Bio-based and Applied Economics 5(1): 27-45, 2016
DOI: 10.13128/BAE-15283

Full Research Article

An estimation of the willingness to pay for biodiesel: a pilot study of diesel consumers

Pathmanathan Sivashankar[1,*], Jeevika Weerahewa[2], Gamini Pushpakumara[3], Lakshman Galagedara[4]

[1] Postgraduate Institute of Agriculture, University of Peradeniya and Sabaragamuwa University of Sri Lanka
[2] Department of Agricultural Economics and Business Management, University of Peradeniya, Sri Lanka
[3]Department of Crop Science, University of Peradeniya, Sri Lanka,
[4] Grenfell Campus, Memorial University of Newfoundland, Corner Brook, NL, Canada

Date of submission: December 28th, 2014; accepted 2016 27th, April

Abstract. Sri Lanka's energy policy presumes that the country will be meeting 20% of its energy requirements by non-conventional renewable energy resources by 2020. This study attempts to assess diesel vehicle owners' willingness to pay (WTP) for Jatropha biodiesel and the factors affecting their decisions. The Contingent valuation method (CVM) was used to elicit the WTP for the non-marketed biodiesel, which leads to a hypothetical allocation. For diesel vehicle users, a single bid approach was used at Rs.121/= per litre (€ 0.83). The study was carried out in Kandy region among diesel vehicle users. The factors affecting WTP were estimated using probit regression and WTP was estimated using nonparametric estimation techniques. The mean WTP for biodiesel by the diesel vehicle users was Rs.109 per litre (€ 0.74) for lower bound levels. The median WTP was Rs.124/= per litre (€ 0.85). Elderly respondents with higher education are less likely to pay for biodiesel in both samples. Married respondents with higher income are more likely to pay higher prices for biodiesel.

Keywords. Willingness to pay, Jatropha Biodiesel, Probit regression, diesel consumers

JEL Codes. Q21, Q41, Q42

1. Introduction

The debate over energy and economic development has received growing attention among economists and policy makers in the post millennia era. Almost all past economic recessions were linked to oil price fluctuations, either directly or indirectly (Hamilton, 2011; Killian and Vigfusson, 2014). Hence, energy conservation and efficient utilization of energy and energy sources play a crucial role for policy makers. Dwindling fossil fuels

* Corresponding author: sivashankar.p@hotmail.com

ISSN 2280-6180 (print)
ISSN 2280-6172 (online)

have been threatening the growth prospects of many countries including Sri Lanka. As Sri Lanka's energy needs have been increasing over the years, its dependence on imported crude oil to meet energy demand has increased. Sri Lanka uses diverse energy sources. The main source is imported petroleum, followed by renewable sources, including hydropower, biomass, solar, and wind (Energy Balance, 2010). Among them, hydropower is widely used for electricity generation. Commercially traded forms dominate the local energy market through petroleum and electricity while biomass is also traded in smaller shares. This heavy dependence on imported crude oil has made the vision of achieving sustained growth in developing countries dubious (Igberaese, 2013; Osman and Nour, 2011; Rodriguez and Sanchez, 2005).

Even for developed countries, economic growth has been limited due to the dependence on fossil fuels (Rodriguez and Sanchez, 2005). Developed countries, having understood the constraints on fossil fuels and depleting natural resources, have begun to embrace the concept of bio-based economy. Their governments promote and invest heavily in the research and development of bio-based products with subsidies at different levels of the supply chain, from the field to the consumer (ERMA, 2007; Steenblik, 2007; Josling *et al.,* 2010; World Bank, 2010). The concept of bio-based economy is still new to many developing countries. The EU defines bio-economy as the economy that "encompasses the production of renewable biological resources and their conversion into food, feed, bio-based products and bio-energy. It includes agriculture, forestry, fisheries, food and pulp and paper production, as well as parts of chemical, biotechnological and energy industries" (EU Commission, 2012). In the literature, there is not yet agreement on a common definition, but studies have emphasised the importance of bio-economy, its challenges, and potential and how it has moved further away from agricultural economies (Roman, 2012; Viaggi *et al.,* 2012). Bio-based products are commercial or industrial products composed of the whole or part of a biological origin from agriculture, forestry, or renewable biological material (USDA, 2006). Similar definitions have also been proposed by the EU Commission (2012) and CEN (2014). Renewable energy is a key component of the bio-based economy.

Biomass (45.80%), petroleum (40.90%) and hydropower (11.10%) are the main energy resources used in Sri Lanka (Energy Balance, 2010). The use of renewable energy sources such as wind power and solar electricity is estimated to be insignificant in comparison to these three sources. Electricity and petroleum products are the main forms of commercial energy, and an increasing amount of biomass is also commercially grown and added to the national energy supply. Demand for energy in Sri Lanka is on the rise. However, the share of electricity generation from non-conventional renewable energy resources is as low as 4%. In 2005, the then government of Sri Lanka's target was to achieve 10% by 2015. The National policy, *viz*, *mahinda chintanaya* (Mahinda's Vision) in 2005 targeted 20% of contribution from non-conventional renewable energy sources by the year of 2020. Biofuel is an energy source/combustible fuel that is produced from plants and other bio-based products. Two different types exist, *viz*, bioethanol and biodiesel, which are not yet locally produced on a commercial scale. Accordingly, it is essential to study the prospects of biodiesel options in Sri Lanka.

Globally, the USA (corn) and Brazil (sugarcane) account for about 89% of global ethanol production (www.dnv.com, 2010). The EU currently represents 90% of global bio-

diesel production and consumption. Due to the competitive advantage in land size and technology, larger economies have reached greater milestones in innovation in biofuels. Due to its environmental merits, the biofuel share in the automotive fuel market will grow rapidly in the future (Demirbas, 2008). Moreover, the combustion of bio-diesel fuels produces fewer emissions than diesel (Mittelbach and Remschmidt, 2004).

Given this context, this study attempts to measure the willingness of Sri Lankan consumers to consume biodiesel produced from a bio-based, non-food agricultural crop, *Jatropha* (Physic nut). Is the Sri Lankan public ready to consume biodiesel instead of conventional diesel? What are their perceptions about biodiesel consumption and investment on this bio-based sector? What is the price they are willing to pay for this environmentally friendly product and what factors affect their intention to consume biodiesel? This study attempts to answer these questions. The study measures the acceptance of biodiesel by diesel consumers in Sri Lanka, and estimates the demand for biodiesel through positive Willingness to pay (WTP) and factors affecting their choices. Although WTP research has been carried out on other bio-based products in Sri Lanka, this is the first of its kind on the estimation of WTP for biodiesel in the country.

The organization of the rest of the paper is as follows. Section 2 discusses the relevant literature on renewable energy and bio-based products and the demand estimation for biodiesel. Section 3 posits the theory for WTP estimation and the methodology followed. Section 4 and 5 present the results and the emerging discussion, respectively. A conclusion is provided in Section 6.

2. Review of literature

2.1 Bio-based products as renewable energy sources.

Bio-based products are products that have a biological origin, be it from agricultural land, the livestock industry, forestry, fisheries, or even from microbes (USDA, 2006; EU commission 2012; CEN, 2014). Bio-based products include, but are not limited to, adhesives, construction materials and composites, fibres, paper and packaging, fuel additives, paints, plant inks, solvents etc. (USDA, 2006). Most of these products are environmentally friendly in nature and fetch higher market prices. These industries are also heavily subsidized in many countries.

Among these bio-based products, biofuel production is particularly common the world over. The most common biofuel types are biodiesel and bioethanol. Biodiesel is produced from oil crops like rapeseed (*Brassica napus*), sunflower (*Helianthus annuus*), Jatropha (*Jatropha curcas* L.) and soybean (*Glycine max*), while bioethanol is produced from starch crops like sugarcane (*Saccharum officinarum*), wheat (*Triticum aestivum*) and corn (*Zea mays*). With the onset of the 2008 food crisis, it has been claimed that the usage of food crops in biodiesel production is a threat to food security (Tenenbaum, 2008; IUFoST, 2010; Jideani *et al.,* 2011; Popp *et al.,* 2014). The current trend is biodiesel extraction from non-edible, oil-bearing trees such as Jatropha, Pongamia (*Milletia pinnata*), Castor (*Ricinus communis*) and Neem (*Azadirachta indica*) (Lele, 2008). In addition to these plant varieties, further research is focussed on biofuel production from algae (Khola and Ghazala, 2012; Pitman *et al.*,2011; Hossain *et al.,* 2008; Park *et al.,* 2011). This could be a

remedy for the challenges faced by land limitations and the food security issues related to biofuel production.

The benefits from biofuel production include a reduction in carbon emissions, job creation, poverty alleviation, and an improvement in the socio-economic conditions of the rural people, especially the rural poor (Francis *et al*., 2005; Tomomatsu and Swallow, 2007; and Pushpakumara *et al*., 2008). The multidimensional long-term benefits of biofuels have created a growing interest in biofuel production in developing countries.

Among other energy crops, Jatropha has been extensively produced in developing countries on the Asian, African, and Latin American continents. Like other energy crops, Jatropha's contribution to mitigate greenhouse gas (GHG) emissions has been emphasised by Tomomatsu and Swallow (2007). If oil prices continue to rise, alternative fuels will become an economic necessity for small economies.

2.2 Demand for Biodiesel

Demand estimation for these types of products through a surrogate market indicates whether there is a market for these bio-based products. WTP for biodiesel or bioethanol could be affected by many reasons. Studies reveal that consumers value the environmental benefits of green energy (Roe *et al*., 2001; Shrum *et al.,* 1995). In terms of ethanol as an alternative fuel, the interaction between intended purchases of E10 blended fuel and environmental, political and national security benefits have also been addressed using the Contingent valuation method (CVM) in a simultaneous latent variable framework (Bhattacharjee *et al*., 2008). The study revealed that males with liberal ideologies who were familiar with ethanol had higher WTP. Jeanty and Hitzhusen (2007) used a CVM estimate WTP for air pollution reduction from using biodiesel in diesel engines. The study focuses on valuing the benefits of biodiesel such as a reduction in CO_2 emissions by 75%, reductions in fine particulates by 47%, sulphur emissions by 100%, and volatile organic compounds by 56%.

Li *et al*. (2009) used a mixed-mode CVM survey to estimate WTP for increased research and development in support of replacing fossil fuels in the United States where WTP was higher for females, people with liberal political ideologies respondents with higher incomes, and those who considered energy issues to be important. Solomon and Johnson (2009) conducted a case study of Michigan, Wisconsin, and Minnesota residents to determine how these residents valued climate protection through the potential purchase and consumption of cellulosic ethanol, using a multi-part, split-sample CVM. Jeanty and Hitzhusen (2007) present the results of a contingent valuation study in two Ohio regions to estimate willingness to pay for air pollution reduction from using biodiesel in diesel engines. The double bounded parametric formulation was used to estimate mean WTP. Gracia *et al.* (2009) suggests that determinants of WTP heterogeneity are not limited to the buyers' socio demographic characteristics. It is also determined by buyers' knowledge on biodiesel, their fuel purchasing habits and factors of the behavioural model. Behavioural model factors include attitudes, subjective norms, and perceived behavioural control, where all three factors affects the intention (Azjen, 1991). The common message of these studies is that the consumers are willing to pay a higher price for biodiesel.

In Greece, 90% of people believe that climate change is related to fossil fuel consumption, whilst only half think that biofuels could be an effective solution (Savvanidou *et al*.,

2010). Although biofuels are not new, usage remains low in certain western countries and public opinion of biofuels is still divided. According to Savvanidou *et al.* (2010), eighty per cent of respondents who owned vehicles were willing to use biofuels, of which 44.8% were willing to pay more for them (€ 0.06 per litre). In particular, the highly educated are more likely to pay this amount whereas the general public is willing to pay more if research organisations manage the introduction of biofuels rather than government or industry. There is a need to educate people on the positive impacts of biofuels through campaigns (Savvanidou *et al.*, 2010). Marra (2010) revealed that, in general, consumers were willing to pay for reductions in greenhouse gas emissions through purchases of E85 and that these amounts vary from one market segment to the next. No such study has been conducted on the WTP of Sri Lankans for biodiesel. This study is the first of its kind targeting Sri Lankan diesel vehicle users.

3. Methodology

3.1 Demand estimation

In this section, the theoretical background and the methods used for estimating the demand for Jatropha biodiesel is discussed. Demand has been estimated using two techniques. The first method is the parametric estimation of demand (Hanemann, 1984). The second method is non-parametric estimation of demand for biodiesel. Studies show that nonparametric estimation can be used as it does not assume the normal distribution of data and at times it is the best method for demand estimation of non-marketed products (Turnbull, 1976; Kristrom, 1990; Haab and McConnell, 1997; Vaughan and Rodriguez, 2001).

3.2 Theoretical and empirical estimation of WTP

Theory of demand suggests demand is a function of price (P). In addition to price P, Lancaster (1971) argues that demand is also a function of other attributes of the product (A) and income (I) of consumers. Farrow *et al.* (2011) expands this theoretical model to include the psychological characteristics (C) of the decision maker. These characteristics include the standard theory of planned behaviour variables: attitudes, beliefs, norms, and perceived behavioural control (Azjen, 1991; Armitage and Conner, 2001; Daigle *et al.*, 2002). The general theoretical model is as follows:

$$WTP = f(P, A, I, C) \quad (1)$$

Welfare change cannot be directly measured; indirect utility function and minimum expenditure function provide the theoretical basis for welfare estimation. In stated preferences, welfare change is measured by a change in these functions. CVM can be viewed as a direct measure of welfare change. WTP is the amount of income that compensates an individual for a welfare change. An individual's WTP for environmental benefit is the amount that must be taken away from the individual's income while keeping his or her utility unchanged (Huang, 2011; Freeman III *et al.,* 2014):

$$V(Y\text{-}WTP, P, Q_1) = V(Y, , P, Z, Q_0) \quad (2)$$

where V is indirect utility function, Y income, P is a price vector, Z is a vector of socio-oeconomic variables, and Q_0 and Q_1 are the environmental quality at status quo and improved levels respectively.

According to this model, choice (the decision to purchase fuel) is based on the attributes of the fuel (environmental, fuel security) and the individual's psychological characteristics, specifically their beliefs (perceptions) about the environment (e.g., global warming), fuel security (dependence on foreign sources of fuel), as well as attitudes towards new technologies, products and their prices. Behavioural theories suggest that attitudes are an important determinant of behaviour (Ajzen and Fishbein, 1988; Ronis *et al.*, 1989; Azjen, 1991; Daigle *et al.*, 2002; Sutton, 2004). From equation (2), WTP function can be obtained as in equation (3).

$$WTP = F(Y, P, Z, Q_0, Q_1) \quad (3)$$

Equation (3) underlies the estimation of a valuation function that depicts the monetary value of a change in economic welfare that occurs for any change in environmental quality. The residuals of the respondents, ε, are assumed to have a standard normal distribution $\boldsymbol{\varepsilon \sim N[0, 1]}$. That is, the distribution of the residuals of the socio-economic variables, denoted by **X**, follows a standard normal distribution with zero mean and a common variance, unity. Given that our response variable is a binary response, with the cumulative density function being normally distributed, a probit model for WTP can be developed. The latent variable WTP^* is linked to the observed binary variable *WTP* through the relationship below:

$$WTP \begin{cases} 1 \; if \; WTP^* > 0 \\ 0 \; if \; WTP^* \leq 0 \end{cases}$$

The probit model can be derived from the following equation:

$$WTP^* = \Phi(X'_j\beta + \varepsilon_j) \quad (4)$$

As equation (4) denotes, WTP*, an unobserved continuous variable, can be written as the function of vector, X_j with a cumulative normal distribution with the predicted probabilities. For a given covariate, the probit function provides the probability area of the standard normal distribution. Mathematically, the probit function results from the inverse of the cumulative density function ($\boldsymbol{\Phi}$) of the standard normal distribution. Accordingly, it can be denoted as in equation (5) (Razzaghi, 2013).

$$WTP = \Phi^{-1}(WTP^*) = (X'_j\beta + \varepsilon_j) \quad (5)$$

$$WTP = (X'_j\beta + \varepsilon_j) \quad (6)$$

WTP* is an unobserved variable. To use it as an observed variable the variable WTP is applied. Here, equation (5) serves as the link function (probit link) between actual WTP*

and estimated WTP. Denoting the willingness to pay determinants as a vector, *X,* then for each respondent *j=1…. N* in the sample, the latent variable, WTP, can be written as in equation (6) for a single bounded model. β is the vector of parameters estimated (Long, 1997).

The level of WTP is investigated using the probit regression to model the respondents' responses against attitudinal variables and several socio-economic variables. This is a common approach in contingent valuation studies to test the validity of WTP results by examining how well the model corresponds to the economic theory in which individuals with higher incomes are expected to have a higher than average WTP. Similarly, individuals with low incomes are expected to have a lower than average WTP. Equation (7) presents the empirical equation for the unobserved continuous variable, WTP^{*}, which determines the value of WTP in the study. The respective variable names and units are presented in Table 1.

$$WTP^{*} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \varepsilon \quad (7)$$

Table 1. Variables used in the probit regression.

Variable	Definition	Type	Expected Sign
X_1	Age	Continuous	+
X_2	Gender (0=female, 1=male)	Dummy	+/-
X_3	Education	Continuous	+
X_4	Marital status (0=single, 1=married)	Dummy	+/-
X_5	Employment (Emp) (0=unemployed, 1=farmer, 2=government, 3=self employed, 4=private, 5=other)	Categorical	+/-
X_6	Income	Continuous	+
X_7	Refuel cost	Continuous	+
X_8	Vehicle age	Continuous	+
X_9	Knowledge on GHG (0 = no idea, 1=heard, 3= know	Categorical	+
X_{10}	Knowledge on Climate Change (0 = no idea, 1=heard, 3= know	Categorical	+

Note: For dummy variables, the first level is chosen as the reference level.

3.3 Nonparametric estimation

The parametric approach to derive the WTP measure requires a distribution assumption (Hanemann, 1984; Bishop and Heberlein, 1979), which may result in inconsistent estimates when the distribution is miss-specified. In order to overcome this potential problem, Turnbull (1976) suggested a distribution free lower bound mean estimate. The Turnbull Lower Bound Mean (LBM) estimate is calculated as (Haab and McConnell, 1997; Vaughan and Rodriguez, 2001):

$$LBM\left(Turnbull\right) = p_1 B_1 + \sum_{i=2}^{m} p_i \left(B_i - B_{i-1}\right) \tag{8}$$

The variance of the LBM:

$$Var\left(LBM\right) = \sum_{i=1}^{m} \frac{p_i\left(1-p_i\right)\left(B_i - B_{i-1}\right)^2}{N} \tag{9}$$

The relationships between WTP responses and characteristics of respondents in the model are hypothesized in line with the economic theory. Thus, variables of income, education, refuelling costs, age of vehicle, and knowledge of greenhouse gases and global warming are expected to have a positive relationship with WTP amount for biodiesel. The gender and age characteristics cannot be directly assumed to have a positive relation with the amount of WTP. Since there is scepticism involved in expecting which direction the gender and age variable will direct the amount of WTP, predictions are not formulated.

3.4 Data collection

A survey was conducted to measure the WTP for diesel vehicle users and the factors affecting their decisions. The sample included one hundred randomly selected diesel vehicle users from Kandy district. The data collection was conducted face to face through an interviewer administered questionnaire, behind the city centre premises leading to the car park. The reason for selecting this location is that it is the centre of the city and is connected to the two main car parks in the central town: the city centre car park and central market car park. The sampling unit for diesel vehicle users were individuals because in this case the driver or the decision maker is an individual who is deemed to be the economic agent, not the family. Since there is no biodiesel in the market of any kind, the conditions of the study were clearly stated to the respondents to elicit answers with less bias. Two types of WTP questions were asked. First, the respondents were asked whether they would like to pay more for Jatropha biodiesel. For this question respondents had to select either yes or no. A subsequent another question followed, irrespective of their answer to the first WTP question. This question directly asked respondents the price they would be willing to pay for a litre of biodiesel. This was an open question, hence allowing respondents to provide their preferred price. As a result, possibility of a Jatropha biodiesel market had to be explained to the respondents, minimizing the bias, in order to create the surrogate market for biodiesel. Also, more generally, the concept of biodiesel had to be introduced to the respondents. The production and availability of biodiesel and how it can be used in the diesel engine, the modification needed for the engine, mileage comparisons, and the benefits and constraints had to be explained to the respondents. After doing so, respondents were asked whether they would be willing to pay more for a litre of biodiesel compared to the conventional diesel price of Rs. 121 per litre. Once respondents had answered either yes or no, another open question was

posed to determine how much respondents are willing to pay. This is an open question, so respondents were free to indicate any amount. This exercise was particularly time consuming as this was the first study of its kind in Sri Lanka, conducted to elicit WTP for biodiesel using a CVM instrument.

The questionnaire for diesel vehicle users consisted of mainly two parts. The first, consisting of thirteen questions, focused on the socio-economic information of the respondents. Categorical and open-ended questions were included to determine the background information of the respondents. The second part captured the respondents' knowledge of biofuels. Knowledge of Jatropha biodiesel and their WTP for Jatropha oil were included in this section. It also included a series of questions related to the respondents' perceptions of renewable energy development in Sri Lanka, and knowledge of greenhouse gases and global warming.

4. Results

4.1 Sample composition and information

Table 2 describes the summary of the demographic variables of the sampled 100 diesel vehicle users. On average, the respondents were educated above 11^{th} grade in the secondary school level (i.e. Ordinary level). The mean age of the sample is 40 years and the average monthly income is around Rs. 28,500. The range of income was from zero to one hundred thousand Sri Lankan rupees. On average they spent around Rs. 15,885 to refuel their vehicles with diesel, with a range of Rs. 500 to Rs. 270,000 per month. This is mainly due to the presence of respondents who do hiring services and transportation services for the finished and intermediary goods.

Table 3 depicts the level of awareness of renewable energy sources, knowledge of greenhouse gases and climate change and, more specifically, awareness of *Jatropha* biodiesel production. The majority of the respondents have basic knowledge of renewable energy sources and all of them were supportive of the development of renewable energy sources in Sri Lanka. Respondents were more familiar with, and knowledgeable of, climate change phenomena than greenhouse gases. This is plausible as climate change is more often cited in local newspapers in the context of floods and droughts. Knowledge of biofuels and *Jatropha* biodiesel production is limited among the respondents. Diesel vehicle users were asked whether they would pay more for biodiesel than conventional diesel. Seventy-two per cent (72%) of the respondents were not willing to pay a higher price for biodiesel. The majority of the sample responded negatively (72%) and only 28% said they would be willing to pay more for biodiesel above the current conventional diesel price of Rs 121 per ltr. For the open-ended WTP question, 7% of the respondents did not indicate a price. The highest price reported was Rs. 140/litre from one respondent whereas around 9% of the respondents were willing to pay between Rs. 130 to 140 per litre. Around 22% were willing to pay Rs 120/litre and another 16% of them were willing to pay Rs.125/litre. Approximately 4% were willing to pay less than Rs. 90/litre. These figures were used to elicit the non-parametric WTP for biodiesel. The mean WTP for biodiesel by the diesel vehicle users was Rs.109 per litre for lower bound levels. The median WTP was Rs.124 per litre.

Table 2. Summary profile of the diesel vehicle users.

Variable	Category	Per cent (%)	Variable	Category	Per cent (%)
Gender	Male	96	Marital Status	Single	14
	Female	4		Married	86
Education	Below 11th Grade(O/L)	18	Religion	Buddhism	97
	Up to 11th Grade	34		Islam	2
	Up to 13th Grade	36		Christianity	1
	Above Secondary Education	12			
Occupation	Unemployed	5	Household (Size) n=89	2	4
	Farmer	1		3	25
	Government	19		4	23
	Student	2		5	26
	Self employed	50		6	7
	Private	19		7	2
	Other	4		8	2
Times Refuelled	Less than once a month	1	Monthly income (Rs.)	Mean	28,494.68
	Once a month	1		Minimum	0.00
	Once every two weeks	18		Maximum	100,000.00
	Once a week	32		Std. Dev	17,685.802
	More than once a week	48			
Age (years)	Mean	40.09	Refuel cost/month (Rs.)	Mean	15,885.00
	Minimum	19.00		Minimum	500.00
	Maximum	71.00		Maximum	270,000.00
	Std. Dev	11.81		Std. Dev	31640.46

Table 3. Summary of perceptions and awareness of Bio-energy issues.

Variable	Category	Percentage
Knowledge of renewable energy sources	Yes	81%
	No	21%
Development of renewable energy in Sri Lanka	Against	1%
	Supportive	99%
Familiarity with Greenhouse Gases (GHG)	No idea	56 %
	Heard about it	36%
	Know about it	8%
Familiarity with Climate Change	No idea	12%
	Heard about it	64%
	Know about it	24%
Knowledge of Biofuels	Never heard about it	39%
	Have heard about it	32%
	Know what it is	14%
	Know its origin	6%
	Know its benefits	9%
Knowledge of Jatropha Biodiesel Production	Yes	36%
	No	64%

4.2 Regression results for factors affecting WTP for Jatropha biodiesel

According to the probit model, only income, age of the respondent, age of the vehicle and education are significantly affecting the decision to use Jatropha biodiesel. The pseudo R^2 (i.e. McFadden R^2) is around 0.29 (Table 4). It is the measure of proximity of the model to the observed data. This suggests that around 29% of the variation is captured from the model and the rest is misclassified and captured by the error term. Since the probability value for the model is 0.043, at a 5% significance level, the hypothesis that all coefficients are equal to zero is rejected. It is noteworthy to mention that this type of regression using survey data usually yields low R^2 values. When incomes increase respondents are more likely to opt for biodiesel. Older people are less likely to pay for biodiesel. Similarly when education levels increase compared to the primary education level, respondents are less likely to pay more for Jatropha biodiesel as an option for the substitution of conventional diesel. This is evident up to the secondary education level. Beyond that it does not posit a significant relationship. Similarly, with the additional increase in a vehicle's age, people are less likely to opt for biodiesel. This is in contrast

Table 4. Probit Regression results for factors affecting WTP for biodiesel.

DV=WTP(1/0)	Coefficient	p- value	Marginal effect
Age	-0.039*	0.098	-0.010
Gender: *Male*	-0.772	0.446	-0.26
Education (Ref: *Grade V*)			
Upto O/L	-1.710**	0.014	-0.543
Upto A/L	-1.239**	0.043	-0.446
Above A/L	-1.423	0.125	-0.490
Marital Status: *Married*	0.904	0.190	0.174
Occupation (Ref: *Unemployed*)			
Government	0.134	0.894	0.051
Self Employ	-0.923	0.322	-0.266
Other	1.047	0.423	0.3924
Income	0.000027*	0.100	7.16e-06
Refuel cost	7.32e-07	0.950	1.93e-07
Vehicle age	-0.00742*	0.083	-0.002
GHG (Ref: *No idea*)			
Heard	-0.138	0.745	-0.043
Know	0.1242	0.415	-0.170
Climate Change(Ref: *No idea*)			
Heard	-0.138	0.833	-0.036
Know	0.124	0.892	0.036
Constant	2.261	0.205	
Probit regression LR $chi^2(17)$ = 28.14		Prob> chi^2 = 0.043	
Log likelihood = -34.258556		Pseudo R^2 = 0.2911	

**,*Significant at 5% and10% significance level respectively.

with the expectation that owners of brand new vehicles will be hesitant to use biodiesel. This may be due to the fact that brand new vehicles are better at energy conservation; hence people may be showing a preference for biodiesel as a result. Older vehicle users might also have the perception that biodiesel is a new concept and thus it is not applicable to older vehicles. It was expected that perceptions of global warming and climate change might have an impact on decisions, but those variables were not significant, even at a 10% significance level. The regression coefficients and their magnitudes cannot be directly used for interpretation. Thus, marginal effects are used to interpret the outcomes of limited dependent variables. A one year increase in age decreases the likelihood of paying more for biodiesel by 1%. Respondents educated up secondary education level are 54% less likely to pay more for biodiesel than people who have education levels below secondary education level. The latter is the base reference level for education categories. Compared to the reference level, the respondents who are educated up to an advanced level are 44% less likely to pay more for biodiesel than the conventional diesel price. People with an educated higher than the advanced level are 49% less likely to pay more for biodiesel compared to the respondents who are educated below ordinary levels. A one-unit increase in income would increase the likelihood of paying more for biodiesel by a very minimal percentage (0.000716%). People with older vehicles are 0.2% less likely to pay more for biodiesel than people with newer vehicles.

4.3 Nonparametric estimation of WTP

As mentioned in the methodology, nonparametric elicitation of WTP has been used in many studies to avoid the assumption of normality. In short, this is calculated based on the cumulative density changes for each price. LBM for diesel vehicle users is Rs 109.46 per litre. The median WTP was Rs. 124.43 per litre. The Kristrom mean was Rs. 112.42/ litre. Though different mean estimations provide different estimates, they are calculated at different boundaries, viz, lower boundary, middle, and the upper boundary.

5. Discussion

The present study looked at the WTP for biodiesel from Jatropha, a bio-based renewable energy product. It hypothesized, in general, that with higher income and education levels diesel vehicle users would be willing to pay more for biodiesel. Hence, they will be willing to pay a higher price for biodiesel than for conventional diesel. Other variables that were considered to have a positive association with higher WTP for biodiesel were age, awareness on greenhouse gases, awareness of climate change, age of vehicle, and monthly refuelling costs. Gender, marital status and employment levels were not assumed to have an impact on WTP for biodiesel as the directions of associations could be either way for these variables. Though there were significant variables, the outcomes were rather mixed, supporting only a few hypotheses. Interestingly, some variables that were expected to have an effect were not significant. Out of the significant coefficients, age, education, and age of vehicle had a negative association with the WTP for Jatropha biodiesel. Income was also significant, but had a very marginal effect on WTP for biodiesel. About 72% of

the sample was not ready to pay an additional price for biodiesel. Past studies also show a mixed response, but mostly favour a positive WTP. Most of the studies have been focused on Europe and North America (Radics *et al*., 2015). In Anderson (2012) and Petrolia *et al.* (2010), there were positive responses for a premium price for ethanol and blended ethanol, respectively. A sizable number of respondents are willing to pay more for biofuel. Even though consumers did not have a clear picture of the benefits of using them, they still preferred to pay a higher price. This is in contrast to the present study. Though consumers are in favour of paying a premium, their preferences are heterogeneous (Fimereli and Mourato, 2009).

To understand the results of the study, it is essential to understand the background of biodiesel production in Sri Lanka. However, this is not the main objective of this article. Although Sri Lankans are aware of biodiesel, it is not commonly compared to petroleum, hydropower or even electricity. Jatropha biodiesel production is in its infancy in Sri Lanka. Unlike the African nations and other Asian countries that have invested in Jatropha production for biodiesel, Sri Lanka has not made any huge investments. Only a few preliminary studies have been conducted on Jatropha biodiesel production. Furthermore, the Jatropha cultivations that were started with the aegis of non-governmental organisations have not provided promising results up to now. Meanwhile, Jatropha plantations can only be cultivated on non-agricultural lands, to avoid negative impacts on food security. In many households, Jatropha has been used as a fence crop. Initially, it is unlikely to produce sufficient Jatropha oil to be used as biodiesel. But, a blend with certain percentage of Jatropha biodiesel mixed with conventional diesel can be used. Moreover, local production has proven that the oil content of Jatropha seeds is not up to the expectations. Sivashankar *et al.* (2014) show that under local conditions, at status quo, biodiesel production is not economically feasible. Yet they stress that if conditions were to improve, i.e. seed yield increases or biodiesel being sold at higher prices than the conventional diesel price (i.e. Rs. 121 per litre) the venture could become feasible. Herath *et al.* (2008) show that Jatropha cultivation and biodiesel production is financially feasible in Sri Lanka and the by-products can be also sold with a benefit cost ratio of 1.92 and 24% internal rate of return. Jatropha cultivation, oil extraction and biodiesel processing are protected by the government given the tax regime and farmers are better off compared with customers (Sivashankar *et al.* 2014). Although, there is an absence of direct government involvement in Jatropha biodiesel production, through the tariff regime Jatropha farmers and oil processors are literally protected from any foreign substitutes. The main issue is: does Sri Lanka have enough land to cultivate Jatropha? Will it be affordable? At present, it is highly unlikely that Sri Lanka will be able to produce higher levels, but with improved Jatropha varieties such as those used in India, Sri Lanka too can expect to have higher yields. Unlike the African experience, Jatropha is not currently cultivated for any commercial purpose. Consequently, there are no value chains in which stakeholders could potentially intervene.

Given the environmental concerns, it is plausible to understand why consumers are willing to pay for biodiesel. However, any biodiesel product in the market in Sri Lanka is going to be a new product and a new concept. Thus, it would take some more time to materialize the repercussions of biodiesel in a country like Sri Lanka. Studies in other countries have been able to analyse at least a primary level biodiesel production line. Sumisaki and Yabe (2007) study the introduction of bioethanol in rural Japan, which is similar

to this study. There, consumers' WTP is positive, but it is plausible that many diesel vehicle users are not willing to pay a higher price for the new product. Furthermore, vehicles are considered to be costly in Sri Lanka, as is the case in other developing nations. Given these factors, rational consumers would logically hesitate to use any new fuel type, despite its merits. The availability factor is a major issue in transportation. The fuel has to be available in the country and limiting fuel availability only to metropolitan cities would not be enough. With education, people tend to look for more benefits and decision factors when they purchase any good. Open remarks from interviewees collected while the survey was conducted, showed that many educated people and people who have recently purchased a vehicle, or rather who own brand new vehicles, are reluctant to pay a premium for biodiesel. They are comfortable with conventional diesel even if the price is high. They have their own reservations on biofuel usage. Even people with higher education and who work in white-collar jobs have their own scepticism when it comes to biodiesel. In contrast, almost all the respondents are in favour of renewable energy development in Sri Lanka. Though in the questionnaire the pros and cons of biodiesel were clearly mentioned compared to diesel, many people still preferred diesel. On the other hand, less educated people are comfortable with biodiesel as long as its price is kept lower than the price of diesel.

The results of this study are not ground breaking, but posit that further consideration should be given to biodiesel generation. The findings are not sufficient to form any policy implications based on this study alone, especially given the relatively small sample size. Yet, this study has added to the literature on the estimation of demand for biodiesel in developing countries, where there is a lack of demand estimation studies on biodiesel. Since the product is still not available on the market, a surrogate market condition had to be created. Data collection was time consuming in this study, as before asking about Jatropha biodiesel, the benefits had to be explained to questionnaire respondents. Only after that the fuel customers were able to gauge and compare diesel with biodiesel and come up with a WTP amount. This had an impact on the decision to proceed with a fairly small sample size. Besides this, the information burden on the interviewees might have had a non-neutral impact on the interviewee WTP. This is another reason to focus the study on the level of WTP for biodiesel rather than on the real WTP value. Though it was obtained, due to the nature of the product and the biases that cannot be eliminated, it is possible that the real WTP value is misleading. *Inter alia*, non-representativeness of the sample for the entire Sri Lankan population could also have led to distortions in WTP for biodiesel. As Gunatilake (2003) suggests, biases from both the respondents as well as the enumerator could lead to distortions in the respondents' answers. Consequently, only the biases that are under control of the enumerator can be mitigated to a certain extent through proper training and research design as is the case in many contingent valuation studies.

6. Conclusion

The main objective of this research is to assess the willingness of diesel vehicle users in Sri Lanka to pay for Jatropha biodiesel. The factors affecting these decisions were identified. The mean WTP for biodiesel by the diesel vehicle users was Rs. 109 per litre (€ 0.74) for lower bound level. The median WTP was Rs. 124 per litre (€ 0.85). Older respondents with higher education are less likely to pay for biodiesel. Married respondents

with higher income are more likely to pay higher prices for biodiesel. It is recommended to use a larger sample of diesel vehicle users for further studies. Choice card experiments would yield better results as the respondents would have the opportunity to directly see the information and pictures related to biodiesel, while listening to the enumerator's description. However, since the experiences of Jatropha biodiesel production are country specific, any support to major policy changes should take in to account the effect it will have on the overall economy. This could be done using a general equilibrium approach. This study posits that at least before pumping heavy investments into different types of renewable energy sources, there should be substantive consideration given to the acceptance of those technologies. At least, Jatropha can be used for production of other bio-based products that might be feasible. Moreover, the State should consider how Jatropha investments could stabilize the rural economy. In this respect, studies should be conducted to evaluate the possibility of using Jatropha to improve rural livelihoods.

Acknowledgement

The authors acknowledge the support for this study provided by NSF Grant No: RG/2009/Biofuel 002. The authors also acknowledge the anonymous reviewers of this manuscript for their comments aimed at improving the study.

References

Ajzen, I. (1991). The theory of planned behaviour, University of Massachusetts at Amherst, Organizational behaviour and human decision processes 50, pp. 179-211

Ajzen, I. and Fishbein, M. (1988). Theory of reasoned action-Theory of planned behavior. University of South Florida.

Anderson, S.T. (2012). The demand for ethanol as a gasoline substitute. *Journal of Environmental Economics and Management* 63(2): 151-168.

Armitage, C.J. and Conner, M. (2001). Efficacy of the theory of planned behaviour: A meta analytic review. *British Journal of Social Psychology* 40(4): 471-499.

Bhattacharjee, P., Petroia, D.R. and Herndon, W.C. (2008). Estimating Willingness to Pay for E10 fuel: a contingent valuation method. Paper prepared for presentation at the Southern Agricultural Economics Association Annual Meeting, Dallas, Texas, February 2-5, 2008 available at http://ageconsearch.umn.edu/bitstream/6730/2/sp08pe13.pdf. Accessed on 20th December, 2013.

Bishop, R. and Heberlein, T. (1979). Measuring values of extra market goods: are direct measures biased? *American Journal of Agricultural Economics* 61: 926-930.

Comité Européen De Normalisation (CEN) (2014), Bio Based Products, European Committee on Standardization, Available at http://www.cen.eu/work/areas/chemical/biobased/Pages/default.aspx. Accessed on 1st August, 2015

Daigle, J.J., Hrubes, D. and Ajzen, I. (2002). A comparative study of beliefs, attitudes, and values among hunters, wildlife viewers, and other outdoor recreationists. *Human Dimensions and Wildlife* 7: 1-19.

Demirbas, A. (2008). Biofuels sources, biofuel policy, biofuel economy and global biofuel projections. *Energy Conversion and Management* 49: 2106-2116.

ERMA (2007). Accelerating the Development of the Market for Bio-based Products in Europe; report of the taskforce on bio-based products. Composed in preparation of the Communication "A Lead Market Initiative for Europe" {COM(2007) 860 final}, Available at http://www.errma.com/wp-content/uploads/2014/02/Annex-5-prep_bio.pdf. Accessed on 13th February 2016.

European Commission (2012). Commission staff working document accompanying the document "Communication on Innovating for Sustainable Growth: A Bio economy for Europe". Brussels, Available at <http://www.eumonitor.nl/9353000/1/j9vvik7m1c-3gyxp/vix15xjtsrxf>. Accessed on 1st August, 2015.

Farrow, K., Noblet, C., Rubin, J., Teisl, M. and McCoy, S. (2011). Does money grow on trees? People's willingness to pay for cellulosic wood ethanol. INTECH Open Access Publisher.

Fimereli E., Mourato S. (2009). Consumer preferences for bioethanol blends. Paper presented at the 2009 EAERE Summer School, 5th-11th July 2009, Venice. Available at<http://www.feem-web.it/ess/files/fimereli.pdf>. Accessed on 1st August, 2015.

Francis G., Edinger R. and Becker K. (2005). A concept for simultaneous wasteland reclamation, fuel production, and socio-economic development in degraded areas in India: Need, potential and perspectives of *Jatropha* plantations. *Natural Resource Forum* 29: 12-24.

Freeman III, A.M., Herriges, J.A. and Kling, C.L. (2014). The measurement of environmental and resource values: theory and methods. Routledge.

Gracia, A., Barreiro-Hurlé, J. and Pérez, P.L. (2009). Understanding Market potential for biodiesel in Spain: A Pilot study based on consumer preferences. International Association of Agricultural Economists Conference, Beijing, China, August 16-22, 2009.

Gunatilake, H. (2003). Environmental Valuation: Theory and Applications. Postgraduate Institute of Agriculture, University of Peradeniya, Peradeniya, Sri Lanka.

Haab, T.C. and McConnell, K.E. (1997). Referendum Models and Negative Willingness to Pay: Alternative Solutions, *Journal of Environmental Economics and Management* 32(2): 251-270.

Hamilton, J.D. (2011). Historical Oil Shocks. National Bureau of Economic Research, Working paper 16790, Cambridge MA.

Hanemann, W.M. (1984). Welfare Evaluations in Contingent Valuation Experiments with Discrete Responses. *American Journal of Agricultural Economics* 66(3): 332-341.

Herath, M., Weerehewa, J., Pushpakumara, G. and Galagedara, L.W. (2008). Financial feasibility of growing Jatropha for Bio-Diesel production in Sri Lanka. Proceedings of the Second Annual Research Forum, Sri Lanka Agricultural Economics Association, 3rd October, 2008, University of Peradeniya, Sri Lanka

Hossain, A.B.M.S., Salleh, A., Boyce, A.N., Chowdry, P. and Nagiuddin, M. (2008). Biodiesel fuel production from Algae as a Renewable energy. *American Journal of Biochemistry and Biotechnology* 4(3): 250-254.

Huang, J. (2011). Combining Dichotomous choice willingness to pay response and recreation demand data. In: Whitehead, J., T. Haab, and J.C. Huang (eds). Preference Data for Environmental Valuation: Combining Revealed and Stated Approaches. Vol. 31. Routledge, 2011.

Igberaese, T. (2013). The Effect of Oil Dependency on Nigeria's Economic Growth. Institute of Social Studies, The Netherlands, Unpublished master's thesis.

IUFoST (2010). Impacts of Biofuel Production on Food Security. Scientific Information Bulletin (SIB) March. Available at http://r4d.dfid.gov.uk/PDF/Outputs/CABI/Norgrove-Biofuel-FoodSecurity.pdf. Accessed on 13th February, 2016.

Jeanty, P.W. and Hitzhusen, F. (2007). Using Stated Preferences to Estimate the Environmental Benefits of Using Biodiesel Fuel in Diesel Engines, Bio-fuels, Food and Feed Trade-offs. Conference St. Louis, Missouri, April 12-13, Department of Agricultural, Environmental, and Development Economics, The Ohio State University.

Jideani, C., Kennedy-Echetebu, C., Chinweze, C. and Abiola-Oloke, G. (2011). Biofuels and food security: Green economy in sub-Saharan Africa. Available at http://www.unrisd.org/80256B3C005BE6B5/search/D3DDEAB7AC94EDABC125794B00486826?OpenDocument. Accessed on 13th February 2016.

Josling, T., Blandford, D. and Earley, J. (2010). Biofuel and biomass subsidies in the US, EU and Brazil: towards a transparent system of notification. IPC Position Paper, International Food and Agricultural Trade Policy Council, Washington, DC.

Khola, G. and Ghazala, B. (2012). Biodiesel production from Algae, Pakistan *Journal of Botany* 44(1): 379-381.

Kilian, L. and Vigfusson, R.J. (2014). The Role of Oil Price Shocks in Causing U.S. Recessions, Board of Governors of the Federal Reserve System, International Finance Discussion Papers Number 1114, Available on www.federalreserve.gov/pubs/ifdp/. Accessed on 13th February, 2016.

Kristrom, B. (1990). A Non-Parametric Approach to the Estimation of Welfare Measures in Discrete Response Valuation Studies. *Land Economics* 66(May): 135-139.

Lancaster, K. (1971). A new approach to consumer theory. *Journal of Political Economy* 74(2): 132-157.

Li, H., Jenkins-Smith, H., Silva, C.L., Berrens, R.P. and Herron, K.G. (2009). Public support for reducing US reliance on fossil fuels: investigating household willingness-to-pay for energy research and development. *Ecological Economics* 68, 731-742.

Long, J.S. (1997). Regression models for categorical and limited dependent variables. Thousand Oaks, CA: Sage

Marra, A.E. (2010). Classification of Ethanol Consumers and Willingness to Pay for Reductions in Greenhouse Gas Emissions through Purchases of E85."Master's Thesis, University of Tennessee, 2010. Available at http://trace.tennessee.edu/utk_gradthes/819. Accessed on 20th December 2013.

Mittelbach, M. and Remschmidt, C. (2004). Biodiesel: The comprehensive handbook. Vienna: Boersedruck Ges.m.b.H.

Osman, S.S. and Nour, M. (2011). Assessment of the Impact of Oil: Opportunities and Challenges for Economic Development in Sudan. *African Review of Economics and Finance* 2(2): 122-148.

Park, J.B.K., Craggs, R.J. and Shilton, A.N. (2011). Wastewater treatment high rate algal ponds for biofuel production. *Bioresource Technology* 102: 35-42.

Petrolia, D.R., Bhattacharjee, S., Hudson, D. and Herndon, C.W. (2009). Do Americans want ethanol? A comparative contingent-valuation study of willingness to pay for E-10 and E-85. *Energy Economics* 32(1): 121-128. doi: 10.1016/j.eneco.2009.08.004

Pittman, J.K, Dean, A.P, Osundeko, O. (2011). Potentials of sustainable algal biofuel production using waste water resources. *Bio Resource Technology* 102(1): 17-25, Special issue: bio fuels II: Algal biofuels and microbial fuel cells.

Popp, J., Lakner, Z., Harangi-Rákos, M. and Fári, M. (2014). The effect of bioenergy expansion: food, energy, and environment. *Renewable and Sustainable Energy Reviews* 32: 559-578.

Pushpakumara, D.K.N.G., Gunasena, H.P.M. and Singh, V.P. (eds) (2008). Jatropha (*Jatropha curcas L.*): A Potential Biodiesel Crop for Sri Lanka. The World Agroforestry Centre, South Asia Office, New Delhi, India and National Multipurpose Tree Species Research Network of Sri Lanka.

Radics, R., Dasmohapatra, S. and Kelley, S.S. (2015). Systematic review of bioenergy perception studies. *Bioresources* 10(4): 8770-8794.

Razzaghi, M. (2013). The Probit Link Function in Generalized Linear Models for Data Mining Applications. *Journal of Modern Applied Statistical Methods* 12(1): 164-169.

Rodriguez, R.J. and Sanchez, M. (2005). Oil price shocks and real GDP growth: Empirical Evidence for some OECD countries. *Applied Economics* 37(2): 201-228.

Roe, G.L., Giraud, K.L. and Loomis, J.B. (2001). Simple Computational Methods for Measuring the Difference of Empirical Distributions: Application to Internal and External Scope Tests in Contingent Valuation. Staff paper, Department of Agricultural, Resource and Managerial Economics, Cornell University, Ithaca, NY.

Romano, D. (2012). The Bio-based Economy: A new development model. *Bio-based and Applied Economics* 1(3): 231-233.

Ronis, D.L., Yates, J.F. and Kirscht, J.P. (1989). Attitudes, decisions, and habits as determinants of repeated behavior. *Attitude structure and function*, Pratkanis, A.R., Breckler. S.J. and Greenwald, A.G. (eds.), Hillsdale, NJ: Lawrence Erlbaum Associates, pp. 213-239.

Savvanidou, E., Zervas, E. and Tsagarakis, K.P. (2010). Public acceptance of biofuels. *Energy Policy* 38: 3482-3488.

Shrum, L.J., McCarty, J.A. and Lowry, T.M. (1995). Buyer characteristics of the green consumer and their implications for advertising strategy. *Journal of Advertising* 24(2): 71-82.

Sivashankar, P., Weerahewa, J., Pushpakumara, D.K.N.G. and Galagedara, L.W. (2014). An Economic Analysis of Jatropha Bio-Diesel Production in Sri Lanka. Peradeniya University International Research Sessions (iPURSE) 4th-5th July, 2014, Faculty of Science, University of Peradeniya

Solomon, B.D. and Johnson, N.H. (2009). Valuing climate protection through willingness to pay for biomass ethanol. *Ecological Economics* 68: 2137-2144.

Sri Lanka Energy Balance (2010). Sri Lanka Sustainable Energy Authority. Colombo, Sri Lanka.

Steenblik, R. (2007). Subsidies: the distorted economics of biofuels. Discussion paper no. 2007-3, Joint Transport research centre of OECD and International Transport forum, International institute for sustainable development, Geneva, Switzerland.

Sumisaki, S. and Yabe, M. (2007). Valuing the Willingness to pay for the introduction of Bio-ethanol on use of domestic Automobile Fuel. *Journal of Rural Planning Association* 26: 347-352, Special issue.

Sutton, S. (2004). Determinants of health-related behaviours: Theoretical and methodological issues. In: Sutton, S., Baum, A. and Johnston, M. (eds.), The Sage handbook of health psychology, pp. 94-126.

Tenenbaum, D.J. (2008). Food vs. fuel: diversion of crops could cause more hunger. *Environmental health perspectives* 116(6): A254-7.

Tomomatsu, Y. and Swallow, B. (2007). *Jatropha curcas* biodiesel production in Kenya: Economics and potential value chain development for smallholder farmers. Working paper No. 54, Nairobi, World Agroforestry Centre, 33 pp.

Turnbull, B.W. (1976). The Empirical Distribution Function With Arbitrarily Grouped, Censored and Truncated Data. *Journal of the Royal Statistical Society* B38(3): 290-295.

United States Department of Agriculture (USDA) (2006). What are bio based products, Federal Bio based Products Preferred Procurement Program. Available on http://www.dm.usda.gov/procurement/programs/biobased/awarenessbrochure_may2006.pdf. Accessed on 1st August, 2015

Vaughan, W.J. and Rodriguez, D.J. (2001). Obtaining Welfare Bounds in Discrete-Response Valuation Studies: Comment. *Land Economics* 77(3): 457-465.

Viaggi, D., Mantino, F., Mazzocchi, M., Moro, D. and Stefani, G. (2012). From Agricultural to Bio-based Economics? Context, State of the Art and Challenges. *Bio-based and Applied Economics* 1(1): 3-11.

World Bank (2010). Analysis of the Scope of Energy Subsidies and Suggestions for the G-20 Initiative. Washington D.C.: The World Bank. Available at http://documents.worldbank.org/curated/en/2010/06/17457082/analysis-scope-energy-subsidies-suggestions-g-20-initiative. Accessed on 13th February, 2016.