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Abstract

Frankincense from Boswellia papyrifera forest (BPF) is a traded commodity used in the pharmaceutical, food, cosmetic and chemical industries. Ethiopia is an important producer of frankincense, but the resource is under continuous degradation and requires conservation. We applied a contingent valuation to assess rural households’ willingness to pay (WTP) and willingness to contribute labor (WTCL) for BPF conservation. Next to the bid, WTP is influenced most by income, education, and WTCL by family labor and gender of the household head. A household is willing to pay at least US$ 4.86 or contribute 7.17 labor days per year, which amounts to US$ 6.64 at per capita daily income. This suggests using per capita daily income rather than market wage rates could result in convergence in response asymmetry of labor and cash payment vehicles. The potential local demand for conservation of BPF could be mobilized effectively with complementary policy interventions aimed at sustainable use and poverty reduction.

Key Words: Willingness to pay; Boswellia papyrifera; Forest conservation; Contingent valuation

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1. Introduction

*Boswellia papyrifera* (Del.) Hochst is an important tree species and grows in the Sudanian and Sahelian regions of Africa (White, 1983). The tree has the ability to grow on shallow or very stony soils and has a high ecological importance for combating desertification (Stiles, 1988). Frankincense from this tree is used as input in the pharmaceutical sector (Michie and Cooper, 1991; Schillaci et al., 2008), in the food, perfume and cosmetics industries (Tucker, 1986), and as a traditional medicine (FAO, 1995). It is widely used for rituals in different religions (Coulter, 1987; Farah, 1994; FAO, 1995; Lemenih et al., 2003) and as a fragrance during coffee ceremonies in Ethiopia. Moreover, it is an income source to rural people and the country gets foreign currency from export. According to data from the Central Statistical Authority (CSA) of Ethiopia, the country exported 14,978 tons of resins (Frankincense, Myrrh, and Gum Arabic) over the period 2003-2007 and earned US$ 21.53 Million.

Although the export sector in Ethiopia accounts for a small share of GDP (13.6%), primary commodities account for 90% of the total export earnings of the country (World Bank, 2010). Exploiting local comparative advantages may lead to increases in primary product exports but also in more environmental degradation (Rock, 1996; Muradian and Martinez-Alier, 2001). In case of forest resources, a number of studies argued that trade in non-timber forest products can promote conservation and the sustainable management of tropical forests while improving rural livelihoods (Belcher and Schreckenberg, 2007). However, it often involves overuse and extreme degradation of forest resources (Arnold and Pérez 2001) mainly in the case of open access forests. Literature on international trade based on the comparative advantage of developing countries from their natural resource endowments also gives insight on how trade in renewable resources from open access resources could lead to overexploitation of the resource and to a loss of social welfare (Azqueta and Sotelsek, 1999).

Forest resources in Ethiopia are state properties. However, there is no policy for the sustainable extraction of resins from the forest. Both technical expertise and skilled labor in the forestry sector are limited in the country at large. Therefore, we can reasonably consider the resource as ‘open access’ despite it is legally state property and see how profit maximizing private firms behave. Given the fact that the international market for primary products is nearly competitive, private firms could maximize their profit by minimizing the private (financial) costs of extracting the resource. Moreover, the critical shortage of foreign exchange and balance of payments problems also force the government to adopt a number of incentive mechanisms to promote the export sector and hence the commercial exploitation of the resource. Prior to 1991 the state-owned Ethiopian Natural Gums and Resins Marketing Enterprise was the only company in the country exporting oleo-gum resins to the international market. According to CSA data, the average annual export of the company over the period 1978-1991 was about 750 tons. Following the post-1991 market based economic policy that allowed the participation of private companies into the business, the country’s export volume of oleo-gum resins increased to 2000 tons per year in the period 1996-2003, and reached to about 3000 tons per year over the period 2003-2007. Ethiopia exported
4,533 tons in 2007 alone to 27 different countries around the world with China, United Arab Emirates, Germany, France and Greece importing 64% of the total.

Although the opening of the market generated more revenue to the country, it is hardly improving the poverty situation of particularly the rural households living around these woodland forests. On the supply side, the low cost of tapping the resource implies low income to rural households who are mostly in the beginning of the market channel and receive low wages for the labor they supply for tapping the resource. They will not have an incentive to maintain the resource as a forestland and will go for shifting cultivation to meet immediate subsistence needs. In effect, the deforestation and degradation of the resource leads to the emission of carbon dioxide into the atmosphere as well as desertification. For example, Lemenih and Itanna (2004) reported annual soil carbon loss rate of up to 3%, which is equivalent 25.82 tons of CO₂ emissions per ha per year, mainly due to the conversion of the natural vegetations to arable land in the southern highlands of Ethiopia. Moreover, oleo-gum resins are important inputs in pharmaceutical industries. Degradation of the resource also implies a negative effect on the services it will provide to research and development in the pharmaceuticals and other sectors, mainly in the importing countries. The international market price for these primary products does not take into account these negative externalities. The public good nature of the resource has contributed to a continuous degradation and has led to this ‘tragedy of the commons’ and a number of studies reported lack of regeneration and continuous degradation of the resource in East Africa (Ogbazghi et al., 2006; Negussie et al., 2008). TRAFFIC (the wildlife trade monitoring program of WWF) has reported *Boswellia papyrifera* as endangered species that needs priority in conservation (Marshal, 1998). Therefore, local, national and international solutions are required for conservation and sustainable use of the resource.

The general objective of this study is to assess rural households’ demand for conserving *Boswellia papyrifera* as a potential local solution and draw some policy measures required at national and international levels for the conservation and sustainable management of the resource. Thus, we hypothesize that despite poverty, people in rural areas are aware of the importance of conserving the resource. They are typically income poor but labor abundant. Therefore, they might not be able to pay cash for resource conservation, but they might be more willing to contribute labor. Hence, we assessed the demand for conservation in terms of their willingness to contribute cash and labor for *Boswellia papyrifera* forest (BPF) conservation. In addition, this paper identifies the factors affecting the willingness to contribute and compares the asymmetry in WTP and WTCL using the market wage, the minimum wage and the per capita daily income for converting WTCL into monetary values. Our study is the first to apply both cash and labor for eliciting rural households’ demand for *Boswellia papyrifera* forest conservation.

### 2. Value to be estimated and the Contingent Valuation method

A review of the environmental economics literature suggests that the total economic value of a resource is the sum of its use, option, existence and bequest values (Campbell and Luckert, 2002). Frankincense of *Boswellia papyrifera* is used as industrial raw material (Michie and Cooper, 1991; Schillaci et al., 2008; Tucker, 1986) and leaves of the tree have high nutritive value as livestock feed (Melaku et al., 2010). These direct uses can be
valued using market-based methods. In addition, the resource has non-market benefits. With uncertainty about future demand, there may be an interest to keep the resource as an option for future use. Given the current trend of degradation, people are concerned about the possibility of extinction and one would get utility from contributing for its conservation and improving the welfare of future generations.

Contingent valuation (CV) methods have received increasing attention as a means to estimate option and existence values. Money is the conventional unit of account of value used in CV questions. In Ethiopia where 39% of the population lives below a per capita income of US$ 1.25 a day (World Bank, 2010), household incomes are often inadequate to meet the basic needs and asking only WTP from their income may not fully capture households’ valuation of environmental amenities and hence their demand for such services. Considering this fact, there are a few studies in developing countries (Swallow and Woudyalew, 1994; Echessah et al., 1997; Kamuanga et al., 2001; Hung et al., 2007) that applied both labor and cash for eliciting willingness to pay for tsetse fly control and prevention of forest fires. These studies found out that relatively more households were willing to contribute for such public amenities in terms of labor than cash. Liquidity (cash) constraints (Vondolia, 2011) and low valuation of time (Ecom and Larson, 2006) are suggested as reasons for rural households’ preferences to contribute more in labor than cash terms for the provision of the public amenities.

Many CV studies rely on a single bound dichotomous choice (SBDC) approach that asks respondents whether they would accept a randomly assigned predetermined single bid amount. However, this method can be statistically very inefficient and requires a large sample to attain a given level of precision (Cameron and Quiggin, 1994). A double-bounded dichotomous choice (DBDC) approach in which the respondent is asked a follow-up question if s/he would pay a higher or lower bid depending on the response to the initial bid (Hanemann et al., 1991) is often used to improve the efficiency of the SBDC model, and it is applied to this study.

3. **Survey design and data collection**

3.1 **Study area and sample selection**

To assess households’ demand for BPF conservation, a CV survey was conducted in the frankincense producing districts of central and western Tigray in Northern Ethiopia. In most BPF areas, the local people were not directly benefiting much from the resource because they lack the skill of tapping frankincense. Mostly young migrant workers from the highlands of Tigray have been practicing the tapping of frankincense. Rural people, mainly in the study site in western Tigray, consider the frankincense tapping activity as an inferior and culturally unacceptable job. The same problem has been reported by Lemenih et al. (2007) as constraint for smallholder farm households to participate in frankincense production in the Metema district of north-western Ethiopia. However, in the last few years, some of the local people, including the settlers who have come to the areas in 2002, are starting to generate income from frankincense, as they became member of local frankincense cooperatives. In order to assess whether there is a difference between users and non-users of the resource in terms of their demand for BPF conservation, five rural communities (Figure 1) were selected based on the availability of rural cooperative firms engaged in frankincense extraction and trading and/or households engaged in frankincense tapping. Lists of household heads obtained from the local administrations were used as a
sampling frame. According to these data, 30.6% of the households are users of the resource either as shareholders in the local frankincense cooperative firms and/or as frankincense tappers. Based on this, the sampling frame was stratified into users and non-users and the proportion of samples from each group was determined accordingly. Next, a random selection of households from each stratum was made, which ended up with a total sample of 520 households of which 159 are users of PBF as a whole either as frankincense tapper, cooperative members, users of the leaf as livestock feed, or both.

Figure 1

3.2 Survey structure
According to CV experts, it is important to provide respondents with adequate and accurate information to make them fully aware of the hypothetical market situation and arrive at correct WTP measures. Therefore, we designed a survey with four major parts (Figure 2). The first part describes the uses of the resource, its state of degradation, the need for conservation and its three purposes. Following the verbal description, households were shown three photographs of *Boswellia* stands taken from two of the villages of the study area. In order to test for the influence of being a user or non-user of the resource on their demand for the planned conservation, questions related to whether the household has been getting income from frankincense as a tapper and/or cooperative member, and whether it has used the leaves of the tree as livestock fodder were posed.

Figure 2

The second part obtains information about the need for financial and labor contributions to conserve the resource and discusses the payment method and the need for participation of enough volunteers for achieving the goals. The cash contributions will be in the form of an annual tax to the local government whereas the annual labor contribution is as a guard for patrolling the conservation site. This guard will be controlling free grazing, cutting of trees, shifting cultivation practices and tapping of frankincense. The third part starts with asking the households about their income and expenditure, the total labor time they require for farming, other household activities as well as community works. This section then continues with the actual valuation questions. The last part inquires about the household’s socio-economic variables.

3.3 Survey pre-test and bid design
We conducted a pretest survey on a sample of 50 randomly chosen households to design bid levels for the final survey and test the questionnaire. In discrete choice CV, welfare estimates could be sensitive to specification and size of the starting bid amounts (Cooper and Loomis, 1992) and different authors (Boyle et al., 1988; Cooper, 1993; Alberini, 1995) proposed a number of methods for designing bids. We used Boyle et al.’s method in which WTP data from open-ended questions are used to set the initial bid amount. We determined the follow-up bids by doubling and halving the initial bids respectively (Table I). After incorporating the findings of the pretest survey, determining the bid levels and random assignment of bids to sample households, interviewers were trained and the final face-to-face survey was conducted in March 2009.
4. Model specification for measuring WTP and WTCL

4.1. Random utility theory and contingent valuation

The analysis of respondents’ choice is based on the random utility model (McFadden, 1974; Hanemann, 1984) in which utility (U) arising from a “Yes” or “No” response to a contingent valuation question is comprised of a deterministic (V), observable component and a random (ε), unobservable component:

\[ U_i = V_i + \varepsilon_i \quad (1) \]

If the household answers ‘Yes’ it receives the public good (BPF conservation program) and its income is reduced by the amount of the bid. The index i reflects the alternatives Yes (i=1) and No (i=0). The dichotomous choice elicitation model relies on the assumption that households maximize their utility function. In this case, utility is assumed to arise from income (m), the presence of a BPF conservation program and other socio-economic characteristics. The \( j^{th} \) household will accept the randomly assigned initial bid only under the following condition (Hanemann, 1984):

\[ v_{1j}(m_j - t_{1j}; S_{1j}; B_1) + \varepsilon_{1j} \geq v_{0j}(m_j; S_j; B_0) + \varepsilon_{0j} \quad (2) \]

where, \( v_{ij} \) is the indirect utility in a state of BPF conservation \( B_i \) and \( v_{0j} \) is the indirect utility in the status quo \( B_0 \). \( B_1 \) is higher than \( B_0 \), indicating higher non-market benefits from the forest in a state of conservation than the status quo. The variable \( m_j \) is income if the bid, \( t_j \), is in cash whereas \( m_j \) is leisure if the bid is in terms of labor. \( S_j \) captures other socio-economic variables. \( \varepsilon_{1j} \) and \( \varepsilon_{0j} \) are the identically, independently distributed random variables with zero means.

The \( j^{th} \) household will say ‘Yes’ to the valuation question if the condition in equation (2) is satisfied and the probability of a yes response will be:

\[
P(yes) = P(v_{1j}(m_j - t_{1j}; S_{1j}; B_1) + \varepsilon_{1j} > v_{0j}(m_j; S_j; B_0) + \varepsilon_{0j})
= P(v_{1j}(m_j - t_{1j}; S_{1j}; B_1) - v_{0j}(m_j; S_j; B_0) > \varepsilon_{1j} - \varepsilon_{0j})
= F_{\eta}(\Delta v)
\]

(3)

with \( \eta = \varepsilon_{0j} - \varepsilon_{1j} \), \( \Delta v = v_{1j} - v_{0j} \), and \( F_{\eta}(\Delta v) \) as the cumulative distribution function of \( \eta \). If the indirect utility, \( (v) \) is assumed to be linear and depends upon income and socio-economic characteristics when the bid is in cash, or alternatively, on leisure and socio-economic characteristics when the bid is labor, then \( v_j \) can be defined with and without the BPF conservation program and the utility difference can be expressed as follows:

\[
v_{1j} = \alpha_1 + \beta(m_j - t_{1j})
\]

\[
v_{0j} = \alpha_0 + \beta(m_j)
\]

\[
\Delta v = (\alpha_1 - \alpha_0) - \beta t_{1j}
\]

(4)

where the vector \( S_j \) with the socio-economic variables is suppressed. The probability of a Yes response becomes:

\[
P(yes) = F_{\eta}(\alpha - \beta t_{1j})
\]

(5)

where \( \alpha = \alpha_1 - \alpha_0 \). If a normal distribution for \( \eta \), the difference in the error terms, is assumed, then the probability to say Yes becomes

\[
P(yes) = \Phi(\alpha - \beta t_{1j})
\]

(6)

Table I
where \( \Phi \) is the normal cumulative distribution function, \( \beta \) is the parameter estimate of the bid amount and \( \alpha \) is either the estimated constant (if no other explanatory variables are included in the equation) or the “grand” constant which is computed as the sum of the estimated constant plus the product of the other explanatory variables times their mean (Holmes et al., 2004).

Welfare estimates in the form of compensating surplus can be derived and when the bid results in a single change in a policy option, the welfare estimate reduces to (Christie et al., 2004):

\[
CV = \frac{1}{\beta_t} (v_1 - v_0)
\]  

(7)

where \( \beta_t \) is the estimate of the marginal utility of money if the bid is expressed in cash or the marginal utility of labor if the bid is expressed in labor contributions. Following Hanneman (1984) who advocated the use of median WTP as a measure of economic welfare, the median WTP was computed from the parameter estimates in equation 5 as \( WTP^{\text{median}} = \alpha / \beta \).

While most empirical studies that used SBDC data assumed a logistic distribution of the difference in error term and use the logit model for its simplicity to compute, this study assumed normality of the difference in the error terms since aims to model each household’s two discrete responses jointly using a bivariate normal probability density function. This function allows testing for a non-zero correlation between initial and follow-up responses, whereas the standard logistic distribution does not (Cameron and Quiggin, 1994). The hypotheses that the follow-up response is independent of the initial response \( (H_0^I: \rho = 0, \ H_1^I: \rho \neq 0) \) can be tested using the likelihood ratio test. A restricted version of the bivariate probit model (i.e., if initial and follow-up responses are assumed to be motivated by same latent WTP value, observed differences are due to randomness in the WTP distribution, and the correlation coefficient \( \rho = 1 \)) leads to a double-bound interval data probit model (Hanemann et al., 1991). The hypotheses that the two stochastic valuation functions of the bivariate probit model have identical distributions of error terms \( (H_0^S: \rho = 1, \ H_1^S: \rho \neq 1) \) so that they are agreeable to the DB probit analysis can also be tested using the likelihood ratio test.

4.2. Empirical specification

The binary choice model in equation (6) can be estimated using a probit model with the following specification:

\[
Pr_j(Yes) = \Phi(\mu_0 + \beta t_j + \delta m_j + \gamma S_j + \lambda r_j)
\]  

(8)

where \( t_j \) is the bid amount, \( m_j \) is the household income for a bid in cash or leisure for a bid in labor, \( S_j \) is a vector of variables measuring household socio-economic characteristics, \( r_j \) is a vector of regional dummy variables. \( \beta, \delta, \gamma, \) and \( \lambda \) are vectors of parameters related to respectively the bid, household income or leisure, socio-economic characteristics and regional dummies.

The dependent variable in equation (8) is a binary variable taking the values of 0 or 1 depending on the response to the randomly assigned predetermined bid levels. LogINC, AGE, EDU, GENDER, and LABOR are the variables designed to capture the sample households’ socio-economic background (Table II). Income refers to
annual income from crop and livestock production plus off-farm income after deducting costs. Age, education and gender refer to the household head, while labor refers to the amount of labor available in the household. Most of these variables have shown significant predictability in other related studies (Swallow and Woudyalew, 1994; Echessah et al., 1997; Kamuanga et al., 2001; Gürlük, 2006; Hung et al., 2007).

A positive impact of LogINC on the likelihood to say yes to the contingent valuation question has been expected. This is because economic theory tells us that conservation is like a normal good, for which peoples’ demand increase with income. Unlike logINC, however, the study has no ex ante expectations in terms of whether AGE and GENDER have a positive or negative impact on the likelihood to accept the bid levels. Higher level of education would imply higher awareness and concern for degradation of natural resources, which should result in higher WTP and WTCL. A large amount of family labor in a household would also imply a higher level of WTCL, because they are more likely to have relatively more labor in excess of farming and other activities compared to households with a small amount of family labor.

The dummy variable RESID is expected to have a positive impact on the likelihood to accept the bid levels in both the WTP and WTCL. This was with the anticipation that those who have been living longer in the area would be more concerned with the existing state of degradation than the newcomers, who are in fact contributing to the degradation of the resource in the course of the resettlement. The variable USER is expected to have a positive impact on the likelihood to say yes for the valuation questions of WTP and WTCL. Because the RESID variable was highly correlated with the age and education level of the household head, the interaction term EduRESID and AgeRESID are included in the model to capture the pure EDU and pure RESID as well as the pure AGE and pure RESID effects on the response variable. Dummies for each villages were included to capture village fixed effects like differences in natural resource endowments and off-farm employment opportunities that could affect household income and hence WTP and WTCL.

4.3. Data calibration
A standard procedure in contingent valuation studies requires identifying and reporting protest responses (Meyerhoff and Liebe, 2010). Before using the data for statistical analysis, it was first calibrated by dropping protest responses. In the CV literature, reasons other than financial constraints and the good having no value to the household are protest responses (Labao et al., 2008). In the WTP bidding, 35 households (6.7%) answered no/no. Among these, 16 (3.1%) replied that they have some interest in the conservation but would not pay anything to join the program. These could be free riders and classified as protest responses. In case of WTCL bidding, there were 51 ‘no/no’ (9.8 %) of which 38 (7.3 %) were protest responses. From the total protest responses of both biddings, 7 households answered ‘no/no’ to both biddings, 9 households only to the WTP bidding, and 31 households only to the WTCL bidding. Therefore, 47 households respond ‘no/no’ at least to one of the biddings. Therefore, in order to see the effect of each covariate on WTP and WTCL using the same sample, they were considered as protest responses. After the protest screening, 473 households were left for statistical analysis. Further calibration of the data was made using the asymmetric uncertainty model (Champ et al., 1997) to correct for potential hypothetical bias. Households who replied yes/yes, yes/no and no/yes to initial and follow-up bids were asked how certain they were in making the payment. A ten-point scale with 1 as ‘Very
uncertain’ and 10 as ‘Very certain’ was used and all yes/yes, yes/no and no/yes responses were calibrated to no/no responses if the household selected certainty scores 1 to 9. Accordingly, responses of 181 households in the WTP and 158 households in the WTCL were classified as ‘no/no’ responses.

To estimate equation (8), four econometric models for each of the WTP and WTCL responses were developed based on the empirical data (Tables III and IV). These models include: two single-bounded dichotomous choice (SBDC1) models (Models I and V) for the initial response on the WTP and WTCL questions, two SBDC2 models for the follow-up response (Models II and VI), two bivariate probit models (Models III and VII), and two double-bounded interval data probit models (Models IV and VIII).

Table II

5. Results

5.1. Households’ knowledge and attitude
The survey showed that a majority of the households (68.7%) had previous knowledge about at least most of the uses of the forest, which include the different uses of frankincense (for rituals, as fragrance in coffee sermonizes, as a raw material for making medicine, perfume, food flavors, as source of foreign currency and rural off-farm income source), uses of the wood (for construction of house and fences, and for fuel wood), leaves for livestock feed, flowers as a forage for bee keeping, and the environmental uses of the forest (climate regulation services, protection of soil erosion and desertification, and as home for wildlife). A little more than a quarter (28.5%) reported that they had previous knowledge about few of the above uses but were able to learn more from the interview and understood all uses very well. Almost all (99.2%) reported that they would prefer to transfer the BPF areas in their village to their grandchildren in good state. All households reported that they are concerned about the deforestation and the risk of extinction of which the majority (66.4%) are very concerned. To elicit households’ attitudes on the conservation goals, they were asked to state their interest on a scale from 1 to 10, with 10 as ‘Very interested’ and 1 as ‘Not at all interested’. Nearly one-third (65.0%) attributed an option value for the resource as they were very interested in keeping it as an option of meeting future demands. Almost the same proportion (66.0%) recognized an existence value for the resource, as they were very interested in realizing its existence and curbing the possibility of its extinction. The majority (72.7%) observed a bequest value for the resource, as they were very interested in conserving it for improving the welfare of future generations. No household selected scale 1 in any question implying that all households attributed option, existence and bequest values for BPF with different degrees of interest. A majority (72.1%) were very much interested in the overall conservation policy.

5.2. Parameter estimates of WTP and WTCL
The BID term is statistically significant at 1% for all the models and has the expected negative sign consistent with the theory of demand. This indicates that, in the case of both WTP and WTCL, the higher the BID price for
the BPF conservation, the less likely households would be willing to pay and contribute labor respectively. The variable LogINC has the expected positive sign and is significant for all the WTP models. This implies that the probability of accepting a higher bid increases with income. In other words, conservation is like a normal good to the rural households for which their demand increases with an increase in income. In the case of the WTCL models, the coefficient of LABOR is positive as expected indicating that the larger the number of family members in the productive age group, the higher the probability of accepting a higher bid. Soil and water conservation works have been common practices in Tigray for which rural households make free labor contributions every year.

GENDER is positive for all the models and significant at 5% for model VI and at 10% for models I, V and VII. This indicates that the likelihood to accept higher bids mainly in terms of labor is higher for male-headed households than female-headed households. AGE has a negative sign for all models of WTCL, but only significant at 10% for model VII. This implies that the older the household head the lower the probability of accepting higher bids in terms of labor. The variable RESID has no significant impact on WTCL, but the interaction term AgeRESID has a positive sign and is significantly different from zero in all WTCL models. Chi²-test results (0.58, p=0.447 for model V; 0.12, p=0.724 for model VI; 0.41, p=0.521 for model VII; and 0.50, p=0.478 for model VIII) revealed that the sum of the coefficients of AGE and AgeRESID is not significantly different from zero. This implies that older households who immigrated into the community as settlers after 2002 are less likely to accept a higher bid than older household heads who have been already living in the community before 2002. This might be because the older households who have been living in the areas for a long time have also been observing the degradation of the resource relatively for a long time than the older settlers who have come to the areas. This might have created a difference in their understanding of the problem and hence difference in their WTCL.

EDU has the expected positive sign for all models, but is only significant at 10% for models I and IV. This implies that the higher the level of education of the household head, the higher the probability of accepting higher bids in cash. The interaction term EduRESID has a negative sign in all WTP models and is significantly different from zero in models I, III and IV. Chi² -test results (0.41, p=0.523 for model I; 0.40, p=0.527 for model III; and 0.25, p=0.615 for model IV) revealed that the sum of the coefficients of EDU and EduRESID is not significantly different from zero. This implies that higher educated households who migrated into the community as settlers after 2002 are more likely to accept a higher bid, while this does not hold for higher educated household heads who were already living in the community before the resettlement in 2002. This might be because severe environmental degradation at the origin is one of the main push factors for the migration of the settlers and they have had experience with the negative consequences of environmental degradation on their livelihood. Therefore, higher educated households who migrated into the community would be more willing to contribute for the conservation compared to earlier residents with a higher level of education for they have been living in a relatively better environment, and at least were not displaced due to environmental degradation. USER is negative for all the models except models II and III and insignificant in all the models indicating no difference in the probability of accepting higher bids between user and non-user households.
In both the WTP and WTCL models, the coefficient on the bid term in the follow-up response model (model II and VI) is much lower in absolute value than the coefficient of the bid term in the initial response model (model I and V). As a result, the spread parameter, which is the inverse of the negative of the coefficient on the bid term, of the follow-up response probit model is higher (by 228.59% in the WTP models and 152.04% higher in the WTCL models) than the spread term of the initial response probit model. This indicates that if distinct valuation functions to each response were fit, the follow-up response is much ‘noisier’ than the initial. This may be due to the presence of some strategic responses in the follow-up. The likelihood ratio test result (Chi² = 79.78; p = 4.19E-19 for model I Vs II) for the WTP models confirms this fact and shows that the restriction that the follow-up response (model II) is independent of the initial response (model I) is not valid and hence is rejected. Similar results were found for the WTCL models (Chi² = 49.55; p = 1.94E-12 for model V versus VI). The statistical significance of the correlation coefficients for models V and VII also confirm these outcomes.

The hypothesis H₀: ρ=1 cannot be rejected both in the case of the WTP models (Chi² = -179.78; p = 1 for models III Vs IV) and the WTCL models (Chi² = -231.97; p = 1 for models VII versus VIII) suggesting the DB models would lead to more efficient estimates of WTP and WTCL than the bivariate models. Nevertheless, the results suggest that the SBDC models I and II have high predictive power and statistical reliability. The percentage of correct prediction in these models is reasonably high.

In all model of WTP and models VI and VII of WTCL, the median values are within the 95% confidence interval of the mean implying no statistically significant difference between mean and median values. In the case of both median and mean values of WTP and WTCL, the SB models give higher estimates than the DB models and the differences are statistically significant.

### 5.3. Robustness tests

In order to check the robustness of our results, some robustness tests were made. First, household income was treated as endogenous anticipating unobservable factors affecting a respondent’s discrete choice response for the WTP questions may also affect household income. The IV-Probit (Probit model with endogenous repressors) was applied to solve the possible problem of endogeneity of income using DEPEND, LABOR, LAND and DisAWRoad as instrumental variables. These variables do not directly affect WTP, but indirectly through their effect on income. The correlation of each of these variables with the error term of equation 9 is statistically insignificant (r = -0.0060, p < 0.897 for DEPEND; r = -0.0095, p < 0.837 for LABOR; r = 0.0037, p < 0.936 for LAND; and r = 0.0144, p < 0.754 for distance to all weather roads). LAND, LABOR, and DEPEND are important inputs in agricultural production and hence affect income positively. DisAWRoad captures access to lower prices in the agricultural input markets and higher prices for the output markets, which have both a positive effect on household income. All of these variables have statistically significant correlations (all at p < 0.001) with log transformed household income (r = 0.1576 for DEPEND; r = 0.1474 for LABOR; r = 0.3523 for LAND; and r = -0.3658 for DisAWRoad).
In the IV Probit model no evidence of endogeneity of logINC was found ($\rho = 0.076$, chi2 = 0.696). All the coefficient estimates of the model are almost similar, in both magnitude and significance, to those in Model I. To see a potential multicollinearity problem due to the inclusion of logINC together with variables capturing the household characteristics, a probit model in which income is excluded was applied (SBDC1a). This resulted in more number of significant variables compared to model I. Therefore, in order to investigate causality and disentangle the effect of household characteristics on the one hand and income on the other, the following two-stage procedure was implemented. In the first stage, a regression of logINC on some household characteristics was done. Next, the residuals were saved under the variable $log\text{INCcorr}$. This variable is by construction orthogonal to the household characteristics. In a second stage, the SBDC1b of the form displayed in Table V was rerun, but logINC was replaced with $log\text{INCcorr}$. The coefficient estimates of income in model I of Table III and that of $log\text{INCcorr}$ in the SBDC1b in Table V are almost the same. Moreover, the confidence intervals for each corresponding coefficient estimates of model SBDC1b model I overlap each other implying no statistically significant differences. This is also evidence that WTP does not merely depend on household characteristics, which are also affecting income and attitude towards conservation of the BPF, but that the WTP for BFP conservation is strongly dependent on the financial means of the household as such.

6. Discussion

The aim of this research was to assess rural households’ demand for *Boswellia papyrifera* forest conservation and identify the factors determining their willingness to pay and willingness to contribute labor. For this, a contingent market situation in which the benefits include option, existence and bequest values of the resource was designed. The results give insight about these values of the resource for the rural population and their demand for conserving the resource. Almost all respondents attributed option, existence and bequest values for the resource and the majority (72%) were very much interested in conserving *Boswellia papyrifera* forest in their villages.

The study shows that the face-to-face contingent valuation survey worked well as revealed in terms of high survey response rate (100%) and low protest rates (3.1% for WTP and 7.3% for the WTCL responses). The protest rates are considerably lower than the protest rates for most contingent valuation surveys in developed countries. Meyerhoff and Liebe (2010) did a meta-analysis of 254 samples from stated preference surveys of environmental valuation, and reported mean a protest rate of 14.19% for 15 studies for which forest resources are the subject of the valuation, and mean of 17.97% protest rate for 108 studies with dichotomous choice format. Hung et al. (2007) also found a very low (3%) protest rate for forest fire prevention in Vietnam compared to related studies in developed countries.

All the probit regression analyses revealed that the probability of a ‘Yes’ response to the willingness to pay and willingness to contribute labor biddings vary with a number of covariates in a reasonable and expected manner,
thereby offering some support for the construct validity of our contingent valuation applications. The variables bid, log-transformed income, education, and the interaction of education and residence length were found as the most important factors affecting willingness to pay. The variables bid, labor, gender, and the interaction term of age and residence length are the most important factors affecting willingness to contribute labor. The results of the statistical tests for independence of initial and follow-up responses as well as on the correlation of error terms of the bivariate probit models indicated that the double-bounded model gives more efficient estimates than the single-bounded model and this result is consistent with the findings of Hanemann et al. (1991).

The monetary value of lower bound mean willingness to contribute labor (7.17 days per household per year) at the market wage rate was 23.34 USD with 99% confidence interval of 22.21 to 24.46 USD which implies a very large asymmetry with the lower bound mean willingness to pay in cash (4.86 USD per household per year). Similar result was found for the upper bound mean willingness to contribute labor. Results from previous studies (Swallow and Woudyalew, 1994; Echessah et al., 1997; Kamuanga et al., 2001; Hung et al., 2007) that used labor and cash contributions for eliciting willingness to pay for natural resource management interventions with benefits of public good character indicated that respondents were willing to contribute more in labor than in money. Specifically Echessah et al. (1997) found higher mean willingness to pay in labor converted at the market wage rate for casual labor than the mean willingness to pay in cash for tsetse fly control in Ethiopia. Eom and Larson (2006) suggest that higher willingness to pay in terms of non-monetary payment vehicles than the monetary payment could be linked to low valuation of time and hypothetical bias. Another reason could be that liquidity constraints could force respondents to pay more in terms of labor than cash, which is a reflection of market imperfections restricting substitution among different resource endowments (Vondolia, 2011). Hung et al. (2007) argue that higher willingness to pay in labor may be due to prior experience of such payments.

It would be correct to value labor contributions at the market and/or minimum wage rates in case the government intends to implement such a program for the fact that these rates are what it would have paid. However, converting labor contributions at the market wage and/or minimum wage may bias our conclusion for the following reasons at least in the context of households characterized by subsistence farming. First, the market for daily labor is imperfect with few employers than the supply in which rural households will not have perfect employment opportunity. Therefore, in making decisions on the labor amount they want to contribute it is less likely that they will compare it with the market wage as opportunity cost of their decision. Secondly, there is no minimum wage rule in most developing countries, including Ethiopia, as it is in the developed world. If it does exist, rural households may not know how much this minimum wage is and use it to calculate the opportunity cost their choices on the amount of labor they would like to contribute for the contingent market. Third, in the contingent valuation survey with money as payment vehicle respondents are reminded to take into account their income and expenditure before the valuation question. Similarly, for labor as payment vehicle they need to be reminded of the total labor time they have and the amount they require to undertake their household activities (farming and community works, etc…). This information is the basis for them for comparing the opportunity cost of their choice. Labor time in the off-farm labor market might be part of this for some respondents but in general rural households allocate much of their labor on their subsistence farming activities than off-farm labor markets. For those who participate, they mostly do this after the crop season and if they could not get
employment in this period, the opportunity cost of labor will then be zero. Therefore, it makes more sense to use the per capita daily income of the respondent himself instead of the market or minimum wage rates as the opportunity cost of labor and test the convergent validity of willingness to pay and willingness to contribute labor values. Furthermore, if one thinks of a CV survey in a developed world with money and labor time contributions as payment vehicles is to take place, respondents would most probably choose to pay more in cash than in labor. In doing so a rational respondent compares the opportunity cost of his/her time valued not at a flat market wage rate but at his own personal earning capacity per unit of time, which will either be large or smaller than the market wage rate.

Therefore, a comparison of willingness to pay in cash with willingness to contribute labor converted at the per capita daily income, the minimum and market wage rates was made. For the minimum wage, Ethiopia has not yet a law for minimum wage. However, public employers and private companies set their minimum wages. Therefore public employers’ minimum wage (320 Birr per month) was considered for the calculation. The monetary value of the lower bound mean willingness to contribute labor valued at the per capita daily income was 6.64 USD and this value is much closer to the lower bound mean willingness pay in cash. Moreover, there is an overlap in the 99% confidence intervals of the two values (4.97 to 8.31 versus 4.55 to 5.18). The monetary value of the lower bound mean willingness to contribute labor at the minimum daily wage rate is 5.72 USD however; the 99% confident interval for this value is (5.58 to 5.85) and does not overlap with the corresponding confidence interval of the mean willingness to pay in cash.

7. Conclusions and policy implications

This study used labor and cash as payment vehicles to measure the non-market benefits of environmental amenities to income constrained rural households in Ethiopia. Our results suggest that labor time contribution valued at the per capita daily income of the respondent is more appropriate to test the convergence validity of willingness to contribute labor and willingness to pay in contingent valuation studies in subsistence economies. From the point of view of the conservation and sustainable management of BPF, the study indicated that despite Ethiopia is a low-income country, people are clearly aware of the importance of conservation of the resource and that they are indeed interested to contribute for the conservation. However, mobilizing this local demand for conservation is only part of the solution to the problem, which requires improving their livelihood.

Therefore, improving the livelihood of the rural communities through increasing the benefits from the resource on the one hand and managing the resource on a sustainable basis on the other is the challenge that calls for national and global level policy interventions. At the national level, increasing the capacity of rural farmers’ cooperatives by providing the necessary training and credit facilities so that they can directly engage themselves in the export market could increase their share of the benefits from the resource. It is also important to build a local and national level skilled work force in forestry and related fields that is now a critical problem in the country. The other possible area of policy intervention could be the development of forest-certification that promotes the sustainable use and management of the resource so that the international market for oleo-gum resins could provide price premiums for resins from sustainably managed forests.
Frankincense forests in particular and oleo-gum resins dry land forests in general could also be worth investing if included in global REDD+ mechanisms for both poverty reduction, biodiversity conservation and for reducing emissions from deforestation and forest degradation. However, a sound justification for such policy interventions may require more research on values of all the ecosystem services from the resource (carbon stock and sequestration, opportunity cost of the forestland, and direct use values from oleo-gum resin production). This research addresses the option, existence and bequest values of the resource to the local people.

References


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Lemenih M, Abebe T, Olsson M. 2003. Gum and resin resources from some *Acacia, Boswellia* and *Commiphora* species and their economic contributions in Liban, south-east Ethiopia. *Journal of Arid Environments* 55, 465-482.


White F. 1983. The Vegetation of Africa: a descriptive memoir to accompany the UNESCO/AETFAT/UNSO vegetation map of Africa. UNESCO, Switzerland.

Table I: Bid design and number randomly assigned sample households.

<table>
<thead>
<tr>
<th>Bid (Birr per year)</th>
<th>Bid (days per year)</th>
<th>Probabilities</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>[19, 38, 10]</td>
<td>[2, 4, 1]</td>
<td>0.15</td>
<td>103</td>
</tr>
<tr>
<td>[47, 94, 24]</td>
<td>[5, 10, 3]</td>
<td>0.35</td>
<td>104</td>
</tr>
<tr>
<td>[68, 136, 34]</td>
<td>[7, 14, 4]</td>
<td>0.50</td>
<td>106</td>
</tr>
<tr>
<td>[84, 168, 42]</td>
<td>[9, 18, 5]</td>
<td>0.65</td>
<td>104</td>
</tr>
<tr>
<td>[113, 226, 57]</td>
<td>[12, 24, 6]</td>
<td>0.85</td>
<td>103</td>
</tr>
</tbody>
</table>

Table II: Description and summary statistics of variables.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Description</th>
<th>Mean(SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BID: WTP</td>
<td>Randomly assigned amount to each household in Birr per year</td>
<td>65.89(32.03)</td>
</tr>
<tr>
<td>: WTCL</td>
<td>Randomly assigned amount to each household in days per year</td>
<td>6.97(3.41)</td>
</tr>
<tr>
<td>logINC</td>
<td>Log transformed household income</td>
<td>9.44(0.92)</td>
</tr>
<tr>
<td>LABOR</td>
<td>Number of household members 15-64 years old</td>
<td>2.70(1.30)</td>
</tr>
<tr>
<td>AGE</td>
<td>Age of the household head</td>
<td>40.49(12.46)</td>
</tr>
<tr>
<td>EDU</td>
<td>Education of the household head: 1=Illiterate, 2=Read and write but no formal schooling, 3= Elementary, 4= Junior High school, 5= High school</td>
<td>2.12(1.10)</td>
</tr>
<tr>
<td>GENDER</td>
<td>Gender of the household head: 1=Male; 0=Female</td>
<td>0.91(0.29)</td>
</tr>
<tr>
<td>RESID</td>
<td>1= The household head has been living in the area since before the resettlement year (2002); 0 = Otherwise</td>
<td>0.72(0.45)</td>
</tr>
<tr>
<td>USER</td>
<td>1= if the household has been using the resource as either fodder, tapper , or member of frankincense cooperative firms; 0 otherwise</td>
<td>0.54(0.49)</td>
</tr>
<tr>
<td>EduRESID</td>
<td>Interaction term for EDU and RESID</td>
<td>1.43(1.27)</td>
</tr>
<tr>
<td>AgeRESID</td>
<td>Interaction term for AGE and RESID</td>
<td>30.43(21.97)</td>
</tr>
<tr>
<td>VIL1</td>
<td>Village dummy: 1= Adi Aser, 0=Otherwise</td>
<td>0.20(0.40)</td>
</tr>
<tr>
<td>VIL2</td>
<td>1= Maykeyhi, 0=Otherwise</td>
<td>0.35(0.48)</td>
</tr>
<tr>
<td>VIL3</td>
<td>1= Moguu, 0=Otherwise</td>
<td>0.14(0.35)</td>
</tr>
<tr>
<td>VIL4</td>
<td>1= Jijike, 0=Otherwise</td>
<td>0.16(0.37)</td>
</tr>
<tr>
<td>VIL5</td>
<td>1= Siye, 0=Otherwise</td>
<td>0.15(0.36)</td>
</tr>
<tr>
<td>DEPEND</td>
<td>Number of household members &lt;15 and &gt;64 years old</td>
<td>2.59(1.60)</td>
</tr>
<tr>
<td>LAND</td>
<td>Land size in hectares</td>
<td>2.32(1.71)</td>
</tr>
<tr>
<td>DisAWRoad</td>
<td>Distance to all weather roads in kilometers</td>
<td>8.12(9.81)</td>
</tr>
</tbody>
</table>
Table III: WTP Models.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model-I</th>
<th>Model-II</th>
<th>Model-III</th>
<th>Model-IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>BID</td>
<td>-0.022(0.002)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.007(0.001)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.021(0.002)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.195(0.055)&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>LogINC</td>
<td>0.842(0.109)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.710(0.098)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.828(0.105)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.832(1.587)&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>AGE</td>
<td>0.010(0.015)</td>
<td>0.007(0.014)</td>
<td>0.007(0.014)</td>
<td>0.048(0.109)</td>
</tr>
<tr>
<td>EDU</td>
<td>0.266(0.138)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.088(0.119)</td>
<td>0.202(0.126)</td>
<td>1.874(1.088)&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>GENDER</td>
<td>0.440(0.255)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.167(0.234)</td>
<td>0.359(0.238)</td>
<td>1.156(1.755)</td>
</tr>
<tr>
<td>RESID</td>
<td>1.226(0.780)</td>
<td>1.055(0.707)</td>
<td>0.944(0.736)</td>
<td>6.890(5.680)</td>
</tr>
<tr>
<td>USER</td>
<td>-0.008(0.148)</td>
<td>0.008(0.136)</td>
<td>0.004(0.145)</td>
<td>-0.032(1.065)</td>
</tr>
<tr>
<td>AgeRESID</td>
<td>-0.018(0.016)</td>
<td>-0.014(0.015)</td>
<td>-0.013(0.016)</td>
<td>-0.100(0.120)</td>
</tr>
<tr>
<td>EduRESID</td>
<td>-0.319(0.159)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>-0.177(0.140)</td>
<td>-0.254(0.149)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>-2.173(1.253)&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>VIL1</td>
<td>0.281(0.264)</td>
<td>-0.027(0.245)</td>
<td>0.323(0.259)</td>
<td>2.090(1.933)</td>
</tr>
<tr>
<td>VIL2</td>
<td>0.443(0.257)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.478(0.240)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.442(0.257)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.006(1.957)</td>
</tr>
<tr>
<td>VIL3</td>
<td>0.349(0.280)</td>
<td>0.330(0.261)</td>
<td>0.454(0.278)</td>
<td>3.300(2.147)</td>
</tr>
<tr>
<td>VIL4</td>
<td>0.104(0.249)</td>
<td>-0.102(0.235)</td>
<td>0.146(0.253)</td>
<td>-0.029(1.786)</td>
</tr>
<tr>
<td>Constant</td>
<td>-7.817(1.162)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-6.716(1.028)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-7.470(1.102)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-50.081(14.453)&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>LogL</td>
<td>-212.192</td>
<td>-252.080</td>
<td>-356.800</td>
<td>-266.908</td>
</tr>
<tr>
<td>Pseudo R²</td>
<td>0.347</td>
<td>0.229</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ρ</td>
<td></td>
<td></td>
<td>0.938(0.020)&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Median WTP*</td>
<td>5.73</td>
<td>9.70</td>
<td>5.68</td>
<td>4.82</td>
</tr>
<tr>
<td>Mean WTP*</td>
<td>5.71(0.15)</td>
<td>10.06(0.41)</td>
<td>5.62(0.15)</td>
<td>4.86(0.12)</td>
</tr>
<tr>
<td>95% CI*</td>
<td>5.4 to 6.01</td>
<td>9.26 to 10.85</td>
<td>5.32 to 5.92</td>
<td>4.63 to 5.10</td>
</tr>
</tbody>
</table>

*Values are in USD (1 USD = Birr 13.3778), values in ( ) are standard error, a= significant at p<1%, b= at p<5%, c= at p<10%; VIL5 is dropped due to collinearity.
### Table IV: WTCL models.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model-V</th>
<th>Model-VI</th>
<th>Model-VII</th>
<th>Model-VIII</th>
</tr>
</thead>
<tbody>
<tr>
<td>BID</td>
<td>-0.180(0.021)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.072(0.010)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.175(0.020)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-2.194(0.640)&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>LABOR</td>
<td>0.210(0.059)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.185(0.055)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.200(0.058)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.948(0.748)&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>AGE</td>
<td>-0.021(0.014)</td>
<td>-0.021(0.013)</td>
<td>-0.023(0.013)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>-0.217(0.141)&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>EDU</td>
<td>0.115(0.109)</td>
<td>0.083(0.108)</td>
<td>0.099(0.108)</td>
<td>0.642(1.036)</td>
</tr>
<tr>
<td>GENDER</td>
<td>0.395(0.227)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.509(0.221)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.388(0.220)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.050(2.250)</td>
</tr>
<tr>
<td>RESID</td>
<td>-0.677(0.696)</td>
<td>-0.533(0.672)</td>
<td>-0.843(0.672)</td>
<td>-7.833(6.757)</td>
</tr>
<tr>
<td>USER</td>
<td>-0.164(0.135)</td>
<td>-0.103(0.129)</td>
<td>-0.155(0.133)</td>
<td>-1.313(1.322)</td>
</tr>
<tr>
<td>AgeRESID</td>
<td>0.026(0.015)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.023(0.014)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.028(0.014)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.264(0.152)&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>EduRESID</td>
<td>0.021(0.132)</td>
<td>-0.038(0.129)</td>
<td>0.053(0.131)</td>
<td>0.415(1.245)</td>
</tr>
<tr>
<td>VIL1</td>
<td>-0.079(0.230)</td>
<td>-0.184(0.217)</td>
<td>-0.107(0.226)</td>
<td>-0.717(2.192)</td>
</tr>
<tr>
<td>VIL2</td>
<td>0.041(0.233)</td>
<td>0.227(0.221)</td>
<td>0.033(0.232)</td>
<td>1.033(2.245)</td>
</tr>
<tr>
<td>VIL3</td>
<td>0.075(0.251)</td>
<td>0.058(0.236)</td>
<td>0.061(0.247)</td>
<td>1.197(2.416)</td>
</tr>
<tr>
<td>VIL4</td>
<td>0.082(0.236)</td>
<td>0.248(0.225)</td>
<td>0.122(0.237)</td>
<td>0.230(2.262)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.992(0.688)</td>
<td>0.453(0.648)</td>
<td>1.148(0.667)</td>
<td>13.360(7.162)&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>LogL</td>
<td>-259.421</td>
<td>-284.195</td>
<td>-428.594</td>
<td>-312.608</td>
</tr>
<tr>
<td>Pseudo R²</td>
<td>0.182</td>
<td>0.128</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ρ</td>
<td>0.919(0.022)&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Values in ( ) are standard error, <sup>a</sup> significant at p<1%, <sup>b</sup> significant at p< 5%, <sup>c</sup> significant at p< 10%.; VIL5 is dropped due to collinearity.
Table V: Models for checking robustness of the WTP models.

<table>
<thead>
<tr>
<th>Variable</th>
<th>IV-Probit</th>
<th>SBDC1a</th>
<th>SBDC1b</th>
</tr>
</thead>
<tbody>
<tr>
<td>BID</td>
<td>-0.022(0.002)*</td>
<td>-0.019(0.002)*</td>
<td>-0.022(0.002)*</td>
</tr>
<tr>
<td>LogINC</td>
<td>0.749(0.267)*</td>
<td>0.844(0.115)*</td>
<td></td>
</tr>
<tr>
<td>AGE</td>
<td>0.011(0.015)</td>
<td>0.013(0.014)</td>
<td>0.017(0.015)</td>
</tr>
<tr>
<td>EDU</td>
<td>0.288(0.148)c</td>
<td>0.355(0.125)a</td>
<td>0.455(0.139)a</td>
</tr>
<tr>
<td>GENDER</td>
<td>0.492(0.286)c</td>
<td>0.752(0.234)a</td>
<td>0.907(0.253)a</td>
</tr>
<tr>
<td>RESID</td>
<td>1.282(0.791)</td>
<td>1.312(0.731)c</td>
<td>1.727(0.781)b</td>
</tr>
<tr>
<td>USER</td>
<td>0.010(0.155)</td>
<td>0.128(0.136)</td>
<td>0.164(0.146)</td>
</tr>
<tr>
<td>AgeRESID</td>
<td>-0.019(0.017)</td>
<td>-0.019(0.016)</td>
<td>-0.025(0.017)</td>
</tr>
<tr>
<td>EduRESID</td>
<td>-0.336(0.165)c</td>
<td>-0.367(0.146)b</td>
<td>-0.469(0.160)a</td>
</tr>
<tr>
<td>VIL1</td>
<td>0.386(0.374)</td>
<td>1.089(0.231)a</td>
<td>1.248(0.247)a</td>
</tr>
<tr>
<td>VIL2</td>
<td>0.521(0.323)</td>
<td>1.054(0.233)a</td>
<td>1.158(0.248)a</td>
</tr>
<tr>
<td>VIL3</td>
<td>0.437(0.357)</td>
<td>1.022(0.255)a</td>
<td>1.150(0.270)a</td>
</tr>
<tr>
<td>VIL4</td>
<td>0.118(0.251)</td>
<td>0.265(0.236)</td>
<td>0.235(0.247)</td>
</tr>
<tr>
<td>Constant</td>
<td>-7.127(2.150)*</td>
<td>-1.231(0.713)c</td>
<td>-1.589(0.764)b</td>
</tr>
<tr>
<td>LogL</td>
<td>-718.447</td>
<td>-248.525</td>
<td>-216.592</td>
</tr>
<tr>
<td>Pseudo R²</td>
<td></td>
<td>0.236</td>
<td>0.334</td>
</tr>
</tbody>
</table>

*Values in ( ) are standard error, a= significant at p<1%, b=significant at p< 5%, c= significant at p< 10%.: VIL5 is dropped due to collinearity.*
Figure 1: Location of the study area.
I. DESCRIPTION OF THE BOSWELIA PYRIFICERA FOREST

1.1. Uses of Boswellia papyrifera:
   Economic, environmental, social and cultural benefits

1.2. State of degradation of the forest:
   Verbal description on deforestation for agricultural land, fire grazing causing lack of recruitment of seedlings, over tapping for frankincense.
   Visual description: A4 size of the following picture

1.3. Need for conservation and conservation objectives:
   Goal 1: Keeping the forest as option for future use
   Goal 2: Realizing the existence of the species (run possibility of extinction)
   Goal 3: Improve the welfare of future generation of the society

II. METHOD OF PROVISION, PAYMENT VEHICLES, DECISION RULE AND TIME FRAME OF PAYMENT

III. THE CONTINGENT VALUATION QUESTION

The workings for initial valuation questions for cash and labour contributions read as:
   a) Would you (your household) contribute for the Boswellia papyrifera forest conservation program if it costs you X ETB per year?
   b) Would you (your household) contribute for the Boswellia papyrifera forest conservation program if it requires you 1 full labour day per year as a guard for patrolling the conservation site given that 1 full labour day = 8 working hours?

The workings of the follow up questions were the same except for the X and L values.

IV. SOCIO-ECONOMIC AND DEMOGRAPHIC CHARACTERISTICS

Figure 2: Structure of the contingent valuation survey