory of Planned Behaviour (TPB), proposed by Ajzen (1991). In order to assess the effect of the different factors on the intention to use biodiesel, an ordered probit model is specified and estimated. Data from a survey administrated to a sample of car drivers in a medium-sized town in Spain in 2010 was used.

Thus, this analysis contributes to the literature that studies the social acceptance of biofuels in two main aspects: first, we expand the analysis comparing how acceptance and factor affecting it differ with regards to the main barriers for adoption; second, we add two new predictors of the intention to use (environmental self-identity and biodiesel knowledge) when applying the TPB.

[4] According to CORES (Spanish Corporation of Strategic Reserves of Oil-based Products) data, nearly all biodiesel in Spain is placed in the market as blends. Pure biodiesel (B100) only represents about one percent of total biodiesel consumption (USDA, 2011).

2. THEORETICAL FRAMEWORK

As our objective is to analyse the intention to use biodiesel, we used a theoretical framework based on social psychology models but also including economic and situational factors. Among the social psychology models, Ajzen´s Theory of Planned Behaviour (TPB) is today one of the most popular social-psychological models for understanding and predicting human behaviour (Ajzen, 2015)[5]. In the TPB, the immediate antecedent of a particular behaviour is the "intention" to perform it. Behavioural intentions are an indication of the extent to which people are willing to try to perform a particular behaviour (e.g., I intend to use biodiesel) while the particular behaviour is something people are currently performing (i.e. I use biodiesel). Intentions are assumed to be determined by attitudes towards the behaviour, subjective norms and perceived behavioural control. Attitudes refer to the favourable or unfavourable evaluation of the behaviour (Ajzen and Manstead, 2007). Subjective norms are the perceived social pressure with respect to performing the behaviour. In other words, they refer to individual perceptions of the extent to which other important people to them would endorse a given behaviour and their individual motivations to comply with this social pressure. Last, perceived behavioural control is related to the perceived presence of factors that can influence a person's ability to perform the behaviour. According to the TPB, the more favorable the attitude and subjective norm, and the greater the perceived control over the behaviour, the more likely it is that a person will have an intention to perform the behaviour (Ajzen. 2015). The TPB has been successfully applied to the prediction of intentions and behaviour in many different domains for several reasons. First, this model is simple, parsimonious, easy to operationalize and application to a wide range of behaviours (Leone et al., 1999). Second, different meta-analysis proved the effectiveness of the TPB in predicting behaviours (Armitage and Conner, 2001; McEachan et al., 2011). Armitage and Conner (2001) and McEachan et al. (2011) found, in a meta-analysis of 185 and 206 empirical studies, that attitude, subjective norms and perceived behavioural control produced mean multiple correlations with intentions that ranged from 0.4 to 0.66 (Azjen, 2011). This model has been widely used in several

[5] Its popularity is revealed by conducting a Google Scholar search for the keyword 'theory of planned behaviour OR theory of planned behaviour.' From 22 citations in 1985, the number of citations per year has grown steadily to a total of 4550 in 2010 (Ajzen, 2011).

empirical studies predicting pro-environmental behaviours: green consumption (Maichum et al., 2016; Yadav and Pathak, 2016); energy-related behaviours (Ha and Janda, 2012; Halder et al., 2013; Shah-Alam and Rashid, 2012), automobile use (Bamberg and Schmidt, 2003), and cleaner production technologies (Zhang et al., 2013). In addition, Chao (2012) studies environmental behaviour comparing the TPB model and the Responsible Environmental Behaviour (REB) model. He found that the TPB model explained much more variance in behavioural intention that the REB model (approximately 69 percent *vs.* 37 percent).

While TPB is useful in its original specification, additional predictors of intention capturing some background factors (demographic or personality traits) mentioned by Ajzen were introduced into the model to increase its predictive performance (Rise et al*.,* 2010). The usefulness of personality traits to explain environmental decision-making had proved recently for Spanish people by Farizo et al., (2016) and Soliño and Farizo (2014). Following this trend, we extend the TPB, including two new predictors into the model, individuals' self-identity and product knowledge. Some theorists argue that identity processes should be taken into account in the prediction of specific behaviours, and empirical evidence supports that it does predict behavioural intentions after attitudes and norms (Sparks and Shepherd, 1992). In our case, someone who sees himself concerned about environment is more likely to participate in environmental practices (such as saving water and energy, recycling, etc.). Rise et al. (2010) demonstrated, using a meta-analysis on the ability of self-identity to increase the performance of the TPB, that self-identity enhances the prediction of the intention in the TPB models. Then, environmental self-identity has been added to the TPB model.

The second predictor of intention added to the model is biodiesel knowledge. Product knowledge has also been identified as a powerful predictor of behavioural intentions (Lane and Porter, 2007), even more important in the analysis of novel products, as product knowledge is the only instrument that consumers have to differentiate the attributes of the new product (Gracia and de-Magistris, 2007).

In the realm of environment-related behaviours, the introduction of self-identity in the prediction of intention has been successfully tested for recycling (Mannetti et al., 2004), organic food (Cook et al., 2002) and animal welfare (Gracia, 2013). Product knowledge has been found to affect intentions to use for

bioenergy (Halder et al., 2013) or renewable energy (Shah-Alam and Rashid, 2012). As common practice in the TPB literature all these concepts are measured using questions posed to survey respondents, details on how each of them is measured can be found in section 3.2 below.

Prior research has identified the potential price premium and the limited availability at fuel stations as the main barriers for biodiesel use (Barisa et al., 2015; Chin et al., 2014; Khachatryan et al., 2013). These drivers were present when the survey was conducted and are still present nowadays. When the survey was carried out biodiesel was sold in few petrol stations and the reason which most interviewees mentioned for not using biodiesel was availability significantly above any other concern regarding impact on vehicle performance or maintenance costs (30% declared availability as a driver compared to less than 5% for the other two issues – see Table 2). As far as prices are concerned we cannot access data on the prices for biodiesel and conventional diesel at the time of the survey but consumers did perceive it as such with over 50% of the sample agreed or strongly agreed with the idea that biodiesel is more costly to produce than conventional diesel and only 15% disagreed. As of today (September 2017) still considering a 25 km radius around the survey area only one petrol station sells biodiesel[6] and at a price that, while not at the high-end of the spectrum of available prices is above the lowest. Considering that the status quo is not delivering increased biofuel use in the transport sector, we apply the extended intention to use biodiesel model to three potential scenarios that could lead to increased consumption. The first scenario (S1) overcomes both barriers simultaneously by making biodiesel available at the same price as fossil diesel in all fuelling stations. The remaining two scenarios relax each of the identified barriers one by one: in Scenario 2 (S2) biodiesel is assumed to be sold at a higher price than fossil diesel but still available in all fuelling stations and in Scenario 3 (S3) biodiesel is assumed to be sold at the same price as diesel, but it is only available in a limited number of fuelling stations. Thus, our scenarios allow studying the market acceptability of biodiesel under increased convenience and/or price.

Figure 1 summarises the basic structure of the original structure of the TPB model and extended model proposed. The dotted box comprises the model as put forward by Ajzen (1991) while the black

[6] Consulted on 11/09/2017 at http://servicios.elpais.com/gasolineras/

frame adds the two new predictors. Each of the extended models of intention to use is estimated separately for the three scenarios described above.

Figure 1 about here

3. MATERIAL AND METHODS

3.1. Questionnaire and survey

Information to apply the theoretical model depicted in Figure 1 was collected through a survey carried out in Zaragoza, a medium-sized town located in northeast Spain (Aragon region) during 2010.a. This town was selected because it is widely used by food marketers and market research consulting companies, as the socio-demographics are representative of the Spanish Census of Population (Table A1 in Annex). Target respondents were adults using a diesel motor engine vehicle and the interviews were carried out face-to-face by a single interviewer who was extensively briefed by the research team. Interviewees were addressed at shopping malls and petrol stations and participation on the survey was voluntary as no compensation was offered for participation. Weekly follow-up meetings were arranged in order to identify any problems with the survey, however no major problems were detected and the process was maintained throughout the whole interview period. A stratified random sample of drivers was made on the basis of district, gender and age. The final sample size was 400, resulting in a sampling error of ±5%, for a confidence level of 95.5% when estimating the proportion of individuals choosing one of the hypothetical options ($p=q=0.5$; $k=2$).

The questionnaire was developed following the general guidelines stated by Ajzen (2013), previous empirical papers on environmental behaviours (Chen, 2007) and a previous pilot study conducted in Spain (Giraldo et al., 2010). It was structured in four parts. The first part included questions related to fuel-purchase habits (where and why). The second part contained questions on biodiesel knowledge, attitudes towards biodiesel, subjective norms and perceived behavioural control. Part three

included questions on actual biodiesel consumption and intention to use it. Finally, the fourth part gathered information on socio-demographics and other personal characteristics.

In order to measure knowledge of biodiesel, an "objective knowledge" approach was used. Respondents were asked to indicate if three statements related to biodiesel were true or false.[7] Respondents providing correct responses to all questions were considered to have an objective knowledge of biodiesel (Table 1). The environmental self-identity construct was measured by asking respondents whether they were members of an environmental conservation association (Table 1).

As knowledge of biodiesel was limited, in order for interviewees to provide meaningful answers to the questions on attitudes, subjective norms and intentions, a brief text with neutral information on biodiesel was read to them before these questions[8]. Because measuring attributes or psychological aspects such as attitudes, subjective norms and perceived behavioural control is challenging, the definition of the scales related to these aspects was based on previous empirical papers (Chen, 2007). Moreover, as many applications of the TPB model assessed the different aspects by obtaining only direct measures of attitude toward the behaviour, subjective norm and perceived behavioural control (Ajzen, 2015) we used this approach. Then, respondents were asked to indicate their agreement or disagreement with different statements using a five-point Likert scale, where 1 indicates strong disagreement and 5 indicates strong agreement. These statements are shown in Table 1. The intention to use biodiesel was measured by asking three intention-to-purchase questions using a scale from "definitely no" (1) to "definitely yes" (5) (Table 2).

Before the final questionnaire was administrated, a pilot survey was undertaken on a small sample of respondents (N=20) to check for understanding and interview length.

[7] The statements were: 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. All three statements are true.

[8] The text [translated by the authors from Spanish] was: *biodiesel is a liquid biofuel produced using vegetable oils and animal fats.*

3.2. Statistical analysis

The three endogenous variables of the model, the intention to use biodiesel under the different scenarios (Figure 1), are discrete variables with five ordered levels. To explain these variables, three ordered probit models were specified:

$$u_i^* = \beta X_i + u_i \quad (1)$$

where, β is the vector of parameters to estimate, X_i is a vector of all exogenous variables (biodiesel knowledge, environmental self-identity, attitudes, subjective norms and perceived behavioural control, which are defined in Table 1 and Table 3), and u_i is the error term normally distributed N(0, σ_u^2). IU_i^* is the intention to use biodiesel that it is an unobserved variable. However, the intention to use stated by the individual (IU_i) is observed and measured by five levels (see definition in Table 2), as follows:

$$\begin{aligned} IU_i &= 1 \quad if, \quad IU_i^* \le \tau_1 \\ IU_i &= 2 \quad if, \quad \tau_1 \le IU_i^* \le \tau_2 \\ IU_i &= 3 \quad if, \quad \tau_2 \le IU_i^* \le \tau_3 \\ IU_i &= 4 \quad if, \quad \tau_3 \le IU_i^* \le \tau_4 \\ IU_i &= 5 \quad if, \quad \tau_4 \le IU_i^* \end{aligned} \quad (2)$$

where τ_i are the unknown threshold parameters to be estimated. The first threshold parameter is normalized to zero ($\tau_1 = 0$).

Like binary data models, we are concerned with how changes in the predictors translate into the probability of observing a particular ordinal outcome. Consider the probabilities of each ordinal outcome:

$$\begin{aligned} &\text{Prob } (IU_i = 1) = \Phi (-\beta X_i) \\ &\text{Prob } (IU_i = 2) = \Phi (\tau_1 - \beta X_i) - \Phi (-\beta X_i) \\ &\text{Prob } (IU_i = 3) = \Phi (\tau_2 - \beta X_i) - \Phi (\tau_1 - \beta X_i) \\ &\text{Prob } (IU_i = 4) = \Phi (\tau_3 - \beta X_i) - \Phi (\tau_4 - \beta X_i) \\ &\text{Prob } (IU_i = 5) = 1 - \Phi (\tau_4 - \beta X_i) \end{aligned} \quad (3)$$

To estimate this model, we use Maximum Likelihood (ML), and so first we need a log-likelihood function. This is done by defining an indicator variable (d_{ij}):

$$\begin{aligned} d_{ij} &= 1 \quad \text{if} \quad IU_i = j \quad \text{and } j=1, 2, 3, 4 \text{ or } 5 \\ d_{ij} &= 0 \quad \text{otherwise} \end{aligned} \tag{4}$$

The log-likelihood is defined as follows (Greene, 1993):

$$L = \prod_{i=1}^{n} \prod_{j=1}^{m} (\Phi(\tau_j - \beta X_i) - \Phi(\tau_{j-1} - \beta X_i))^{d_{ij}} \tag{5}$$

The estimated parameters for the model defined by (1) for the three different scenarios were estimated using STATA 10.0.

4. RESULTS

Summary statistics for the characteristics of the sample are presented in Table 3, together with their population equivalents where available. The sample is representative of the population in terms of gender and age as half of the respondents were female (50%) with an average age of 44. However, more than half of the participants had university studies and only 12% and 30% of respondents indicate that they had primary or secondary education level implying that people with primary and secondary studies were under-represented, while higher educated people were over-represented. The higher proportion of people with university studies in the sample is common in all studies because more educated people are more prone to respond to questionnaires. The under- or over-representation of the sample is a feature common to many other surveys and empirical studies (Verhoef, 2005).

Around 30 percent of respondents stated that their household monthly net income was between € 1,500 and € 2,500 and between € 2,500 and €3,500, respectively.

4.1. Survey results

Table 1 shows the descriptive measures for the exogenous variables of our model. First, we can see that around 20 percent of respondents knew what biodiesel is, because they answered correctly to the three questions related to biodiesel. The environmental self-identity was low, because only 10 percent of respondents stated that they belong to one environmental association.

Respondents showed favorable attitudes towards biodiesel as they strongly believed that biodiesel can be produced from raw material from their region, its use may reduce oil import dependence, it contributes to the increase of farmers' income and it decreases the greenhouse gas emissions (average rating 4 or higher). On the other side, they believed to a lesser extent that biodiesel might increase the price of food products. In addition, attitudes towards using biodiesel were measured also close to 4 indicating a favourable attitude towards its use. However, the measures of the subjective norms and the perceived behavioural control were around 3, which mean they are indifferent with these aspects.

Table 2 presents the actual frequency of purchase, the intention to purchase under the three scenarios as well as the declared reasons for not using biodiesel. Around two-thirds of the respondents stated that they had never used biodiesel. On the other hand, only 0.2 percent (one respondent) indicated that he/she always used biodiesel and 12 percent stated that use biodiesel often or sometimes. This actual frequency of use is similar to Kallas and Gil (2015) for drivers in Cataluña (other northeast region in the Iberian Peninsula east of Aragon). Respondents were asked the reasons for not using biodiesel (Table 2) and the main reason of not using it is the lack of availability in the regular petrol station. On the other hand, the majority of drivers are not worry about the influence of the biodiesel in the power, consumption and cost of maintenance of the car. This result is in line with Kallas and Gil (2015) who found for Catalonian drivers that biodiesel availability in petrol stations is the most important reason of not using biodiesel. On contrary, results differ from Giraldo et al. (2010) who found that the most important reasons preventing the use of biodiesel are the lack of information about the product and about the effect it may have on the car engine.

Most respondents (76.5 percent) manifested that they would probably and definitely use biodiesel if sold at the same price as diesel and available at the same fuelling stations. However, only 39.5 percent

of respondents would use biodiesel if they had to pay a higher price than for diesel. This percentage is lower than the percentage of people that express they will use renewable electricity even at higher prices (49 percent-65 percent) in the same town reported by Gracia et al. (2012). This result indicates that price could be a limiting factor in the expansion of biodiesel use. Finally, 61.2 percent of respondents stated that they would definitely or probably use biodiesel, even if they had to go to another fuelling station, because it would not be available in the one they usually use.

4.2. TPB intention to use biodiesel results

First, we estimated the model defined in equation (1) with all explanatory variables defined in Tables 1, 2 and 3 for each of the three endogenous variables. Those variables individually and/or jointly insignificant (at 5-percent significance level) were dropped, one by one, in the subsequent estimations until we got the final model for each endogenous variables presented in Table 4. For the final model, all the threshold parameters in the three estimated equations were positive and significant at the 5-percent significance level, indicating that the endogenous variables do indeed suggest an ordered sequence.

4.2.1. Scenario 1: Same price and availability in all fuelling stations

Out of the five socio-demographic variables for which information was gathered (see table 3) only two were statistically significant at the 5-percent significance level in the intention to use biodiesel in this scenario, gender (FEMALE) and income level (HIGH INCOME). The positive coefficients associated with these variables indicated that females with a higher income level were more likely to use biodiesel in the future if sold at the same price as diesel and easily available in the market. Similar result for renewable energy is reported by Soliño et al. (2009) who found that income positively influences the willingness to pay for renewable energy from biomass in Galicia (a region in the Northwest of the Iberian Peninsula).

As stated by the TPB, the intention to use biodiesel within the first scenario was statistically related to attitudes towards the product and towards its use, subjective norms and perceived behavioural control. The positive, statistically significant coefficients for the attitudes towards the product (DEPENDENCE, FARMERS and GHG) and its use (GOOD) indicated that the more favourable consumers' attitudes, the stronger should be their intention to use biodiesel. In particular, the positive value for the DEPENDENCE variable indicates that the more consumers believed that biodiesel may

diminish import oil dependence, the more likely they were to use it. In the same way, the more consumers believed that the use of biodiesel may help to increase the incomes of farmers (FARMERS) and decrease the greenhouse gas (GHG) emissions; the more likely they were to use it. The positive coefficient for the variable GOOD indicates that consumers who believed that using biofuels is good were more likely to use it. Subjective norms were also positively related to the intention to use indicating that the stronger the consumer subjective norms, the higher would be their intention to use biodiesel. In particular, this result means that social pressure felt by the consumer had a positive influence on the intention to use biodiesel. Similar findings for renewable energy use are reported in Shah-Alam and Rashid (2012). Last, there was a negative and significant relation between the intention to use biodiesel under this first scenario and the perceived behaviour control (ABILITY). Because the perceived behavioural control is measured in a reverse scale (Table 1), results indicated that the more consumers believed that they were not able to use biodiesel, the less likely they were to use it.

Finally, the two new predictors of the TPB intention-to-use biodiesel model, biodiesel knowledge and environmental self-identity coefficients (KNOWLEDGE and SELF-IDENTITY), were positive and statistically significant. This result indicates that consumers with a higher knowledge of biodiesel and environmental self-identity were more likely to definitely use biodiesel in the future. In other words, as stated by several studies on the intention to purchase/use different products, consumer self-identity (Shaw et al., 2000; Shaw and Shiu, 2003) and product knowledge are good predictors of the intention to use (Halder et al., 2013; Shah-Alam and Rashid, 2012).

To assess the magnitude of the impact of the exogenous variables on the intention to use biodiesel to be able to compare the effect of these variables among the different scenarios, the marginal effects were calculated. For the continuous exogenous variables, effects were calculated by means of the partial derivatives of the probabilities, with respect to a given exogenous variable. In the case of dummy variables, the marginal effects were calculated as the difference between the predicted probabilities in the respective variables of interest, changing from zero to one and holding the rest constant. The marginal effects for the dummy exogenous variables are shown in Table A2 and for the continuous ones in Table A3 in the Annex.

Table A2 shows that the impact of these dummy variables on biodiesel use was statistically different from zero, although rather small, except for the effect on the probability to definitely use biodiesel. We can see that females with higher income, more knowledge about biodiesel and higher environmental self-identity were more likely to report that they would definitely use biodiesel if sold at the same price and available in all fuelling stations. In addition, the highest impact on this probability corresponds to environmental self-identity, followed by biodiesel knowledge. This last result indicates that the two new predictors of the TPB model had more impact on the probability to definitely use biodiesel than the consumers' socio-demographic characteristics.

The results in Table A3 indicate that the impacts of the continuous exogenous variables on biodiesel use were statistically different from zero for the attitudes towards the use (GOOD), the subjective norms (SNORMS) and the perceived behavioural control (ABILITY) and for some attitudes towards the biodiesel (DEPENDENCE, FARMERS and GHG). However, the magnitude of these effects are rather small, except for the attitudes towards the use (GOOD), which was the most important factor explaining the intention to use biodiesel in this scenario. Then, an increase in the consumers' attitudes towards the use of biodiesel increases the probability of reporting higher use.

4.2.2. Scenario 2: Higher price and availability in all fuelling stations

Similar results were found for the intention to use biodiesel in this scenario for the socio-demographic characteristics (FEMALE and HIGH INCOME), the knowledge of biodiesel (KNOWLEDGE), environmental self-identity (SELF-IDENTITY), attitudes towards the use (GOOD) and subjective norms (SNORMS). Then, as in the previous section, results indicated that females with a higher income level were more likely to use biodiesel in the future if sold at a higher price than biodiesel and easily available in the market. In addition, consumers with more favourable attitudes towards biodiesel use and stronger subjective norms were more likely to use this biodiesel. Finally, consumers with a higher knowledge of biodiesel and environmental self-identity were more likely to definitely use biodiesel in the future.

However, the attitudes towards the product which statistically significant explained the intention to use biodiesel sold at a higher price and in all fuelling stations were also three: FOOD, DEPENDENCE and FARMERS but different from the ones in the previous scenario. In particular, the belief that biodiesel use

may diminish GHG emissions, which was statistically significant in the previous scenario, is not significant now, while the belief that biodiesel use may increase the price of food products (FOOD), which was not statistically significant in the first scenario, was in the second. The statistically significant negative coefficient for the variable FOOD means that the more consumers believed that biodiesel may increase the price of food, the less likely they were to use biodiesel at a higher price and available in all fuelling stations. Similar to the previous scenario, the more consumers believed that biodiesel may diminish import oil dependence and may help the increase of farm incomes, the more likely they were to use it. Finally, the perceived behavioural control (ABILITY), which was statistically significant in the first scenario, is not in this second scenario.

The marginal effects of the socio-demographic characteristics, biodiesel knowledge and environmental self-identity on biodiesel use sold at a higher price and in all fuelling stations were statistically different from zero, although rather small, except for the effect on the probability to definitely use biodiesel. We can see that females with higher income, more knowledge about biodiesel and with higher environmental self-identity were more likely to report that they definitely use biodiesel sold at a higher price and available in all fuelling stations. In addition, the highest impact on this probability corresponds to the self-identity followed by the biodiesel knowledge and the income level very closely.

The marginal effects of attitudes towards the use and the subjective norm on biodiesel use in this scenario were statistically different from zero. Moreover, the effects of some attitudes towards the biodiesel (FOOD, DEPENDENCE and FARMERS) were also statistically significant, although rather small. In this scenario, the attitudes towards the use (GOOD) were also the most important factor explaining the intention to use biodiesel.

4.2.3. Scenario 3: Same price and availability only in some fuelling stations

Finally, results in the third scenario diverge more from the previous two. The first important difference is that biodiesel knowledge is no longer statistically significant in explaining the intention to use biodiesel. Second, consumers´ belief that biodiesel can be produced from regional raw materials (REGIONAL), which was not statistically significant in the previous scenarios, was positive and statistically significant in this scenario. This means that the more consumers believe that biodiesel can be produced

from regional raw materials, the more likely they were to use it. Third, consumers' belief that biodiesel may help to increase farm incomes (FARMERS), which was statistically significant in the previous cases, was not significant in this third scenario.

Taking into account all the different factors affecting the intention to use biodiesel, we can conclude that the two most important were the environmental self-identity and the attitudes towards its use, followed by biodiesel knowledge (but for this case only in the first two scenarios). Moreover, it is observed that the effect of these three factors is almost double for the first scenario (biodiesel sold at the same price and in all fuelling stations) than for the other two scenarios.

5. DISCUSSION

The aim of the paper was to find the factors affecting active-market acceptance of biodiesel and several interesting results have been identified for the Spanish biodiesel market that would help policy makers face the great challenge to expand the use of pure biodiesel to meet its renewable energy in transport targets. Results show that the intention to use biodiesel varies with price and availability at stations. If biodiesel was sold at the same price and fuelling stations as diesel, almost half of car drivers would definitely use it. However, if it is sold at a higher price, yet in the same fuelling stations as diesel, only 20 percent of car drivers will definitely use biodiesel. Finally, the number of car drivers willing to finally use biodiesel when sold at the same price but only in fewer fuelling stations lies in-between those figures (30 percent). This indicates that the main limiting factor for using biodiesel is price, although availability also plays a role. Similar results were found by Giraldo et al., (2010) who state that a lower availability of biodiesel in the fuelling stations entails a lower consumption of biodiesel, regardless of its price. In addition, these authors pointed out that the proximity of a service station where refueling biofuel was one of the most important elements to increase its consumption. In this line, Chin et al. (2014) also report that when the price of biofuel is the same than the fossil fuel, other factors will become significant in influencing consumers use of fuel such as refueling convenience, fuel performance, etc.

Another important finding is that biodiesel knowledge is still very limited among car drivers, as less than 20 percent knew what biodiesel is. Biodiesel knowledge is one of the most important factors affecting biodiesel use, and specifically, car drivers who did know what biodiesel is were more likely to definitely use

biodiesel. The other relevant factors were environmental self-identity, positive attitudes towards its use, gender and income. In particular, higher-income females with high environmental self-identity and more positive attitudes towards its use were more likely to definitely use biodiesel. Finally, results suggested that the other factors associated with the intention to use biodiesel were attitudes, subjective norms and perceived behavioural control, but they had a smaller impact on biodiesel use.

Taking into account the different price and availability scenarios, we can conclude that even when biodiesel would be available in the market at the same price as diesel and widely spread through the current retail network, less than 50 percent of car drivers would definitely purchase it. In such a scenario, increasing biodiesel knowledge and environmental self-identity would be the best policy option. Moreover, car drivers should be reassured that biodiesel actually reduces energy dependence and GHG emissions. The same approach would also increase the acceptability of biodiesel when sold at higher prices (second scenario). However, in this scenario, special attention should also be given to the potential negative impact of biofuels on food security. Finally, in the last scenario, where the biodiesel is sold at the same price but in few fuelling stations, biodiesel knowledge has no effect on the intention to use biodiesel, but the intention to use would increase when it is known that the biodiesel is produced from regional raw materials. In order to attract car drivers' intention to use biodiesel when changing their purchase location, special attention should be given to advertise the biodiesel regional origin.

6. CONCLUSIONS

This paper studies the market acceptance of biodiesel in Spain, a country with a low rate of biodiesel consumption and a high production capacity. In particular, it analyses the intention to use biodiesel and measures the effect of the factors explaining this intention that can be useful for deriving recommendations and policy implications.

We can conclude that the TPB model should be extended to analyse the intention to use biodiesel. Results indicated that apart from the attitudes towards biodiesel use, the most important factors explaining the intention to use biodiesel are biodiesel knowledge and environmental self-identity, in other words, the new predictors in the TPB model. In addition, the effects of all the factors (attitudes, subjective

norms, perceived behavioural control, biodiesel knowledge, environmental self-identity and socio-demographics characteristics) on the intention to use were different, depending on the price and the availability of the biodiesel in the market. This last result proves that to analyse the intention to use biodiesel, different price and availability scenarios should be taken into account.

The results of the paper constitute a further contribution within the debate on social acceptance of biodiesel for an EU region. In particular, we can provide some recommendations to increase biodiesel use. First, as more positive attitudes towards biodiesel use was one of the most important factors driving biodiesel use, public authorities should promote and implement educational programs with a message designed to increase public awareness of environmental conservation, thereby enhancing attitudes towards biodiesel use reducing egoistic decisions and enhancing altruistic behaviour. Education should be directed not only at the adult population but also to children and youth in schools for a more environmentally concerned society. Second, as biodiesel knowledge and attitudes towards biodiesel also increases intention to use biodiesel, stakeholders could jointly launch an information and communication campaign. This campaign should explain to car drivers what biodiesel is and the benefits that its use represents for the whole society. In particular, attention should be paid to communicate that biodiesel reduces oil dependence and GHG emissions and may help to increase farmer income. Finally, as results indicate that price and availability of biodiesel in the market are two limiting factors in the expansion of biodiesel use, producers, wherever possible, should explore ways to decrease the cost of production in order to market biodiesel at a price similar to conventional diesel and make it available at all fuelling stations where conventional diesel can be found.

Finally, this work has limitations that must be taken into account and constitute further research avenues on the topic. All our analysis focused only on consumer demand and is contingent in the technical feasibility of biodiesel use in car engines which is given for granted both in the study design and by a vast majority of our sample (Table 2). In addition, and as a common limitation to all TPB applications, although intentions are good predictors of final behaviour, the analysis should also be extended to analyse real use. Second, the study was only conducted in a Spanish region, and empirical results apply only to this geographical coverage, with potential extensions to other markets.

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Figure 1. Theoretical framework explaining the consumers' intention to use biodiesel. Black frame represents the extended model while dotted frame is the original theory of planned behaviour as put forward by Ajzen (1991).

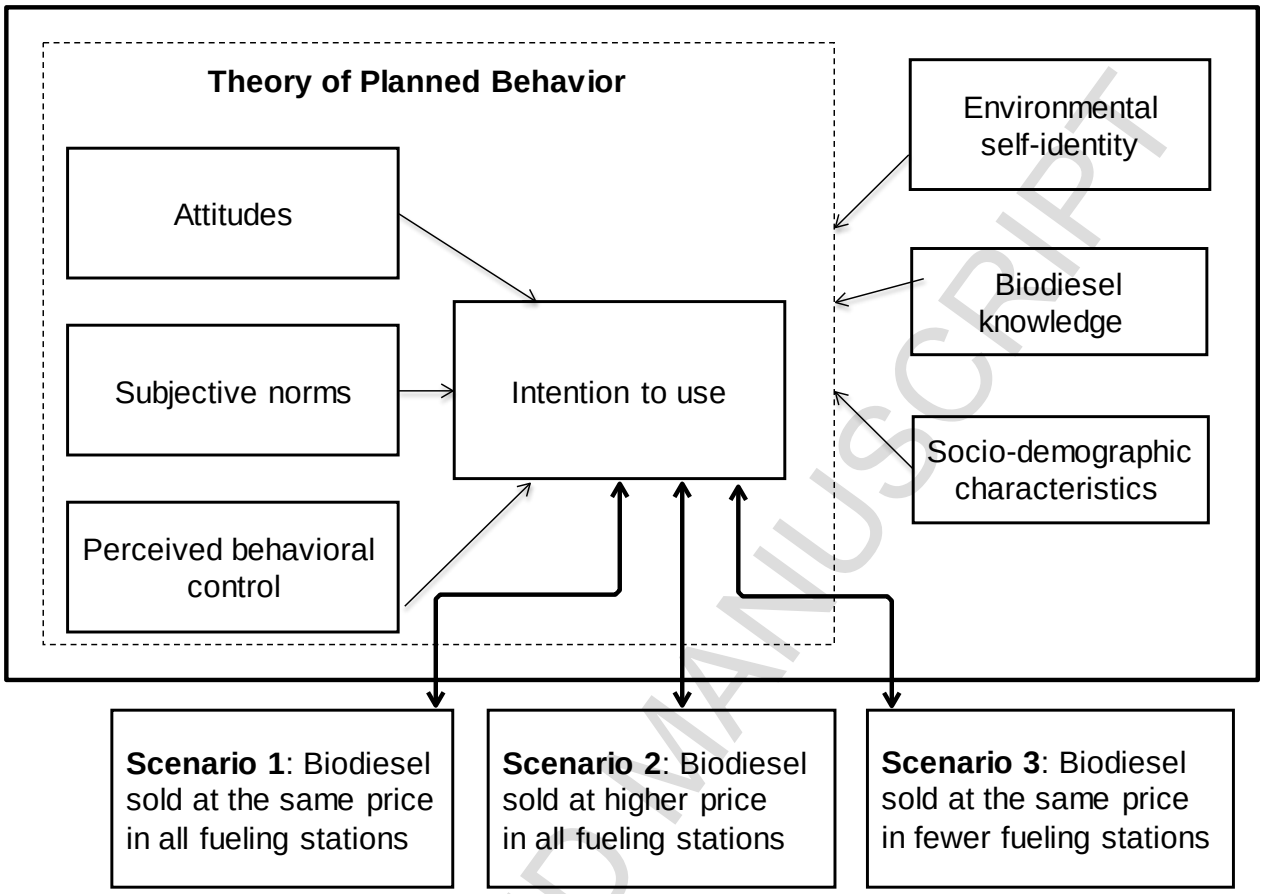

Table 1. Explanatory variables used in the estimated models: definition and descriptive statistics. For knowledge and self-identity frequency of positive responses are reported while for attitudes, subjective norm and perceived behavioural control average and standard deviation (in brackets) is reported based on a five point likert-scale where 1 indicates strong disagreement and 5 strong agreement.

Variable definition	Name	Value
Knowledge *Dummy 1=correct answer to the three statements; 0=otherwise*	KNOWLEDGE	19.2%
Self-identity: Membership of an environmental association *Dummy 1=yes; 0=otherwise*	*SELF-IDENTITY*	10.0%
Attitudes towards biodiesel[1]		
Biodiesel use can be produced from raw material from my region	REGIONAL	4.1 (0.67)
Biodiesel use may increase the price of food products	FOOD	3.4 (1.03)
Biodiesel use may diminish import oil dependence	DEPENDENCE	4.0 (0.77)
Biodiesel use may help the increase of farmers' income	FARMERS	4.0 (0.84)
Biodiesel use may decrease the greenhouse gas emissions	GHG	4.0 (0.81)
Attitudes towards using biodiesel[1]		
I believe that using biodiesel is good	GOOD	3.8 (0.70)
Subjective norm[1]		
People close to me think that I should use biodiesel	SNORM	3.0 (0.87)
Perceived behavioural control[1]		
Whether I will eventually use biodiesel is entirely up to me	CONTROL	3.4 (1.08)
If biodiesel was available at all fuelling stations, I do not think I would ever be able to use	ABILITY	3.0 (1.00)

Table 2. Dependent variables used in the estimated model: definition and frequencies reported as percentage of total respondents.

Intention to use biodiesel if…..	Name	Value
sold at the same price as diesel and available in the same fuelling station.		
Definitely not	IU1	3.0
Probably not		5.3
Indifferent		15.2
Probably yes		30.3
Definitely yes		46.2
sold at a higher price than the diesel but available in the same fuelling station.		
Definitely not	IU2	19.7
Probably not		18.3
Indifferent		22.5
Probably yes		19.5
Definitely yes		20.0
sold at the same price as diesel but not available in the same fuelling station.		
Definitely not	IU3	8.8
Probably not		11.5
Indifferent		18.5
Probably yes		31.0
Definitely yes		30.2
Frequency of biodiesel use		
Never	BIOUSE	73.4
Rarely		14.8
Sometimes		10.5
Often		1.0
Always		0.2
Reasons for not using biodiesel….(% of respondents citing)		
Biodiesel is not sold in the petrol station I usually refuel in		30.4
Biodiesel can affect the performance of my car's engine		1.3
Biodiesel increases fuel consumption of my car		1.3
Biodiesel could increase the price of food products		2.3
Biodiesel increases the maintenance costs of my car		9.3

Table 3. Characterization of the sample respondents and related socio demographic independent variables used in the estimated model. Figures reported are percentage of total respondents unless otherwise stated.

Variable definition	*Name (type)*	*Sample*	*Population*
Gender[1]			
Male	FEMALE (dummy: 1=female)	48.8	49.3
Female		51.2	50.7
Age[1] (Average)	AGE (continuous)	44.0	41.4
Education of respondent[2]			
Primary School	UNIVERSITY (dummy: 1=university)	12.2	20.0
Secondary School		30.0	50.0
University or higher		57.8	30.0
Average monthly household income			
Less than 1,500 €	HIGH INCOME (dummy: 1=higher than 3,500 €)	13.8	
Between 1,501 and 2,500 €		31.2	
Between 2,501 and 3,500 €		29.5	na
Between 3,501 and 4,500 €		14.0	
More than 4,500 €		11.5	
Household Size (Average)	HSIZE (continuous)	3.2	na

[1] INE (2012) and [2] OECD (2012).

Table 4. Model coefficient estimates and t-ratios results for the ordered probit model (equation 1 and 2) under the three scenarios. Positive coefficients indicate higher intention to use while negative one indicate lower intention to use.

		Scenario					
		S1		**S2**		**S3**	
		Same price and convenience		**Higher price and same convenience**		**Same price and lower convenience**	
Concept	**Variable**	*Coefficient*	*T-ratio*	*Coefficient*	*T-ratio*	*Coefficient*	*T-ratio*
ATTITUDES TOWARDS BIODIESEL / BIODIESEL USE	REGIONAL	---	---	---	---	0.2886	3.18
	FOOD	---	---	-0.1583	-2.65	-0.1339	-2.20
	DEPENDENCE	0.2250	2.74	0.2636	3.27	0.2809	3.44
	FARMERS	0.1480	1.85	0.1897	2.63	---	---
	GHG	0.1725	2.11	---	---	0.2310	2.74
	GOOD	0.6605	5.51	0.6793	5.84	0.5677	5.46
SUBJECTIVE NORMS	SNORMS	0.1720	1.87	0.2314	2.79	0.2131	2.94
PERCEIVED BEHAVIOURAL CONTROL	ABILITY	-0.1512	-2.38	---	---	---	---
SELF IDENTITY	SELF-IDENTITY	0.6803	2.96	0.7422	3.47	0.5508	2.48
KNOWLEDGE ABOUT BIODIESEL	KNOWLEDGE	0.4709	3.08	0.4181	2.93	---	---
SOCIO DEMOGRAPHIC CHARACTERISTICS	FEMALE	0.2592	2.18	0.2805	2.50	0.2319	2.09
	HIGH INCOME	0.2892	2.01	0.3826	2.73	0.2441	1.89
THRESHOLD PARAMETERS	μ_1	2.5610	4.39	3.7753	6.80	3.9450	6.78
	μ_2	3.2117	5.61	4.5088	7.88	4.6624	8.00
	μ_3	4.1270	6.81	5.3171	9.03	5.4163	9.15
	μ_4	5.2500	8.26	6.1628	10.2	6.5326	10.65
MODEL INFORMATION	N		400		400		400
	Log Likelihood		-407.14		-521.79		-488.69

Annex

Table A1. Population by sex and age in Spain and the Town (%)

		Sex		Age				
	Total	Female	Male	0-19	20-34	35-54	55-64	More than 64
Spain	46,148,605	50.99	49.01	19.88	20.80	31.10	11.05	17.14
Town	952,383	50.90	49.10	18.46	19.63	30.83	11.64	19.42

Source: Spanish Census of Population, 2011. www.ine.es

Table A2. Marginal Effects of dummy variables on the Ordered Probit model

Variable	*Prob. definitely not*	*Prob. probably not*	*Prob. indifferent*	*Prob. Probably yes*	*Prob. Definitively yes*
FEMALE					
IU1 - Biodiesel same price and convenience	-0.004*	-0.012**	-0.045**	-0.042**	0.103**
IU2 - Biodiesel higher price and same convenience	-0.054**	-0.046**	-0.006	0.050**	0.056**
IU3 - Biodiesel same price and less convenience	-0.016**	-0.031**	-0.038**	0.013	0.072**
HIGH INCOME					
IU1 - Biodiesel same price and convenience	- 0.003*	-0.012**	-0.048**	-0.052*	0.115**
IU2 - Biodiesel higher price and same convenience	-0.066**	-0.064**	-0.018	0.063**	0.085**
IU3 - Biodiesel same price and less convenience	-0.015**	-0.031*	-0.041*	0.008	0.079*
KNOWLEDGE					
IU1 - Biodiesel same price and convenience	-0.005**	-0.017**	-0.073**	-0.091**	0.186**
IU2 - Biodiesel higher price and same convenience	-0.059**	-0.070**	-0.024	0.066**	0.096**
IU3 - Biodiesel same price and less convenience	---	---	---	---	---
SELF-IDENTITY					
IU1 - Biodiesel same price and convenience	-0.005**	-0.020**	-0.093**	-0.144**	0.262**
IU2 - Biodiesel higher price and same convenience	- 0.098**	-0.120**	0.071**	0.090**	0.200**
IU3 - Biodiesel same price and less convenience	-0.025**	-0.060**	-0.093**	-0.014	0.193**

*** (**) (*) denotes statistical significance at the 1- (5-) (10-) percent significance levels

Table A3. Marginal Effects of continuous variables on the Ordered Probit model

Variable	*Prob. definitely not*	*Prob. probably not*	*Prob. indifferent*	*Prob. Probably yes*	*Prob. Definitively yes*
REGIONAL					
IU1 - Biodiesel same price and convenience	---	---	---	---	---
IU2 - Biodiesel higher price and same convenience	---	---	---	---	---
IU3 - Biodiesel same price and less convenience	-0.020**	-0.039**	-0.472**	0.017**	0.090**
FOOD					
IU1 - Biodiesel same price and convenience	---	---	---	---	---
IU2 - Biodiesel higher price and same convenience	0.030**	0.026**	0.003	-0.028**	- 0.031**
IU3 - Biodiesel same price and less convenience	0.009**	0.018**	0.022**	-0.008*	-0.041**
DEPENDENCE					
IU1 - Biodiesel same price and convenience	-0.003*	-0.010**	-0.039**	-0.036**	0.089**
IU2 - Biodiesel higher price and same convenience	-0.051**	-0.043**	-0.005	0.047**	0.052**
IU3 - Biodiesel same price and less convenience	-0.019**	-0.038**	-0.046**	0.016**	0.087**
FARMERS					
IU1 - Biodiesel same price and convenience	-0.002	-0.007*	-0.0260*	-0.024*	0.059*
IU2 - Biodiesel higher price and same convenience	-0.036**	-0.031**	-0.004	0.034**	0.038**
IU3 - Biodiesel same price and less convenience	---	---	---	---	---
GHG					
IU1 - Biodiesel same price and convenience	-0.002	-0.008*	-0.030**	-0.028**	-0.068**
IU2 - Biodiesel higher price and same convenience	---	---	---	---	---
IU3 - Biodiesel same price and less convenience	-0.016**	-0.031**	-0.038**	0.013*	0.071**
GOOD					
IU1 - Biodiesel same price and convenience	-0.009**	-0.031**	-0.115**	-0.107**	0.262**
IU2 - Biodiesel higher price and same convenience	-0.131**	-0.111**	-0.014	0.121**	0.135**
IU3 - Biodiesel same price and less convenience	-0.039**	-0.077**	-0.093**	0.033**	0.176**
SNORMS					
IU1 - Biodiesel same price and convenience	-0.002*	-0.008*	-0.030**	-0.028**	0.068**
IU2 - Biodiesel higher price and same convenience	-0.045**	-0.038**	-0.005	0.041**	0.046**
IU3 - Biodiesel same price and less convenience	-0.015**	-0.029**	-0.035**	0.012*	0.066**
ABILITY					
IU1 - Biodiesel same price and	0.002*	0.007**	0.026**	0.024**	-0.060**

convenience					
IU2 - Biodiesel higher price and same convenience	---	---	---	---	---
IU3 - Biodiesel same price and less convenience	---	---	---	---	---

*** (**) (*) denotes statistical significance at the 1- (5-) (10-) percent significance levels