Revisiting money and labor for valuing environmental goods and services in developing countries

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Abstract

Many Stated Preference (SP) studies conducted in developing countries exhibit a low willingness to pay (WTP) for a wide range of goods and services. However, recent studies in these countries indicate that this may be a result of the choice of payment vehicle, not the preference for the good. Thus, low WTP may not indicate a low welfare effect for public projects in developing countries. We argue that in a setting where there is imperfect substitutability between money and other measures of wealth (e.g. labor), including two or more payment vehicles may be needed to obtain valid welfare estimates. Otherwise, we risk underestimating the welfare benefit of projects. We demonstrate this through a rural household contingent valuation (CV) survey designed to elicit the value of access to reliable irrigation water in Ethiopia. Our result shows that both absolute and relative endowment of labor and income highly influence respondents’ choices. Of the total average annual WTP for access to reliable irrigation service, cash contribution comprises only 24.41\%. Our findings highlight the importance of accounting for cross payment vehicle correlation and potential endogeneity biases that arise in the sequence of WTP and Willingness to contribute (WTC) valuation questions.

**Keywords:** Endogeneity; bivariate probit model; Contingent valuation; Stated preference methods; Irrigation service; Ethiopia; Developing countries

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1. Introduction

The application of stated preference (SP) methods such as contingent valuation (CV) and choice experiments (CE) for valuing environmental goods and services has become more commonly applied in developing countries in recent years (Alemu et al., 2017; Bennett and Birol, 2010; Kassahun et al., 2016; Kassahun et al., 2020; Meginnis et al., 2020; Navrud and Vondolia, 2019; Rai and Scarborough, 2015; Tilahun et al., 2017; Vondolia and Navrud, 2019; Zemo et al., 2019). The results of such studies provide valuable information about citizens’ preferences for environmental goods and services and thereby input to the decisions of whether to advocate for the provision of these goods and services. An issue that remains relatively unexplored is that many SP studies conducted in developing countries exhibit a low willingness to pay (WTP) for a wide range of goods and services (Whittington, 2010). This could suggest that the good or service under valuation is not a priority for many of the respondents in developing country settings. However, recent SP studies in developing countries indicate the need for more careful interpretation of low WTP estimates (Abramson et al., 2011; Kassahun, 2014; Meginnis et al., 2020).

WTP estimates based on monetary contributions alone may result in understated welfare effects for environmental goods and services, due to the limited importance of the cash economy in rural areas of developing countries (Abramson et al., 2011; Gibson et al., 2016; Schiappacasse et al., 2013). As a result, many researchers have used alternative payment vehicle systems for welfare measurement in valuation studies, often labor contribution\(^2\). Nevertheless, labor contributions are not a perfect substitute for cash payments (Kassahun and Jacobsen, 2015; Vondolia and Navrud, 2019), for two main reasons. First, labor contributions may not be a feasible option from the perspective of environmental service users as key

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\(^2\) Section 2 provides an overview of valuation of environmental goods and service for the last 30 years using both money and labor in developing countries.
environmental management activities often take place far from the location of service users and by other users. Thus, the ones who benefit may not legally nor geographically be the ones who can provide labor. Second, because of the potential difference in whether cash or labor works can best be substituted, some individuals may not want to/be able to contribute in labor, preferring cash contributions and vice versa. Thus, including both payment vehicles in a valuation study can capture the demand for an environmental good in a more flexible and accurate way for respondents with different endowments of income and labor. This is particularly important in developing countries due to large heterogeneity in the population’s wealth. However, three potential issues are overlooked in the literature on contingent valuation (CV) methods that combine labor and money to elicit value in developing countries.

The first issue arises when two CV questions are asked in a sequence of different payment vehicles, and then independent WTP and willingness to contribute labor (WTC) models are estimated assuming that the distribution of the sequence of choice between two payment vehicles are exogenous. Numerous studies employ this approach, for example Hung et al. (2007) for forest fire prevention, Kassahun (2009) for reliability of irrigation service, Casiwan-Launio et al. (2011) for sustainable marine fisheries, Tilahun et al. (2015) for forest conservation, and Tilahun et al. (2017) for prevention of expansion of alien tree species. However, this approach can result in biased coefficients and welfare estimates due to the correlation of the unobservable components of utility across the sequence of valuation questions. This is a case similar to the issue of correlation in double-bounded CV method with the same (money) payment vehicle, that Alberini et al. (1997) and Poe et al. (1997) emphasized in early applications of CV, but mostly ignored in the CV literature that combines money and labor as a payment vehicle.

Second, in dichotomous choice CV, the trade-off between two payment vehicles for two consecutive valuation questions is conditional on the first valuation equation. This differs from
CE, which allows respondents to trade-off between different payment vehicles for each repeated valuation question (Kassahun and Jacobsen, 2015; Kassahun et al., 2020; Meginnis et al., 2020; Rai and Scarborough, 2013). Thus, capturing trade-offs across the sequence of choice between two payment vehicles requires the use of the response from the first valuation question (lagged payment vehicle) as a determinant of the second valuation question. This not only captures trade-offs between payment vehicles but also avoids potential omitted variable bias. However, including response from the first valuation question as a determinant of the second valuation question also raises a potential endogeneity problem which needs to be handled.

The third issue is related to payment vehicle trade-off and sequence of choices. This is a related concept with starting point bias in double bounded CV methods with monetary payment vehicles (Flachaire and Hollard, 2007; Herriges and Shogren, 1996) but ignored when there are different payment vehicles. Payment vehicle trade-offs might be influenced by valuation question order because it may pressure respondents to indicate a false value for the second payment vehicle following rejection of the first payment vehicle, independent of the respondent’s income and labor status. If this is the case, it distorts the value of the environmental service under consideration. Thus, further analyses of relative and absolute income and labor differences between respondents are required to identify whether the trade-off is determined by question order effect or by the opportunity cost of labor or a combination of the two.

Given the foregoing, we argue that in a setting where there is imperfect substitutability between money and other measures of wealth (e.g. labor), including both payment vehicles may be needed to obtain valid welfare estimates. Otherwise, we risk underestimating the welfare benefit. Furthermore, we investigate the consequences of the payment vehicle exogeneity assumption and endogeneity on utility and parameter estimates. We demonstrate this through a rural household contingent valuation (CV) survey designed to elicit the value of
access to reliable irrigation water in Ethiopia. Our findings highlight the importance of accounting for cross-payment-vehicle correlation and potential endogeneity biases that arise in the sequence of WTP and Willingness to contribute (WTC) valuation questions. The implication is also valid for a choice experiment (CE) survey that allows the respondent to choose payment vehicles and administer the CE survey using the selected payment vehicle.

The remaining sections of the article are as follows: Section 2 describes the method, Section 3 presents the data, Section 4 describes and discusses the results. Finally, Section 5 provides brief concluding remarks.

2. Overview of money and labor for valuation of environmental goods and services

Starting from the work of Swallow and Woudyalew (1994), assessment of labor contributions has received increasing attention in the valuation of environmental goods and services in developing countries. We reviewed scholarly articles from 1994 to 2020 that combined money with labor in various developing countries (Table 1). Application areas include land management, tree planting, fire prevention, weed control, animal disease control, irrigation service, flood risk reduction, water quality improvement, drought insurance, and maintaining fishery reserve. In these valuation studies, the addition of labor is inspired by the absence of a well-developed labor market (Barrett et al., 2008) and the limited importance of the cash economy (Schiappacasse et al., 2013) in rural areas of developing countries. Thus, labor contribution is advocated as an alternative means of valuing the demand for public projects for labor-intensive projects.
This literature indicates that both CV and CE are extensively used in the studies. In recent years, CE has become more popular among practitioners due to its flexibility for allowing tradeoff between payment vehicles and other attribute within a single choice task (Kassahun et al., 2020; Rai and Scarborough, 2013). However, given these studies often assess valuation in remote rural areas where substantial proportion of respondents is illiterate, adding two payment vehicles in a choice task leads to a concern about choice complexity. Concerned with choice complexity, Rai and Scarborough (2015) propose an alternative means of elicitation of values.
In their CE study, if respondent refused to contribute in monetary terms, respondent is asked to contribute in labor. Nevertheless, their analysis did not address the sample selection issue raised because of the format of the questionnaire for labor contribution as noted previously for CV literature.

Other noticeable features of the literature are about the uses of labor and money on how the payment vehicles are used in the valuation study. For example, Navrud and Vondolia (2019) and Vondolia et al. (2014) used a split-sample design to test the effect of alternative payment vehicles on the purchase of environmental goods and services. Their result shows that experience in payment vehicle is crucial in the decision process to reduce the asymmetry in the acceptance rate of payment vehicles. This provides a justification for adding one or more payment vehicles. However, any comparison of valuation studies with a split-sample design between different payment vehicles must rely on a functioning labor market, which is often absent in most rural developing countries (Barrett et al., 2008).

The current study focuses on literature that combines labor and money on CV study. We will show the importance of accounting for cross-payment-vehicle correlation using a CV survey. For this, in the following section, we present the case study and describe how the payment vehicles are designed in the valuation study to provide a context for the method, which we provide in sequence.

3. Case study

The data for this study were obtained from proposed irrigation beneficiary farmers in Koga Watershed of the Upper Blue Nile Basin part of Ethiopia, although during the survey period irrigation had not yet begun. The watershed is located south of Lake Tana in an area with high erosion rates for the Blue Nile Basin (Gebrehiwot et al., 2010; Reynolds, 2012). The newly constructed irrigation reservoir has capacity to irrigate 7,000 hectare of land and extends to seven administrative districts (Kebele).
Using random sampling, 210 irrigation beneficiary household heads were selected from two randomly-selected districts (Enguti and Ambo-Mesk Kebele), which represent approximately 12 percent of the households in the selected districts\(^3\). The data were collected using face-to-face interviews from July to October 2008\(^4\). The main purpose of the survey was to value reliability of irrigation service both in terms of monetary and labor contribution.

3.1. CV data

The CV study involves directly asking farmers how much they would be willing to pay or work in exchange for reliable irrigation service with a capacity to produce three times per year. In the valuation scenario, farmers were informed about the potential threat of reservoir and irrigation channel sedimentation for reliable irrigation services and the need for appropriate soil conservation measures both in the upstream and downstream parts of the watershed.

The purpose of monetary and labor contributions was explained to farmers before they were asked to contribute. The monetary contribution was to promote soil conservation measures by upstream land users (non-irrigation users) in the upstream part of the watershed. Respondents were also informed that upstream land users are not responsible for the consequences of their land use decisions for downstream water users. Thus, in order to encourage the adoption of appropriate soil conservation measure by upstream land users, a monetary contribution from all households benefiting from irrigation is required. The purpose of labor contributions was to manage and protect irrigation infrastructure, which includes removal of sediment from irrigation canals as well as implementation of soil conservation structures in nearby upstream areas.

\(^3\) The identities of irrigation beneficiary households were obtained from the Agricultural Development office of each district.

\(^4\) Kassahun et al. (2016) use part of the data in an integrated choice and latent variable framework to show how irrigation users’ expectations about future productivity affect WTP. Labor contribution was not part of their analysis.
During the focus group discussion and pre-test, we found that farmers have a distrust of a government institution (Kassahun, 2014). To reduce a protest response because of distrust, in the final questionnaire, farmers were informed of the money to be collected under the control of their own newly established irrigation users’ cooperative rather than the government. The wording of the valuation questions are as follows as presented to the irrigation beneficiary farmers:

I. **If you are provided access to irrigation water, will you vote for irrigation cooperative rules and regulation that will create a fund, if its passage will require all irrigation users to contribute (___) ETB/household/Year/ kada of land to keep the health of the dam and common irrigation channels to get year round reliable irrigation water supply? (Yes, No)**

II. **What is the maximum amount that you are willing to pay per kada of land for such a project per year for ten years? ____**

III. **In addition to cash contribution, if you are requested to contribute (____) labor days per Kada of land per month to maintaining the health of the dam and irrigation channels from sedimentation to get year round irrigation water supply, are you willing to contribute, if its passage require all irrigation users to contribute? (Yes, No)**

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5 Another concern the issue valuation in a developing country context is public trust in the development and implementation of environmental goods and services (Birol and Das, 2012; Oh and Hong, 2012). Kassahun (2014) found that the WTP of a public project in Ethiopia was underestimated as a result of distrust in government even if both the government and citizens were interested in the implementation of proposed public projects. Similarly, Chen and Hua (2015) have reported about 62% of the sampled respondent refused to pay for a project because of distrust in government in China. Distrust is not only limited to government, for managing common-pool resource, but Kassahun et al. (2020) also shows that farmers with high doubts about cooperation among themselves have a lower WTP for a collaborative livestock management system to reduce on-farm and off-farm impacts of soil erosion in the Blue Nile Basin. Farmers require an alternative means of incentives to participate in the land management program. Thus, issues more common in developing country context should be carefully accounted for in the design of the study and also in the analysis before making an inference about WTP.

6 Kada is a local area measurement. 1 kada = 0.25 hectare
IV. **What is the maximum number of days that you are willing to contribute for such a project per month for ten years?*** ___

The purpose of open-ended follow up questions (II and IV) is to evaluate inconsistent responses. We considered responses inconsistent if the respondent agreed to pay the randomly assigned bid price (*BidCash*) or contribute by the randomly bid working days (*BidLabor*) in dichotomous choice (DC) response valuation question (I and III) *and* he or she states a lower amount of labor or money in the follow up valuation questions (II and IV). Accordingly, 16 responses were removed from the analysis because of inconsistency between bid values and the follow up valuation questions. The range of bid price, (25, 31, 37, 43, 49, 58 and 70 ETB/year/Kada of irrigable land) and bid working days (1, 1.5, 2, 2.5 and 3 days/month/kada of irrigable land) are determined from focus group discussion and pretest. The bid values were randomly assigned for each respondent.

### 3.2. Socioeconomic and demographic data

In addition to data generated from CV scenario and valuation questions, we collected data on socioeconomic and demographic variables hypothesized to have an impact on WTP/WTC for reliable irrigation service. The average gross household cash income is about 6,473 ETB. It is the sum of all marketed agricultural outputs plus income from off-farm activities by all members of the household. The average number of economically active household member (working individual in the household) is about 3.53. We also collected data on the value of daily labor cost for the slack (14 ETB) and peak (18 ETB) agricultural seasons (Table 2).

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7 The value of marketed agricultural output uses annual average prices for 2007/8 (2000 in the Ethiopian calendar).
Table 2: Descriptive Statistics for N = 194: Households Surveyed in the Koga Watershed, and the Expected impact of the variables on willingness to contribute labor and willingness to pay (WTP)

| Variable       | Description                                                                 | Mean  | Std. Dev. | Expected sign |
|----------------|-----------------------------------------------------------------------------|-------|-----------|---------------|
| $y_{2i}$       | 1 if household is willing to contribute the proposed bid working days for reliable irrigation service, otherwise 0 | 58%   |           | -             |
| BidLabor       | Bid number of working days per month                                         | 1.99  | 0.71      | -             |
| Land per household holding per household size (kadu household size) | 1.04  | 0.54      | -             |
| Experience with irrigation | 1 if household head indicated s/he has practical irrigation farming experience, otherwise 0 | 18%   |           | +             |
| Working household members | Number of economically active individuals in a household i.e., working-age population age above 14 and below 66 years of age | 3.53  | 1.64      |               |
| Dependency ratio | Ratio of dependents (people younger than 15 or older than 65) to the working-age population | 0.86  | 0.63      | -             |
| Farm cart ownership | 1 if a household owns a farm cart either with horse or mule or both, and 0 otherwise | 31%   |           | +             |
| Young household head | 1 if age of household head is less than 43, otherwise 0 (division based on mean age) | 55%   |           | +             |
| Education      | Highest formal schooling completed by any household member in years          | 5.65  | 4.15      | +             |
| Gross household income | Sum of all marketed agricultural outputs plus income from off-farm activities by all members of the household | 6473  | 5943      |               |
| Per capita income | Gross household income divided by household size                            | 1123  | 1462      | +             |
| $y_{1i}$       | 1 if household is willing to pay the proposed bid price (cash) for reliable irrigation service, otherwise 0 | 63%   |           | -             |
| BidCash        | Bid price                                                                   | 44.44 | 14.46     |               |
| Labor cost, slack period | Average slack agricultural season daily labor cost in ETB                  | 14    | 2.53      |               |
| Labor cost, peak period | Average peak agricultural season daily labor cost in ETB                  | 18    | 2.62      |               |
| Shadow wage, slack | Estimated average slack agricultural season daily shadow wage rate in ETB | 5.23  | 0.97      |               |
| Shadow wage, peak | Estimated average peak agricultural season daily shadow wage rate in ETB    | 6.84  | 1.01      |               |

NOTE: ETB indicates Ethiopian Birr. At the time of the survey, 1 ETB was equal about 0.1 USD.
4. Method

Correlation between unobservable and observable components of utility is a well-documented issue in discrete choice analysis with repeated response. Accounting for this effect is a routine procedure in CE and double-bounded dichotomous choice CV for the same payment vehicle (Alberini et al., 1997; Poe et al., 1997; Train, 2009). Similar methodological approaches can be applied to test the exogeneity of sequence of two different dichotomous choice CV questions using a bivariate probit model. The bivariate probit model addresses potential endogeneity issues without the need for instrumental variables for one endogenous variable (Filippini et al., 2018; Heckman, 1978; Maddala, 1983; Martínez-Espiñeira and Lyssenko, 2011; Monfardini and Radice, 2008).

If we assume that the utility of individual, $i$, for reliable irrigation service valued in a sequence of valuation questions with money, $U_{1i}$, and labor, $U_{2i}$, then $1$ is the valuation question in cash contributions and $2$ in labor contributions. Thus, the utility for reliable irrigation service can be specified as:

$$U_{1i} = v_{1i} + \varepsilon_{1i} = \alpha + \beta_{1} Bid\text{Cash}_{1i} + \sum_{\beta = 2}^{n} \beta_{\beta} x_{\beta} + \varepsilon_{1i} \tag{1}$$

$$U_{2i} = v_{2i} + \varepsilon_{2i} = b + \theta_{1} Bid\text{Labor}_{2i} + \sum_{\theta = 2}^{\Theta} \theta_{\theta} x_{\theta} + \eta y_{1i} + \varepsilon_{2i}$$

Here the $v$’s are systematic utility components, and the $\varepsilon$’s are error terms. $\alpha$ and $b$ are constants to be estimated. $\beta_{1}$ and $\theta_{1}$ are parameters associated with bid price, $Bid\text{Labor}$, and bid working days, $Bid\text{Labor}$, respectively. $\beta$ and $\theta$ are a vector of parameters associated with socio-demographic variables, $x_{i}$, and $\eta$ is a parameter associated with observed dichotomous response for WTP for randomly assigned bid prices, $y_{1i}$.
Assuming that the two errors in Equation 1 have a joint bivariate normal distribution, the
measurement model for the choice indicators for the dichotomous response for WTP and WTC
for randomly assigned bid price, $y_{1i}$, and working days, $y_{2i}$, are specified in Equation 2 and 3.

\[
y_{1i} = \begin{cases} 
1 & \text{if } U_{1i} > \text{BidCash} \\
0 & \text{if } U_{1i} \leq \text{BidCash}
\end{cases} \tag{2}
\]

\[
y_{2i} = \begin{cases} 
1 & \text{if } U_{2i} > \text{BidLabor} \\
0 & \text{if } U_{2i} \leq \text{BidLabor}
\end{cases} \tag{3}
\]

Here, the joint probability of observing $y_{1i}$ and $y_{2i}$, i.e. $P_{11}=[y_1=1, y_2=1]$, $P_{10}=[y_1=1, y_2=0]$, $P_{01}=[y_1=0, y_2=1]$ and $P_{00}=[y_1=0, y_2=0]$ is the product of probability of $y_{1i}$ and probability of $y_{2i}$ conditional on probability of $y_{1i}$. Here, $y_{1i}$ is a potentially endogenous variable:

\[
L = \prod_{i=1}^t \left[ \int_{-\infty}^{\alpha_1} \int_{z_2}^{\gamma_2} \phi(z_1, z_2; \rho) dz_1 dz_2 \right]^{y_{1i}} \left[ \int_{\gamma_1}^{\alpha_1} \int_{-\infty}^{\gamma_2} \phi(z_1, z_2; \rho) dz_1 dz_2 \right]^{(1-y_{1i})} \left[ \int_{-\infty}^{\gamma_2} \int_{\alpha_1}^{\alpha_2} \phi(z_1, z_2; \rho) dz_1 dz_2 \right]^{y_{2i}} \left[ \int_{\gamma_1}^{\gamma_2} \int_{\gamma_1}^{\gamma_2} \phi(z_1, z_2; \rho) dz_1 dz_2 \right]^{(1-y_{2i})} \tag{4}
\]

where $z_1 = -v_1 / \sigma_1$, $z_2 = -v_2 / \sigma_2$, $\sigma_1$ and $\sigma_2$ are standard errors, $\phi(z_1, z_2; \rho)$ is the standard bivariate normal distribution, which can be specified as (Poe et al., 1997):

\[
\phi(z_1, z_2; \rho) = \frac{\exp\left(-z_1^2 + z_2^2 - 2\rho z_1 z_2\right)}{2\pi(1-\rho^2)} \tag{5}
\]

where $\rho$ is correlation parameter.

Equation 2 can be estimated using maximum likelihood procedures. We will test for the null hypothesis $\rho = 0$, i.e. the two equations in Equation 1 are independent\(^8\). If we cannot reject

\(^8\) It is a common practice to test of exogeneity assumption between $y_{1i}$ and $y_{2i}$ without incorporating the endogenous ($y_{1i}$) variable as a regressor in the bivariate probit model. However, Filippini et al. (2018) show
the null hypothesis, the two equations can be estimated using independent univariate probit models and \( \phi(.) \) in Equation 5 takes the usual standard univariate normal distribution (Train, 2009).

Besides observing \( \rho \), exogeneity can be tested by evaluating the significance of and any sign change on the coefficient of the potential endogenous variable, \( y_{1i} \), between the independent probit models and the bivariate probit model. A large change in the parameters of \( y_{1i} \) shows the model is not independent and it also confirms that the variable is endogenous (Waters, 1999).

Once potential endogeneity and correlation of unobservable components utility addressed between the sequences of choices, the ultimate objective of any environmental valuation study is to calculate welfare change. Following Hanemann (1984, 1989), the compensating surplus welfare measure of change is calculated using the following formula:

\[
CV^M = \left( V^1_i - V^0_i \right) / \beta_i \\
CV^L = \left( V^2_i - V^0_i \right) / \theta_i 
\]

where \( CV^M \) and \( CV^L \) are the compensating surplus welfare measure of change in terms of money and labor. \( V^1_i \) and \( V^2_i \) are the systematic component of utility if the farmer is WTP and WTC in money and labor respectively. \( V^0_i \) are the status-quo alternative (doing nothing). Note that in our valuation scenario, both labor and money are required, they are not a substitute one other, to access reliable irrigation services. Thus, the total compensating surplus welfare measure for accessing reliable irrigation services, \( CV^{ML} \), is calculated using Equation 7:

\[
CV^{ML} = CV^M + CV^L 
\]

that the practice may lead to an erroneous conclusion about the correlation of error terms considering the data generation process.
The annual seasonal average market wage rate as reported by ample respondent (average slack and peak agricultural season daily labor cost) may be used to convert to monetary units. However, this may not be a real wage rate considering the absence of a well-developed labor market. In a similar context, Kassahun et al. (2020) reported the estimated shadow wage rate is 38.63% of the sample respondent average reported wage rate. Therefore, in this study, the reported seasonal average market wage rate will be adjusted to reflect the shadow wage rate in the calculation of the total compensating surplus welfare measure for accessing reliable irrigation services.

5. Results and discussion

The estimates of the univariate probit model for labor contribution and the bivariate probit model for the joint cash and labor contribution (Table 3) indicate that the likelihood-ratio test for $\rho = 0$ is significant at 0.0001 significant level, so we can reject the null hypothesis that the decision money and labor contribution for reliable irrigation service are exogenous. Consequently, the two models in Equation 1 should not be estimated using two separate univariate probit models. Further, when the two models are estimated with direct incorporation of the response of WTP decision, $y_{1i}$, as an explanatory variable for WTC for reliable irrigation service decision, $y_{2i}$, which is positive and insignificant for the case of the univariate probit model. For the bivariate model the sign is negative and significant. This also supports the hypothesis that the response of WTP decision is endogenous for WTC, and that the bivariate probit model for accounting both the correlation of the sequence of choices and endogeneity problem would be a better option. Thus, the rest of our discussion is based on the results of the bivariate probit model.
Table 3: Estimated Coefficients for Univariate and Bivariate Probit Models

| Equation, Variable | Univariate Probit | Bivariate Probit |
|--------------------|-------------------|------------------|
|                    | Coefficients      | t                | Coefficients | t               |
| Dependent $y_2$    |                   |                  |               |                 |
| $y_1$              | 0.09              | 0.36             | -1.21        | -7.66           |
| BidLabor           | -0.98             | -5.45            | -0.73        | -5.46           |
| Land per household | -0.28             | -1.27            | -0.18        | -1.02           |
| Experience with    | 0.34              | 1.21             | 0.71         | 2.48            |
| irrigation         |                   |                  |              |                 |
| Dependency ratio   | -1.02             | -4.71            | -1.06        | -5.84           |
| Farm cart ownership| 0.41              | 1.72             | 0.32         | 2.00            |
| Young household head| 1.25              | 4.75             | 1.49         | 6.68            |
| Education          | 0.02              | 0.83             | 0.07         | 2.56            |
| Constant           | 2.37              | 4.64             | 2.19         | 4.93            |
| Dependent $y_1$    |                   |                  |               |                 |
| BidCash            |                   | -0.04            | -5.71        |                 |
| Dependency ratio   | -0.89             | -4.09            |              |                 |
| per capita income  | 0.55              | 4.14             |              |                 |
| Experience with    | 1.17              | 3.14             |              |                 |
| irrigation         |                   |                  |              |                 |
| Young household head| 0.84              | 3.67             |              |                 |
| Education          | 0.07              | 2.48             |              |                 |
| Constant           | 1.43              | 3.18             |              |                 |
| Athrho*            |                   | 12.95            | 11.4         |                 |
| rho**              |                   |                  |              |                 |
| Log likelihood     | -85.67            | -162.31          |              |                 |
| Chi-squared        | 68.04             | 147.61           |              |                 |
| P                  | 0.00              | 0.00             |              |                 |
| N                  | 194               | 194              |              |                 |

* is the Fisher's Z transformation of the correlation.
**Likelihood-ratio test of rho=0: chi2(1) = 130.027  Prob > chi2 = 0.0000

One of the fundamental reasons for incorporation of labor time contribution as payment vehicle for valuation of environmental services in developing countries is that scarcity of cash exchanges may lead to underestimation of the value of ecosystem services. Therefore, it is hypothesized that including labor contributions as a payment vehicle gives more flexibility for the majority of the poor in rural areas to reveal their preferences (Schiappacassee et al., 2013). Our result confirms this hypothesis. Holding the effect of other variables constant, the probability of an individual’s willingness to contribute labor (WTC) for reliable irrigation
service will increase by 37.8% if the respondent chooses not to pay ($y_{it} = 0$) a monetary contribution (Table 4). However, this result alone doesn’t provide evidence that including labor as a payment vehicle increases flexibility for the low-income residents of rural areas to reveal their preference. Thus, further analyses of relative and absolute income and labor differences between respondents are required to identify whether the relationship is due to the question order effect or consistent with the hypothesis of greater flexibility.

Table 4: Marginal effects of explanatory variables on WTC ($y_{2i}$), N=194

| Variable                        | Marginal effects (ME) | 95% C.I.      | Mean for ME computation |
|---------------------------------|-----------------------|---------------|-------------------------|
| $y_{it}^*$                      | -0.378                | -0.502        | -0.255                  | 0.00                     |
| BidLabor                        | -0.164                | -0.241        | -0.087                  | 1.99                     |
| Experience with irrigation      | 0.196                 | 0.007         | 0.385                   | 0.18                     |
| Dependency ratio                | -0.237                | -0.339        | -0.134                  | 0.86                     |
| Farm cart ownership*            | 0.084                 | -0.004        | 0.172                   | 0.00                     |
| Young household head*           | 0.519                 | 0.386         | 0.651                   | 0.00                     |
| Education                       | 0.015                 | 0.003         | 0.027                   | 5.65                     |

(*) ME is for discrete change of dummy variable from 0 to 1

The result of the average per capita income and household active labor (economically active household member per economically dependent household) differences are presented for the three groups of respondents that are classified according to their responses for the sequence of the two dichotomous choice CV questions (Figure 1). About 41% of respondents are willing to contribute for reliable irrigation service in both money and labor (Yes-Yes), 22% only in monetary contribution (Yes-No) and 20% only in labor contribution (No-Yes). As expected, both per capita income and household active labor are highest for the groups that are willing to contribute through both payment vehicles. A comparison of respondents that are willing to pay only in monetary contribution (Yes-No) with respondent group of willing to pay in both payment vehicles (Yes-Yes) shows significantly lower values in household with active labor.

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9 For computing the marginal effect both significant and insignificant variables are considered. However, in Table 3 only the marginal effects of significant variables presented.
labor (P= 0.0004) but not in the value of per capita income (P= 0.8921). On the other hand, a comparison of the groups willing to contribute only labor (No-Yes) with the groups willing to pay only in money (Yes-No) shows significantly lower value of per capita income (P= 0.0012). However, there is no significant difference in the amount of labor between the two groups (P=0.4171). The implication is that respondents’ choices are highly influenced by both absolute and relative endowment of labor and income rather than the order of dichotomous CV questions. More importantly for this particular study, besides the significant proportion of individuals willing to contribute in both payment vehicles, the incorporation of labor as a payment vehicle increases flexibility for the 20% low income households in our sample to more accurately express their preferences about reliable irrigation service. This is a valid conclusion considering the significant and positive effect of income on willingness to pay (Table 3).

![Figure 1: Respondent relative endowment of income and labor and their responses from the sequence of valuation question in the order of WTP and WTC](image)

As the standard theory of demand suggests, both the bid price (BidCash) and the bid working days (BidLabor) are highly significant determinants of WTP and WTC for reliable irrigation service decisions. The higher the bid price and the working days, the lower the probability of an individual WTP and WTC for reliability irrigation service (Table 3).
Other than the bid working day, dependency ratio is a significant but negative determinant of WTP and WTC values (Table 3). A higher dependency ratio may decrease the probability of WTC for reliable irrigation service because caring for dependents and accomplishing basic household tasks take considerable labor time (Shiferaw and Holden, 1998). Similarly, a higher dependency ratio means a lower available disposable income for WTP.

Agriculture is still considered the most labor-intensive sector in developing countries. Moreover, lack of road infrastructure and means of transportation in rural areas of developing countries can increase the amount of time required to accomplish various agricultural activities. Having a farm cart with pack animals considerably reduces the amount of time required to transport various agricultural material and inputs, and hence, it increases the probability of WTC for reliable irrigation service (Table 3).

The other variable that has a highly significant and positive impact on the WTP and WTC for reliable irrigation service is household head age (Table 3). The marginal effect of being young increases the probability of WTC for reliable irrigation service by 52%. Other hypothesized variables such as irrigation farming experience and education are highly significant.

Thus far we have examined the sign and magnitude of the determinants of WTC for a number of relevant explanatory variables. However, the total value of reliable irrigation service is also important. Different from many of the valuation studies that combine money and labor, our study differentiates the purpose of money and labor contribution for managing reliable irrigation service in the framework of watershed management. Thus, in our valuation set up, contributions in both types of payment vehicles are considered necessary (i.e., there is not a choice between payment vehicles) with the ultimate objective of access to reliable irrigation water. However, if the respondents consider upland soil conservation measures and
downstream irrigation infrastructure management different bundles of service, some caveats may apply to the relative size of the money/labor contribution. In this case, the respondents may reveal a different WTP/WTC regardless of the amount of cash and labor available to them. Nevertheless, we do not consider this as an issue in our case. This is because of our result shows that respondents’ choices are highly influenced by both absolute and relative endowment of labor and income (Figure 1). The mean WTP for reliable irrigation service is about 57 ETB (about 5.7 USD at the time of the survey) per kada of irrigable land per year and 29 working days of labor per year per kada of irrigable land (Table 5).

**Table 5: Mean WTP and WTC for reliable irrigation service (N=194)**

| Valuation Measure | Mean willingness to contribute | Standard dev. |
|-------------------|-------------------------------|---------------|
| WTP               | 57.37 ETB /Year               | 31.68         |
| WTC               | 28.77 Days/year               | 14.85         |
| WTC*              | 177.82 ETB /Year              |               |
| Total mean annual willingness to contribute | 235 ETB/Year |

*The cash equivalent of labor contribution is obtained by the multiplying 28.77 Days/year and adjusted average labor cost of 6.18 ETB per day. Note: At the time of the survey, 1 ETB was equal about 0.1 USD.

The total monetary value of reliable irrigation service is the summation of the two estimates. For this, the annual seasonal average wage rate (Table 2) can be used to convert labor contribution to monetary unit. However, sample respondents’ reported annual seasonal average wage rate might not be realistic for conversion of labor into monetary unit in areas where the market supply of labor is negligible. For example, in a watershed management valuation study, Kassahun et al. (2020) reported the estimated shadow wage rate is 38.63 % of the sample respondent average reported wage rate. Thus, to calculate the total monetary value of reliable irrigation service, first the sample reported wage rate is adjusted to reflect shadow wage rate in the local area. Since the situation in our study and Kassahun et al. (2020) are the same in terms of labor market and farming activities, we use their conversion factor. Accordingly, the monetary equivalent of labor contribution is equal to -177.82 ETB per kada.
of irrigable land per year. Hence, the average annual willingness pay for access to reliable irrigation service is 235 ETB (23.5 USD) per kada of irrigable land.

Here, considering the fraction of the lower-income respondents who are not able to contribute in cash, the total value of reliable irrigation service could be underestimated if reliable irrigation service would have been estimated using only monetary contribution. Of the total average annual willingness pay for access to reliable irrigation service, cash contribution comprises only 24.41%. The implication is that socially desirable projects might be rejected based on cost-benefit analysis as a result of welfare gain under estimation due to mismatch of payment vehicles choice in valuation studies.

6. Conclusions

Considering the limited importance of the cash economy in rural areas, many researchers in developing countries propose WTC as a means of welfare measurement along with the WTP value in monetary contribution. We agree on this, and further demonstrate that the use of two payment vehicles, money and cash, is needed to give valid welfare estimates in a setting where substitutability between payment vehicles is not smooth. In other words, no single payment vehicle can be used as a measure stick due to differences in endowment of the two and lack of substitutability between them. We demonstrate this through a rural household contingent valuation survey designed to elicit the value of access to reliable irrigation water in Ethiopia.

The average annual willingness pay for access to reliable irrigation service is 235 ETB per Kada of irrigable land. Of this, cash contribution comprises only 24.41%. We contribute with empirical evidence on the hypothesis that including both payment vehicles in valuation studies can capture the demand for environmental good in a more flexible and accurate manner for respondents with different endowments of income and labor. Thus, payment vehicle choice is an important consideration for valuation of environmental and natural resource in rural areas of developing countries and can help to avoid potential rejection of socially-desirable projects
based on cost-benefit analysis as resulting from under-estimation of demand due to inappropriate payment vehicles. However, value estimation that incorporates labor contribution for cost-benefit analysis should consider estimation of the shadow wage rare for the conversion of labor into a monetary unit. The face value of the labor wage rate obtained by asking respondents in a survey may not be a realistic representation of the wage rate in the absence of a functional labor market.

This article also provides empirical evidence that the assumption of exogeneity in the sequence of WTP and WTC valuation questions leads to a biased estimated coefficients and erroneous conclusions regarding the effect of cross-payment vehicle trade-offs. The implication is also valid for a choice experiment (CE) survey that allows the respondent to choose payment vehicles and administer the CE survey using the selected payment vehicle.

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