Do Supervisors Affect the Valuation of Public Goods?

Dina Franceschi and William F. Vásquez

Systematic supervision procedures have been proposed to improve contingent valuation surveying, particularly in developing countries. Surprisingly, the CV literature does not say much about the potential effects of supervision even though there is evidence of interviewer effects and social desirability issues that can bias results. This paper investigates the effects of interview supervision on the valuation of public services, using split-sample treatments to include a test of scope of a nested good and to assess the effect of interview supervision on reported WTP. Results suggest that supervisors can be used to improve quality with no effect on WTP estimates.

Key Words: contingent valuation, drinking water, Nicaragua, social desirability, supervision effects, willingness to pay

Survey-based stated preference approaches, such as the contingent valuation (CV) method, have proved to be useful in providing input for policy and planning purposes when a good or service is not traded in a market setting (Freeman 2003). Applying CV techniques to value public services and natural resources is becoming more common in developing countries where information on local preferences is scarce and consequently not included in the policy design process. Gunatilake et al. (2007) and Whittington (2002), however, point to the need to improve the quality of CV studies that are often poorly implemented, particularly in developing countries. Both Gunatilake et al. (2007) and Whittington (2002) provide a number of recommendations to enhance the quality of fieldwork in which they include implementing systematic supervision procedures. Field supervision entails assessing the quality of interviews, reviewing completed questionnaires before leaving the location, and ensuring that the intended sample is interviewed. In addition, shirking behavior by the interviewer has been observed (in this and other studies) by falsifying information or sample locations (Whittingon 2002), further motivating a supervisory model. Moreover, Whittington (2002) recommends supervision of interviews even if there is a language barrier between supervisor and interviewee, given that a lot can be learned from observing the body language of the interviewer and respondent.

Interview supervision, however, can be costly and counterproductive if respondents report different preferences in the presence of supervisors than they would report to the interviewer alone. Warren-Leubecker and Bohannon (1982), for instance, show that respondents systematically vary their speech when a foreigner accomplice participates as a listener in qualitative interviews. If respondents misreport their preferences before foreigners, Whittington's (2002) recommendation of using foreign supervisors would bias CV results. Surprisingly, the CV literature does not say much about the potential effects of supervising interviews even though there is evidence of interviewer effects and social desirability issues that can bias the results (Laughland, Musser, and Musser 1994, Legget et al. 2003, Loureiro and Lotade 2005).

CV results are reported to be sensitive to the survey administration mode (List et al. 2004), characterized as social desirability and yea-saying issues. Laughland, Musser, and Musser (1994) define social desirability as basing responses on social norms rather than individual values and show that CV studies may be influenced by social desirability. Legget et al. (2003) found that

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individuals report a higher willingness to pay (WTP) when the survey is implemented through in-person interviews, than when the survey is self administered. Marta-Pedroso. Freitas, and Domingos (2007) also found that in-person interviews produce higher WTP estimates compared to Web-based surveys. This evidence suggests that the presence of an interviewer may increase the reported WTP, consistent with social desirability bias. That is, respondents may misrepresent their true preferences and provide responses that they think will please the interviewer or that they believe to be consistent with societal norms (Legget et al. 2003). Based on this evidence, it may be expected that the presence of a supervisor in the interview may lead the respondent to provide answers that please the supervisor (and interviewer) rather than basing their answers on individual values, hence upwardly biasing the results.

Respondents may also answer strategically according to interviewer characteristics. For instance, interviewer appearance can have an impact on WTP, as shown by Bateman and Mawby (2004). They found that a more formal dress (business attire) is associated with higher WTP estimates in contrast to more casual clothing. Previous research has also found that respondents may be influenced by the gender of the interviewer (e.g., Groves and Fultz 1985). Loureiro and Lotade (2005) find that WTP estimates are also associated with the race of the interviewer. Race-of-interviewer effects have been found in telephone interviews (Cotter, Cohen, and Coulter 1982), as well as in virtual and live interviews (Krysan and Couper 2003). If racial differences exist between respondents and supervisors, the former can respond strategically and thus bias WTP estimates. In addition to appearance, racial differences can be identified in terms of language competence and accent. Expectations of the language competence of supervisors can also affect the response of interviewees (Warren-Leubecker and Bohannon 1982). Hence, using foreigners to supervise the implementation of CV surveys, as suggested by Whittington (2002), may be counterproductive.

This paper investigates the effect of interview supervision on CV outcomes in a developing country context. The CV method is used to elicit households' willingness to pay for improved, reliable water services in León, Nicaragua. Split-sample treatments were designed to include a test of scope of a nested good (i.e., with and without improvements of water quality) and to assess the effect of interview supervision on reported WTP. In-person interviews were conducted using a random sample of more than 600 geographically stratified households. Findings indicate that households would be willing to pay an increase of more than 56 percent in their monthly water bills for a reliable water system (i.e., no service interruptions), and an increase of almost 100 percent if water quality is also improved to be safe to drink. Results also suggest that supervisors can be used to improve the quality of CV studies in developing country contexts with no effect on WTP estimates.

The rest of the paper is organized as follows. The next section provides background details of the study location and water delivery systems in the area. Section three describes the survey design process for this particular study. Sections four and five provide the modeling theory and variable construction details. Section six presents the study results. The final section finishes with an impact analysis, suggested policy outcomes, and future research potential.

Background

León, Nicaragua, where our elicitation study was based, was the first capital city of Nicaragua after state independence in 1839; shortly afterwards, in 1858, Managua was selected to hold the seat permanently. Located in the northwest quadrant of the country, it is the second largest city, with a total population of 174,051, many of whom (139,433) live in the urban center of the municipality as of the 2005 Census (INEC 2006a). León hosts the main campus of the country's premier university, Universidad Nacional Autónoma de Nicaragua (UNAN), as well as strong and growing industrial, agricultural, and commercial sectors. León boasts the highest literacy rates in the country, 92.9 percent as of 2007 (MINED 2008a), which is significantly higher than the national rate, 86.5 percent (INEC 2006a). Yet León ranked only 49 (out of 153) on a countrywide educational index that includes net enrollment, repetition, retention, and promotion rates (MINED 2008b). The Ministry of Health reports that the third most significant reason for children aged 3-18 years old to miss school was illness, affecting 6.3 percent of the children, likely attributable, at least in part, to

water resources and consumption. The average number of years of schooling in 2007 in the Department (State) of León was 5.04 years (MINED 2008a).

The World Bank (2008) reports 36.9 percent of the population living under the poverty line in the city of León, with 7.1 percent in extreme poverty, which is below statewide rates of 49.4 percent and 13.1 percent, respectively. However, the availability of resources such as housing, water, and energy for residents of León is a mixed bag. Of the 39,895 homes within urban León, 31.9 percent were assessed to be constructed with inadequate materials for flooring and/or walls (INEC 2006b). Nevertheless, the majority of the population of León has access to water from a private faucet on their property, reported to be 94.1 percent in 2005, far higher than the national average of 80.3 percent (INEC 2006b).

Fifteen percent of Nicaragua's surface area is water, with about 75 rivers, 32 lagoons, and 2 lakes that cover 9,000 km^2 (Guevara Jerez 2007). Most of the tap water, however, comes from underground water sources—an estimated 73 percent to 90 percent, in fact. León in particular is endowed with the country's largest underground aquifer, though water access is still a challenge in the arid season. The Pan American Health Organization (PAHO) and the Nicaraguan Company of Water and Sanitation (ENACAL) rank León first among municipalities prone to droughts (PAHO and ENACAL 2004). In addition, the León aquifer is contaminated with high concentrations of agrochemical waste, as well as fecal coliform and bacteria (Guevara Jerez 2007, PAHO and ENACAL 2004). In reports assembled by the Ministry of Health in León (MINSA), the most prominent water-borne illnesses requiring hospital visits in 2008 were diarrhea/gastroenteritis (4,288 cases), intestinal parasites (3,736 cases), and giardiasis (1,470 cases) (MINSA 2008). These figures demonstrate that approximately 5.4 percent of the population seeks treatment for water-related illnesses. Throughout Nicaragua, other commonly reported illnesses related to water are typhoid fever, kidney failure, and chronic intoxication (Guevara Jerez 2007).

Three state institutions take responsibility for the provision of water services throughout the country: the Nicaraguan Institute of Water and Sanitation (INAA), the Social Investment Fund (FISE), and the Nicaraguan Company of Water and Sanitation (ENACAL). INAA is the regulator of water resources and is responsible for setting water tariffs and supervising the quality of water services. FISE aims at extending water infrastructure particularly to rural areas. ENACAL operates water and sanitation systems in urban areas. There exists a concentration of managerial, operational, and financial functions that diminish ENACAL's capacity to maintain water infrastructure and provide reliable water services (PAHO and ENACAL 2004). Attempts to decentralize water services at the state level failed in five states, including León. Limited federal funding and lack of cost recovery have jeopardized ENACAL's operations persistently. In 2003, INAA fixed water tariffs below supply costs in response to political pressures (World Bank 2008). ENACAL has operated in a financial deficit as a result, with a significant debt for overdue electricity bills (Guevara Jerez 2007). Currently, the central government has to subsidize ENACAL to operate water systems and maintain water infrastructure.

As a result of poor system operation and infrastructure maintenance, interruptions of water services have become more common in recent years. Major losses of water occur due to dated and damaged pipelines. In an interview conducted by the research team with the Mayor of León on June 4, 2009, he reported that the water delivery system, composed of seven pumps, is over 50 years old and that 30 percent of the water being extracted is lost before it reaches consumers, due to breaches in the piping and piping connections. The system seems to be unable to keep up with the demands of the rapidly growing population, which has more than doubled in the last decade. In addition, water treatment is limited to chlorination, and water quality is not tested on a regular basis. To cope with unreliable water services, consumers often purchase water from water vendors (e.g., bottled water), which can be up to five times more expensive than official water tariffs in Nicaragua (World Bank 2008).

Survey Design and Supervision Procedure

The CV method is a nonmarket valuation technique suitable for collecting information about household preferences for improved public goods and services in developing countries (Whittington 1998). This method requires careful survey design, choice of survey mode, and selection of a

random sample to be effective in eliciting household preferences (Bateman et al. 2002, Whittington 2002). In this study, the survey design follows an iterative approach based on a number of semi-structured interviews (with officials, activists, and water users) and two focus groups of water users. In addition, a pilot survey was implemented in the field by trained interviewers, with a random sample of 30 households.

The final version of the survey consisted of six sections. In the first section, respondents were asked to report their water uses and practices and to evaluate the current water system. In the second section, respondents reported on their consumption of bottled water, as households could reveal their preference regarding drinking water by consuming a substitute good for tap water (i.e., bottled water). Households were then asked in the third section about their expenditures on tap water, bottled water, and water from other sources. The fourth section included the contingent scenario, after which respondents were presented with a referendum valuation question where the total fee was randomly varied across the sample from C$100 to C$600 in increments of C$50 (the Cordoba is the national currency and was traded at about US$1:C$20 at the time of the survey in 2009). The CV question was followed by questions about the level of certainty of the reported referendum response and the perceived consequentiality of the survey. The fifth section of the survey asked about socio-demographic characteristics. Finally, interviewers were asked to evaluate the interview quality in the sixth section.

All respondents were presented with a basic good in the referendum, which consisted of providing tap water 24 hours per day, every day of the year. The experimental design also included four split-sample treatments (2x2), with variations in the water quality and in the supervision of the interview. This design allowed for a scope test for a nested good (Carson and Mitchell 1995). That is, in addition to the provision of uninterrupted water services, the quality of the water under the proposed system varied among respondents in two split-sample levels: (a) maintenance of current water quality, and (b) provision of safe drinking water. The design also varied in interview supervision: (a) unsupervised interview, and (b) supervised interview. Three undergraduate students and three graduate students were previously trained to supervise the interviews. Four of the six supervisors were females. While the level of Spanish varied among supervisors, they were trained to introduce themselves to respondents in Spanish and were provided with corresponding identifications that differed from interviewers' identification in title (interviewer vs. supervisor) and institution. Table 1 shows the number of household responses obtained for each split sample treatment in the experimental design.

Households were randomly selected according to a stratified random sampling strategy. Urban León was stratified into eight geographical zones. Then, parcels in each stratum were selected from a map that was used by the city of León for assessment and tax purposes in 2002. This map was the best framework for sampling, given that mailing addresses are not used in Nicaragua. Sampled households were randomly assigned one of the four treatments.

First, the CV scenario presented the characteristics of the existing water system, followed by an improvement in the water system reliability (no interruptions). The water quality varied according to the experimental design. Then, the CV question asked households to pay a monthly fee for improved water services and confronted respondents with their budget constraint. Finally, respondents were asked to vote for or against the project. The referendum voting question presented in the survey is as follows:

> *Keep in mind that current service of tap water in León is commonly interrupted. Suppose that León residents will have the opportunity to vote for or against a project that would improve the current drinking water system. With the new system, your household would have tap water 24 hours per day, every day of the year.*
>
> ***Current Quality: [The water quality would remain the same.]***
>
> ***Improved Quality: [In addition, the new system would treat water to make it totally safe to drink.]***
>
> *The new system would continue being administered by ENACAL in a global way. If the project is approved, your household would pay a total of* ***$FEE***

Table 1. Split-Sample Experimental Design

Survey Mode	Attributes		
	Reliable system with existing (unsafe) water quality	Reliable system and provision of safe drinking water	Total
Unsupervised	n =158	n = 155	n = 313
[local surveyor alone]	Average fee = 376.90	Average fee = 348.06	Average fee = 362.62
Supervised	n =153	n =142	n = 295
[local surveyor + foreign supervisor]	Average fee = 376.14	Average fee = 379.93	Average fee = 377.97
Total	n = 311	n = 297	n = 608
	Average fee = 376.53	Average fee = 363.30	Average fee = 370.07

Notes: Average fee is expressed in Nicaraguan currency, the Cordoba (1 US$ is equivalent to approximately 20.87 Cordobas as of June 2009).

per month for water services. Keep in mind that ***$FEE*** *per month spent on the improved drinking water services will not be available to purchase food, clothing, and other items needed in your household.*

Would You Vote For or Against the Project?

___In favor of the project

___Against the project

A follow-up question about the certainty of responses was included to estimate WTP for improved water services. Blumenschein et al. (2008) and Champ, Moore, and Bishop (2009) argue that this approach can be used to correct ex post for the possible existence of hypothetical bias. A number of recent studies show that recoding "Yes" responses based on the condition of at least a 7 (on a scale of 0-10) is required to mitigate hypothetical bias (Groothius, Groothius, and Whitehead 2007, Morrison and Brown 2009, Poe, Girard, and Loomis 2002, Whitehead and Cherry 2007). Thus, respondents were asked about the certainty of their voting responses on the dichotomous CV question using a scale from zero to 100 (where zero meant completely uncertain and 100 completely certain) as follows:

On a scale of 0 to 100, where 100 means completely certain, and 0 is completely uncertain, how sure are you of the answer you just gave to the voting question?

_____ / 0-100

Similar follow-up certainty questions using 0-10 or 0-100 scales, or categorical scales (ranging from definitely unsure to definitely sure) have been widely used in recent CV studies (see Berrens et al. 2004, Li et al. 2009, Vásquez et al. 2009).

Econometric Modeling

A utility-theoretic framework was used to model individual preferences for water services, in which $V(Y, W, P, Z)$ represents the indirect utility function of a household that increases with income (Y) and positive attributes of water services (W), including system reliability and water quality. In contrast, indirect utility (V) decreases with prices of other goods (P) and also depends

on relevant household characteristics (*Z*). This framework predicts that a household will be willing to pay for improvements of water services up to the extent that this payment does not decrease their utility below the original utility level as follows:

$$(1)\quad V(Y, P, W_0, Z) = V(Y\text{-}WTP_A, P, W_A, Z)$$

$$= V(Y\text{-}WTP_B, P, W_B, Z)$$

where W_0 represents the current provision of water services, and W_A represents the improved water service under the proposed referendum (i.e., uninterrupted water services). WTP_A represents the maximum willingness to pay for 24-hours-per-day provision of water services every day of the year. W_B represents a further improvement of water services, which include providing better *quality* of water in addition to uninterrupted water services (i.e., $W_A \subset W_B$). Therefore, a household's WTP for improved W_B is expected to be greater than WTP for the basic improvement W_A (i.e., $WTP_B > WTP_A$). This provides a test of scope for a nested good (Carson and Mitchell 1995).

The willingness to pay for improved water services is assumed to follow a log-linear form:

$$(2)\quad \text{LnWTP} = X\beta + e$$

where Ln*WTP* stands for the natural logarithm of a household's willingness to pay (WTP) for a change in the public water system; *X* is a vector of covariates that includes treatment variables (e.g., different scope levels of water services and interview supervision), household income and other characteristics; β is a vector of coefficients to be estimated; and *e* is the stochastic error term.

WTP for proposed water system improvements at the household level is not directly observed in the referendum data but is indirectly observed. It is expected that households will vote in favor of the proposed improvement only if Ln*WTP* is greater than or equal to the natural logarithm of the increased tax or fee (Ln*FEE*) presented to the respondent. Otherwise, the respondent is expected to vote against the improvement. Let *I* be an indicator equal to one, if the respondent votes in favor of the proposed improvement and equal to zero if the respondent votes against it. That is, *I*=1 if Ln*WTP*>Ln*FEE*, and *I*=0 otherwise. Given this equivalence, the indicator *I* and the variable Ln*WTP* censored by Ln*FEE* have the same distribution [i.e., P(*I*=1) = P(Ln*WTP*>Ln*FEE*)]. Cameron (1988) proposed using this equivalence to directly estimate WTP models from referendum voting data under the assumption that the stochastic error term in equation (2) follows a logistic distribution. This assumption allows for scaling the error term and hence directly estimating coefficients β even though Ln*WTP* is not observed as follows:

$$(3)\quad P(I=1) = P(\text{LnWTP} > \text{LnFEE})$$

$$= P(X\beta + e > \text{LnFEE})$$

$$= P(e/K > \text{LnFEE}/K - X\beta/K)$$

where *K* is a scaling parameter of the logistic function.[1] Cameron (1988) argued that the β coefficients obtained from the optimization of the corresponding log-likelihood function could be interpreted as equivalent to the marginal effects of an OLS equation. This paper follows Cameron's (1988) censored logistic regression procedure to directly estimate WTP models.

The CV method has been shown to be subject to upward hypothetical bias. While a referendum format has been proposed to minimize hypothetical bias (Arrow et al. 1993, Carson and Groves 2007), there is not consensus that this format can completely eliminate such bias (Little and Berrens 2004, Murphy et al. 2005). Blumenschein et al. (2008) argued that hypothetical bias may be reduced by recoding responses to the referendum voting question, based on the certainty of household responses measured on a scale of 0 to 100, where 0 means absolute uncertainty and 100 means absolute certainty (e.g., Berrens et al. 2002, 2004). Following Groothius, Groothius, and Whitehead (2007), Morrison and Brown (2009), and Whitehead and Cherry (2007), the responses to the referendum voting question in this study are recoded as favorable answers only if the respondent votes in favor of the proposed improvement (*I*=1) and reports a certainty of response to the referendum question above the threshold of 70. Otherwise respondents are assumed to be against

[1] The parameter *K* is related to the standard deviation of the error term where $K = \sigma_e\sqrt{3}/\pi$.

Table 2. Variables Definition and Descriptive Statistics

Variable	Definition	Mean	S.D.
LnFEE	Natural log of the additional fee charged for water improvement presented to respondents in the CV survey	5.82	0.46
QUALITY	Quality of the tap water to be provided (1=safe drinking water; 0=maintaining the current water quality)	0.49	0.50
SUPERVISED	If the interview was supervised (1=Yes, 0=Otherwise)	0.49	0.50
INCOME	Household's income grouping, in Nicaraguan Cordobas (0=no income, 1=less than 1000, 2=1001 to 2000, 3=2001 to 3000, 4=3001 to 4000, 5=4001 to 5000, 6=5001 to 6000, 7=6001 to 7000, 8=7001 to 8000, 9=8001 to 9000, 10=9001 to 10000, 11=more than 10000) [1 US$ = 20.87 C$]	4.07	3.15
EDUC	Respondent's education (in years of schooling)	10.00	4.84
HOURSATIS	Subjective perception of the number of hours of water supply on a 5 point scale (1=very bad, 2=bad, 3=regular, 4=good, 5=very good)	3.30	0.99
BOTTLEWAT	If the household currently consumes bottled water on a regular basis (1=Yes, 0=Otherwise)	0.37	0.48
AGE	Age of respondent (in years)	43.95	17.78
OWN	If the respondent household is owner of the house (1=Yes, 0=Otherwise)	0.87	0.34
POTENTIAL	If the respondent thought that the proposed project could be implemented in León (1=Yes, 0=Otherwise)	0.68	0.47
INTEREST	If the respondent showed any interest by asking any question regarding the implementation of the new water system during the interview (1=Yes, 0=Otherwise)	0.38	0.49
LISTENING	If there was anyone else (other adult household member) with the respondent during the interview (1=Yes, 0=Otherwise)	0.36	0.48

the proposed improvement. The recoded indicator is then used to estimate WTP models through Cameron's (1988) censored logistic regression procedure. This approach provides more conservative and presumably realistic estimates of the household's WTP (Blumenschein et al. 2008, Vossler et al. 2003).

Variables and Hypotheses

Table 2 presents the definitions and descriptive statistics of the variables used in the analysis. The dummy variable *QUALITY* is used to estimate the effect of the change in the scope of water system services through the absence or presence of water treatment to purify drinking water, combined with the improvement in system reliability. The variable *SUPERVISED* is included to observe individuals' responses to the presence of a supervisor in the interview. The variable *HOURSATIS* is included to measure the effect of households' perception about the current water system reliability on WTP for safe drinking water. The effects of the household's averting behavior are estimated by including the variable *BOTTLEWAT*. The respondents' characteristics include *AGE, INCOME, EDUC*, *OWN,* and some other relevant variables. Specifically, the variable *INTEREST* is included to gauge the household's interest in the proposed water project. The variable *LISTENING* is used to capture the potential social contexts (List et al. 2004). The variable *POTENTIAL* is an indicator of whether sampled households believe that the project is feasible.

Table 3. Average Profile of Respondents

Description	Mean	S.D.
Age of the respondent (in years)	43.95	17.78
Number of schooling years of the respondent	10.00	4.84
Number of adult males in the household (>15 years)	1.69	1.29
Number of adult females in the household (>15 years)	2.17	2.25
Number of children in the household (<15 years)	1.24	1.33
Percentage of female respondents	66.28%	57.31%
Monthly household income (in Cordobas)	3614.31	3096.02
Number of rooms in the housing unit	2.72	1.47
Percentage of households who own the housing unit	86.68%	34.01%

In addition to estimating WTP of a representative household, we also test a number of specific hypotheses (against the null of no effects). The first hypothesis (H_1:$\beta_{QUALITY}>0$) posits that household WTP for safe drinking water increases with improvements in water quality. Given that the split-sample treatment is designed in terms of valuing only an improvement in system reliability or valuing an improvement both in system reliability and water quality, then this is a test of scope of a nested good (Carson and Mitchell 1995). The split-sample treatment also allows for estimating the effect of supervising the interview. No previous expectations are held for the supervision effect, given that existing theory and evidence are very limited. Thus, hypothesis H_2:$\beta_{SUPERVISED} \neq 0$ states that supervising the interview may have an effect on WTP for a reliable water system, but it does not indicate the direction of such an effect.

As a measure of construct validity, in the theoretical framework it is assumed that safe and reliable drinking water is a normal good (a positive income effect on the WTP), as stated in hypothesis H_3:$\beta_{INCOME} > 0$ (Whitehead 1995). As a further measure of construct validity (and the substitution effect), hypothesis H_4:$\beta_{BOTTLEWAT} > 0$ implies that households who purchase bottled water are expected to report a higher WTP, given that the proposed improvement in the water system would be expected to provide a less expensive substitute for bottled water. Hypothesis H_5:$\beta_{HOURSATIS} < 0$ states that households with a better perception of the water system reliability (*HOURSATIS*) are expected to report a lower WTP since they may perceive a smaller improvement from the current water supply system.

We also evaluate a number of more open conjectures in hypotheses H_6:$\beta_{POTENTIAL} > 0$ and H_7:$\beta_{LISTENING} < 0$. As stated in H_6, it is expected that households are more likely, ceteris paribus, to support a project (vote "Yes" on a referendum) when they consider it to be feasible and consequently believe that the survey will ultimately impact policy (Herriges et al. 2010). Further, a number of studies have found potential upward social desirability bias (e.g., List et al. 2004) when individuals give valuation responses in front of others; however, these usually do not involve household members, which instead might

Table 4. Averting Behavior of Sampled Households

Description	Mean	S.D.
Percentage of households with water storage facilities at home	77.14%	42.03%
Investment and maintenance cost of water storage facilities, annual	245.02	697.84
Percentage of households who treat tap water at home	25.16%	43.43%
Percentage of households who boil tap water at home	15.13%	35.86%
Percentage of households who filter tap water at home	3.29%	17.85%
Percentage of households who treat tap water at home with chlorine	8.72%	28.23%
Percentage of households who drink tap water	94.88%	22.05%
Percentage of households who purchase bottled water	37.13%	48.35%
Weekly expenses on bottled water (of those households who reported that they buy and consume bottled water)	58.55	91.96
Monthly expenses on tap water	263.36	243.19

Notes: Maintenance cost, expenses on bottled water, and expenses on tap water are expressed in Nicaraguan currency, Cordoba (1 US$ = 20.87 C$).

be expected to be a check on any yea-saying behavior. Thus, H_7 holds that WTP will be lower when another household member is listening.

Results

Table 3 shows the average profile of respondents and their households. As the surveys were implemented predominantly during the daytime hours, most of the respondents were females (66.28 percent), with an average age of about 44 years and 10 years of schooling. On average, 5 people live in each household, with more than 2 adult females, about 1.7 adult males, and slightly above 1 child. Almost 87 percent of the respondents own their homes (with an average of 2.72 rooms). Respondents reported an average monthly household income of 3,614.31 Cordobas (US $173.418).

León's inhabitants have adopted several water practices to cope with unreliable water services. In the last year, more than 77 percent of sampled households invested an average of 245.02 Cordobas in water storage facilities (see Table 4). While almost 95 percent of respondents report that they drink tap water, more than 25 percent treat tap water at home. The most popular treatment is boiling tap water, followed by treating tap water with chlorine, and then water filtering. These indicators suggest that the quality of water is unsatisfactory for drinking purposes. Along the same line, more than 37 percent of sampled households spend 58.55 Cordobas per week on bottled water, which accounts for about 6.5 percent of the average income. If spending on storage facilities and bottled water is added to a monthly average of 263.36 Cordobas spent on tap water, an average household may spend as much as 14.8 percent of the average monthly income on water (535.54 Cordobas). This expenditure on water seems to be high, particularly in a developing country.

Table 5. Estimated Willingness To Pay Models

Variables	Model 1: Referendum with No Certainty Correction [Sample = Pooled]	Model 2: Referendum with No Certainty Correction [Sample = Supervised]	Model 3: Referendum with No Certainty Correction [Sample = Unsupervised]	Model 4: Referendum with 70% Certainty Correction [Sample = Pooled]	Model 5: Referendum with 70% Certainty Correction [Sample = Supervised]	Model 6: Referendum with 70% Certainty Correction [Sample = Unsupervised]
SUPERVISED	0.076	---	---	-0.053	---	---
	(0.116)			(0.134)		
QUALITY	0.236	0.524	0.039	0.370 (0.136)***	0.687	0.189
	(0.115)**	(0.233)**	(0.119)		(0.345)**	(0.123)
INCOME	0.075	0.102	0.042	0.080 (0.024)***	0.125	0.047
	(0.021)***	(0.043)**	(0.021)**		(0.063)**	(0.021)**
EDUC	0.008	-0.007	0.022	-0.003	-0.030	0.014
	(0.014)	(0.025)	(0.015)	(0.016)	(0.038)	(0016)
HOURSATIS	-0.070	-0.144	-0.027	-0.056	-0.074	-0.044
	(0.057)	(0.109)	(0.057)	(0.064)	(0.151)	(0.057)
BOTTLEWAT	0.143	0.018	0.192	0.017	-0.197	0.106
	(0.124)	(0.218)	(0.138)	(0.140)	(0.313)	(0.137)
AGE	-0.009 (0.004)**	-0.012	-0.006	-0.008	-0.018	-0.003
		(0.007)*	(0.004)	(0.004)*	(0.011)	(0.004)

(Continued)

Table 5. Estimated Willingness To Pay Models (continued)

OWN	0.079	-0.033	0.153	0.096	0.082	0.122
	(0.166)	(0.306)	(0.173)	(0.190)	(0.425)	(0.178)
FEMALE	0.086	-0.019	0.167	0.081	-0.175	0.196
	(0.122)	(0.218)	(0.131)	(0.139)	(0.305)	(0.135)
POTENTIAL	0.909	1.035	0.769	0.915	0.929	0.790
	(0.166)***	(0.332)***	(0.161)***	(0.194)***	(0.452)**	(0.166)***
INTEREST	0.099	0.420	-0.144	0.203	0.541	-0.019
	(0.118)	(0.237)*	(0.122)	(0.137)	(0.338)	(0.123)
LISTENING	-0.028	-0.075	-0.019	-0.069	-0.264	0.005
	(0.117)	(0.208)	(0.129)	(0.135)	(0.304)	(0.131)
Constant	5.124	5.553	5.007	4.856	5.312	4.737
	(0.396)***	(0.725)***	(0.408)***	(0.463)***	(1.026)***	(0.430)***
K	0.559	0.723	0.399	0.656	1.053	0.405
	(0.078)***	(0.170)***	(0.065)***	(0.098)***	(0.329)***	(0.066)***
Observations	563	278	285	563	278	285
Log Likelihood	-306.84	-158.08	-140.16	-319.91	-168.88	-140.37
AIC	641.68	342.17	306.33	667.81	363.76	306.74
BIC	702.35	289.32	353.81	728.47	410.92	354.22
Maddala R^2	0.169	0.164	0.272	0.128	0.145	0.250

Notes: Dependent variable = Vote (Yes/No). ***, **, * imply significance at 1 percent, 5 percent, and 10 percent levels, respectively; numbers in parentheses are corresponding standard errors.

Table 5 shows six WTP models estimated using individuals' responses to the referendum and certainty questions presented in the section Survey Design and Supervision Procedure. Models 1, 2, and 3 are based on the raw responses to the referendum question. Model 1 is estimated using the pooled sample. Models 2 and 3 are estimated using the subsamples of supervised and unsupervised interviews, respectively. Models 4, 5, and 6 are estimated using the referendum responses corrected for a 70 percent certainty level or above to mitigate potential hypothetical bias (Morrison and Brown 2009, Whitehead and Cherry 2007). These models (4, 5, and 6) are also estimated using the pooled, supervised, and unsupervised samples, respectively. Since Cameron's (1988) approach is used to estimate all models, estimated coefficients are interpreted as semi-elasticities of WTP with respect to the associated variable (i.e., $\beta_X = \partial \text{Ln}WTP/\partial X$). In terms of the signs and significance of the explanatory variables, the results in Table 5 show a considerable degree of robustness across six models.

In support of hypothesis H_1, the estimated coefficients on *QUALITY* are positive and statistically significant for the pooled-sample and supervised-sample models (see Models 1, 2, 4, and 5). This result shows evidence of sensitivity to scope for a nested good (Carson and Mitchell 1995). That is, individuals are willing to pay more for a reliable system that provides safe drinking water than for tap water with the current quality. Similar results are found by Vásquez et al. (2009) in Parral, Mexico. However, the estimated coefficients on *QUALITY* are statistically insignificant for WTP models estimated using the unsupervised sample. This may raise the question about a potential structural change in coefficients between supervised and unsupervised samples. Likelihood-ratio tests rule out this possibility for models based on the raw voting data (χ^2=17.61), indicating that supervised and unsupervised samples can be pooled, but they suggest a structural change in the coefficients when voting data is corrected for 70 percent of certainty (χ^2=21.47) based on a 5 percent significance level test. These results provide ambiguous evidence against hypothesis H_2. Models 1 and 4, however, indicate that interview supervision has no effect on reported WTP, as corresponding coefficients are not statistically significant in contrast to hypothesis H_2. This evidence shows an absence of supervisor effect from the use of supervisors with interviewers, even if they are foreigners, to improve the quality of CV survey data in developing countries as recommended by Gunatilake et al. (2007) and Whittington (2002). Results not presented here, but available upon request, show that this effect holds for female and male supervisors, and for all individual supervisors but one who is associated with lower WTP estimates (only at a 10 percent significance level).

Consistent with the hypothesis that water is a normal economic good (i.e., hypothesis H_3) and with previous studies in Latin American contexts (e.g., Rodríguez, Southgate, and Haab 2009, Soto Montes de Oca and Bateman 2006), a household with a higher income would pay more for reliable water services as shown by the positive and significant coefficient of *INCOME* across all models (see Table 5). In contrast, the evidence does not appear to support H_4, since there is no statistical difference between the WTP of households who purchase and consume bottled water and households who do not. This result is in accord with the findings of Vásquez et al. (2009) who also report insignificant effects of bottled water consumption on WTP for improved water services in Mexico, but it contradicts the positive and significant impact of monthly expenses for water outside the home that Casey, Kahn, and Rivas (2006) found in Brazil. Also, in contrast to hypothesis H_5, the estimated coefficients on *HOURSATIS* indicate that households with a more positive perception of the number of hours with water services are not willing to pay less than households with a bad perception of the service hours. Similarly, Rodríguez, Southgate, and Haab (2009) found no WTP differentials between households that experience water service interruptions and households with no interruptions in the 12 months previous to their study in Ecuador.

Table 5 also presents evidence in support of hypothesis H_6. The estimated coefficients on *POTENTIAL* suggest that individuals who believe that the project may be implemented in the city of León report a higher WTP than individuals who do not [see Vásquez et al. (2009) for similar results in Parral, Mexico]. Respondents who believe in the project's feasibility may also believe that the survey will have policy consequences and therefore tend to report higher WTP (Herriges et

Table 6. Comparison of Median WTP, with Corresponding Confidence Intervals

	Median WTP	95% CI Lower Bound	95% CI Upper Bound	Median WTP in Relation to Current Tap Water Expenditure (%)	Median WTP in Relation to Reported Household Income (%)
Model 1 (Pooled, No Certainty Correction)					
QUALITY=1	397.57	336.10	466.39	198.79%	14.44%
QUALITY=0	313.90	266.92	363.94	156.95%	11.40%
Model 2 (Supervised, No Certainty Correction)					
QUALITY=1	512.38	363.24	717.09	256.20%	18.61%
QUALITY=0	303.53	225.40	400.33	151.77%	11.02%
Model 3 (Unsupervised, No Certainty Correction)					
QUALITY=1	334.44	284.24	388.81	167.22%	12.15%
QUALITY=0	321.70	269.15	382.65	160.85%	11.68%
Model 4 (Pooled, 70% Certainty Correction)					
QUALITY=1	322.53	267.58	385.12	161.27%	11.71%
QUALITY=0	222.68	177.37	271.31	111.34%	8.09%
Model 5 (Supervised, 70% Certainty Correction)					
QUALITY=1	339.55	232.65	502.82	169.78%	12.33%
QUALITY=0	170.86	92.40	303.21	85.43%	6.20%
Model 6 (Unsupervised, 70% Certainty Correction)					
QUALITY=1	310.42	263.88	364.53	155.21%	11.27%
QUALITY=0	256.98	213.41	310.35	128.49%	9.33%

Notes: 95 percent CI is derived using the Krinsky and Robb (1986) procedure (using 5,000 simulations).

al. 2010). No evidence was found that indicates that the social context in which the interview is conducted affects the reported WTP, in contrast to hypothesis H_7.

Other respondents' characteristics such as *EDUC, OWN*, and *FEMALE* do not impact the WTP for reliable water services. Vásquez et al. (2009) also found insignificant effects of education and home ownership, and Soto Montes de Oca and Bateman (2006) found no difference between WTP for male and female respondents. Similarly, the interest shown by the respondents by asking for the project implementation potential has no effect on reported WTP. However, the estimated coefficients of *AGE* suggest that the WTP for reliable water services decreases with the respondent's age in accordance with the findings of Casey, Kahn, and Rivas (2006), Soto Montes de Oca and Bateman (2006), and Vásquez et al. (2009). The estimated coefficient on the scale

parameter *K* (the negative of the inverse of the fee coefficient in a regular logit model) is positive and significant, implying that respondents are sensitive to the price (Cameron 1988, Whitehead 1995).[2]

Table 6 presents the median WTP for reliable water services with corresponding 95 percent confidence intervals, calculated using Krinsky and Robb's (1986) boot-strapping procedure (with 1,000 simulations), and a comparative perspective of WTP estimates in relation to current expenditures spent on tap water and also in relation to median household income. The median WTP for reliable water services estimated using the pooled sample (Model 1) is 313.90 Cordobas per month if the water quality is maintained at current levels and 397.57 Cordobas if the improved system provides safe drinking water. This estimate accounts for more than 150 percent of current median expenditures on tap water, or an increase of more than 50 percent in the median water bill, and more than 11 percent of median monthly income if current quality levels are maintained. The median WTP almost doubles the current median expenditure on tap water when households are presented with a reliable system that provides safe drinking water. This median WTP accounts for more than 14 percent of median monthly household income. Similar WTP estimates are obtained when using supervised and unsupervised samples if current quality levels are maintained. However, when households are presented with a reliable system that provides safe drinking water, the WTP estimated using the supervised sample is higher than the one based on the unsupervised sample, with the former reaching about 18.6 percent of the median household income. This is consistent with the (in)significance of *QUALITY* coefficients for the supervised and unsupervised samples presented in Table 5 (see Models 2 and 3).

More conservative (but still significant) estimates are presented by Models 4, 5, and 6, in which responses are corrected for 70 percent certainty. Estimates based on Model 4 indicate that the median household is willing to pay at least 222.68 Cordobas per month, or more than 8 percent of median monthly income, if current quality levels are maintained. That is equivalent to an increase of at least 11.34 percent in current water bills. If the improved system provides safe drinking water, the median WTP is 310.42–339.55 Cordobas (depending on the model), which corresponds to an increase of more than 55 percent in water bills. That is, households are willing to pay more than 11 percent of the median monthly household income.[3] As a point of comparison, Vásquez et al. (2009) report that households in Parral, Mexico are willing to pay as much as 11.5 percent of their income for reliable and safe drinking water. Soto Montes de Oca and Bateman (2006) note that earlier CV studies conducted in urban communities in Asian and African countries report a willingness to pay for an improved water supply system of 50 percent to 340 percent of the existing water bills. WTP estimates presented in this paper for León, Nicaragua appear to lie in the lower half of that range.

WTP estimates are compared through formal tests based on a complete combinatorial approach suggested by Poe, Girard, and Loomis (2005) to further investigate the effects of interview supervision (see Table 7). Poe, Girard, and Loomis (2005) show that probabilities calculated through combinatorial approaches are analogous to conventional *p* values for hypothesis testing. The underlying distributions generating uncorrected median WTPs are similar if current quality levels are maintained. However, if safe drinking water is provided, uncorrected median WTP distributions seem to be different, with both the pooled and supervised samples generating higher estimates than the unsupervised samples (significant at 10 percent and 5 percent levels, respectively). This is expected, as the estimated coefficient on *QUALITY* is significant for the pooled and supervised samples, but statistically insignificant for the unsupervised sample. As mentioned above, likelihood-ratio tests rule out the possibility of structural changes in coefficients across supervised and unsupervised samples when voting responses are not corrected for (un)certainty. Distributions of WTP corrected for 70 percent cer-

[2] Results reported in Table 5 are robust across different model specifications not reported here but available upon request. For instance, averting behavior variables other than tap water (e.g., households that treat tap water at home and that have storage facilities) were included in model estimations. Results showed that those variables are statistically insignificant and that reported findings are unchanged.

[3] Even more conservative estimates are obtained when voting responses are corrected for 80 percent and 90 percent certainty. If the presented system provides safe drinking water, estimates corrected for 80 percent and 90 percent certainty suggest that households would pay 258.75 and 195.29 Cordobas, respectively. If the current quality level is maintained, the WTP estimated is 183.18 Cordobas for 80 percent certainty correction, and 116.67 Cordobas for 90 percent certainty correction.

Table 7. Tests of Median WTP Differences

	Probabilities of significant differences in median WTP: QUALITY=1	Probabilities of significant differences in median WTP: QUALITY=0
No Certainty Correction		
$P(WTP_{pooled} > WTP_{unsupervised})$	0.929	0.416
$P(WTP_{pooled} > WTP_{supervised})$	0.101	0.585
$P(WTP_{supervised} > WTP_{unsupervised})$	0.987	0.362
Corrected for 70% certainty		
$P(WTP_{pooled} > WTP_{unsupervised})$	0.612	0.156
$P(WTP_{pooled} > WTP_{supervised})$	0.427	0.801
$P(WTP_{supervised} > WTP_{unsupervised})$	0.635	0.097

tainty are similar, with the exception of the WTP distribution from the unsupervised sample, which generates higher WTP estimates than the supervised sample (at a 10 percent significance level) if current water quality is maintained.

Conclusions

Findings indicate that there is a latent demand for improved water services as households adopt different practices to cope with current, unreliable water services. Conservative estimates requiring at least a 70 percent certainty level on responses indicate that households are willing to pay an increase of at least 11 percent in their current water bills for uninterrupted water services. That increase can be as high as 60 percent over monthly water bills when a minimum level of certainty is not required. In total, households would be willing to pay 6.2 percent to 11.7 percent of the reported median household income for uninterrupted water services, which is above a suggested affordability threshold of 3 percent of household income (OECD 2003). Results show scope sensitivity in reported WTP, which serves as a test for validation of CV studies (Arrow et al. 1993, Soto Montes de Oca and Bateman 2006). According to conservative estimates, households are willing to pay at least an increase of 55 percent in the water bill when the system proposes to treat water to safe levels, in addition to providing uninterrupted water services. In total, households would pay at least 11 percent of their income, which is consistent with the average water expenditure of households investing in storage facilities and purchasing bottled water (about 14.8 percent of the average monthly income). As a further test for validity, results indicate that WTP for improved water services is positively related to income, and the probability of voting for the improved system is negatively associated with the level of the proposed fee (Whitehead 1995).

The focus of this study is on the effects that interview supervision may have on reported willingness to pay for improved water services in a developing country context. This is an issue that has received little attention in the CV literature even though there is extensive evidence that CV studies can be affected by social desirability bias, interviewer effects, and social isolation issues (Laughland, Musser, and Musser 1994, Legget et al. 2003, List et al. 2004, Loureiro and Lotade 2005). Results suggest that the presence of supervisors in the interview do not affect the WTP

estimates. That is true even when foreign individuals who do not speak the local language fluently or understand the local culture fully are used as supervisors. Thus, this analysis has a methodological implication: supervisors can be used to enhance the quality of CV data collection, as recommended by Gunatilake et al. (2007) and Whittington (2002). That is, foreign supervisors may assess the quality of interviews, review completed questionnaires before leaving the location, and ensure that the intended sample is interviewed.

We hope that the results from this study help stimulate further investigation regarding supervision effects on CV outcomes. Logical extensions would be to assess supervision effects in stated preference methods other than the referendum elicitation format (e.g., open-ended question and choice experiments), as the latter has proved to reduce other types of issues such as hypothetical bias (Murphy et al. 2005). It is also important to analyze supervision effects in the valuation of other goods, given that social desirability bias seems to vary across different products and services (Loureiro and Lotade 2005). While the evidence presented here cannot be deemed conclusive, it suggests that supervising may help improve the quality of fieldwork in developing countries.

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