Scope sensitivity in households' willingness to pay for maintained and improved water supplies in a developing world urban area: Investigating the influence of baseline supply quality and income distribution upon stated preferences in Mexico City

Gloria Soto Montes de Oca[1,2] and Ian J. Bateman[1,3]

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[1] We present the first assessment of willingness to pay (WTP) for water supply change to be conducted in the largest city in the developing world: Mexico City. Two large sample contingent valuation surveys are conducted to investigate WTP for two levels of water service quality: maintenance of or improvement over current provision levels. This study design permits one of the first tests of the "scope sensitivity" of WTP responses to different levels of baseline supply provision. This testing is complicated within the present case because as our study confirms, higher-income households typically enjoy better levels of current provision, while poorer households generally endure lower current standards of water supply. We incorporate this heterogeneity of service and correlation with income within a suite of novel scope sensitivity tests. These confirm prior expectations that richer households enjoying higher baseline service levels would prefer programs to maintain the status quo, while poorer households enduring lower initial quality of service would prefer schemes which improve the quality of supplies. The implications of these findings are further investigated by contrasting conventional benefit-cost analysis aggregation procedures with an equity weighting approach which confirms the difference in priorities according to initial supply conditions. In this case, the ranking of programs changes when the ability to pay is equalized across society. In fiscal terms, aggregate WTP figures show that authorities could collect the resources necessary to fund households' preferred schemes and simultaneously substantially reduce current subsidies.

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1. Introduction

[2] Many large urban areas in developing countries face severe and long-term challenges regarding the sustainability of their water supplies. The enormous volumes of water and the extent of the infrastructure development required to meet demand have frequently exceeded supply capacity and generated acute environmental imbalances [*Hardoy et al.*, 1992; *Serageldin*, 1994; *International Environmental Technology Centre*, 1997; *Drakakis-Smith*, 2000]. While the costs of addressing this issue are enormous and are frequently the focus of considerable political pressures within such countries, international financing agencies argue that the necessary resources need to come from domestic consumers [*World Bank*, 1991; *Brookshire and Whittington*, 1993; *Asian Development Bank*, 1999]. These pressures, allied with greater reliance among such agencies upon benefit-cost analysis (BCA), have led to an increased interest in the assessment of households' willingness to pay (WTP) for changes in water supplies *Hensher et al.* [2005].

[3] Despite the rapid growth of urban populations in developing countries, to date most applications have perhaps surprisingly focused upon rural communities in such countries. These studies suggest a positive, although highly variable, WTP for supply improvements [*Brookshire and Whittington*, 1993; *Briscoe et al.*, 1993; *Saleth and Dinar*, 2001] with some evidence that values were higher for groups enduring lower initial ("baseline") levels of supply [*Altaf et al.*, 1992]. The magnitude of estimated WTP can be substantial, reflecting the value of the resource under investigation. On the basis of the few African and Indian case studies that have examined WTP in an urban developing country contexts it seems that values for improvements are typically around 5% but range up to 18% of household income [*McPhail*, 1993; *Goldblatt*, 1999]. Given that tariffs in many such areas are typically highly subsidized, these WTP sums often represent very substantial increases in water bills, ranging between 50% to 340% of

[1]Centre for Social and Economic Research on the Global Environment, School of Environmental Sciences, University of East Anglia, Norwich, UK.
[2]Also at Department of International Studies, Universidad Iberoamericana, Mexico City, Mexico.
[3]Also at School of Agricultural and Resource Economics, University of Western Australia, Perth, Western Australia, Australia.

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current levels [*Zerah*, 1998; *United Nations Development Programme*, 1999].

[4] Subsidy schemes are frequently prompted by the heterogeneous service conditions which characterize many large urban areas in developing countries. Water supply problems are typically unevenly distributed across such societies with poorer households enduring lower levels of service provision than their wealthier neighbors [*World Bank*, 1988; *Fass*, 1988; *Goldblatt*, 1999; *World Health Organization*, 2000; *Wegelin-Schuringa*, 2001; *Saleth and Dinar*, 2001]. For instance, while recommended daily water consumption is 150 liters per person and at least 40 liters to ensure sanitary conditions, among poorer groups in developing countries consumption is likely to be less than half this minimum recommendation [*Fass*, 1993; *Drakakis-Smith*, 2000]. However, while prompted by good intentions, subsidy schemes are frequently economically inefficient [*Brookshire and Whittington*, 1993; *Boland and Whittington*, 2000]. Given that the incidence of poor water supply is typically related to income distribution, with higher-income households enjoying better water supply, wealthy households are at least (if not more) likely to capture the benefits of subsidies than are poor households [*Serageldin*, 1994; *Briscoe*, 1999; *Schwartz and Clements*, 1999; *Boland and Whittington*, 2000; *Foster et al.*, 2000]. This correlation between low incomes and poor water supplies raises empirical problems in the modeling of WTP and for undertaking BCAs of investments in supply improvements and alternatives to subsidy schemes. Here analysts need to be aware that the income constraint will bind hardest upon those who are likely to gain most in welfare terms from supply improvements. The need to address this problem provides the central focus and methodological contribution of the present paper.

[5] A commonly applied approach for assessing WTP for improved water services is the contingent valuation (CV) method [*Whittington and Swarna*, 1994]. This employs survey-based techniques to directly elicit households' preferences [*Mitchell and Carson*, 1989; *Arrow et al.*, 1993; *Bateman et al.*, 2002]. The technique requires the construction of a contingent market through which respondents may state their WTP for a specified provision change in a particular good. Because of the hypothetical nature of this market there is considerable emphasis upon the need to validate results. This is most often achieved through theoretical validity tests [*Mitchell and Carson*, 1989; *Arrow et al.*, 1993; *Bateman et al.*, 2002] wherein WTP responses are subject to econometric modeling techniques designed to test the conformity of findings with prior expectations derived from economic theory. Arguably the most important of these tests, and one highlighted in best practice guidelines [*Arrow et al.*, 1993], is the "scope sensitivity" test. This concerns the expectation that, as the magnitude of the specified provision change increases so should WTP (or, more accurately, WTP should increase up to a level of consumption at which demand is satiated and not decline thereafter).

[6] As noted above, when estimating WTP for water supply improvements within developing countries the scope test is complicated by the fact that income levels are correlated with current levels of supply, such that those who would benefit most from a provision change to some specified level are those least able to pay for such changes. We therefore need to discriminate between the influences of income and provision change upon WTP. This requires more than simply controlling for variations in income within an estimated WTP bid function as the level of provision change varies across respondents and is correlated with income. This study provides a solution to this problem via a split sample design in which survey respondents are (unbeknown to themselves) randomly allocated to one of two samples, each facing a differing scenario as follows.

[7] 1. The first sample is presented with a scenario in which policy ensures that the status quo levels of provision (which vary across households) is maintained so as to avoid a specified "do-nothing" alternative state in which supply quality would reduce to a specified lower level (equivalent to the lower bound provision level suffered within the study area). This is subsequently referred to as the "maintenance" scenario.

[8] 2. The second sample is presented with a scenario which improves supply quality from the status quo level enjoyed (endured) by each household to a specified common higher level (equivalent to the upper bound provision level enjoyed within the study area). This is subsequently referred to as the "improvement" scenario.

[9] This split sample approach provides the classic treatment test of any hypothesis and is the standard approach to testing for scope sensitivity [*Kahneman and Knetsch*, 1992]. The alternative approach of asking the same group of respondents to value two schemes can encounter problems of sequencing where values become dependent upon the order in which schemes are presented to respondents [*Carson et al.*, 1998, *Bateman et al.*, 2004].

[10] The split sample, dual scenario approach also allows us to formulate two novel approaches to scope sensitivity testing. First, given the strong positive correlation between income levels and current levels of provision (which we confirm as part of our subsequent discussion of results), we have different expectations for our scope sensitivity test depending on the current income/provision level of the household. We expect households with higher levels of income (and therefore, typically, higher status quo levels of current provision) to have greater WTP for the maintenance scenario (WTP_M) than for the improvement scenario (WTP_I) as the former avoids a substantial loss in provision relative to the more modest gains of the latter. For similar reasons, scope sensitivity would require that poorer households (who typically have lower status quo levels of current provision) will have WTP_M lower than WTP_I as the former concerns a smaller provision change than the latter. Put simply, given a positive correlation between household income and current provision levels, then the scope sensitivity requirement can be formalized within the following hypotheses (in which the superscripts H and L denote higher- and lower-income households, respectively):

$$H_o^1 : WTP_M^H \geq WTP_I^H$$

$$H_o^2 : WTP_M^L \leq WTP_I^L$$

[11] This is a new form of scope sensitivity test, not assessed in prior studies. Yet we argue that such a test, is more rigorous than prior analyses as failure to satisfy both

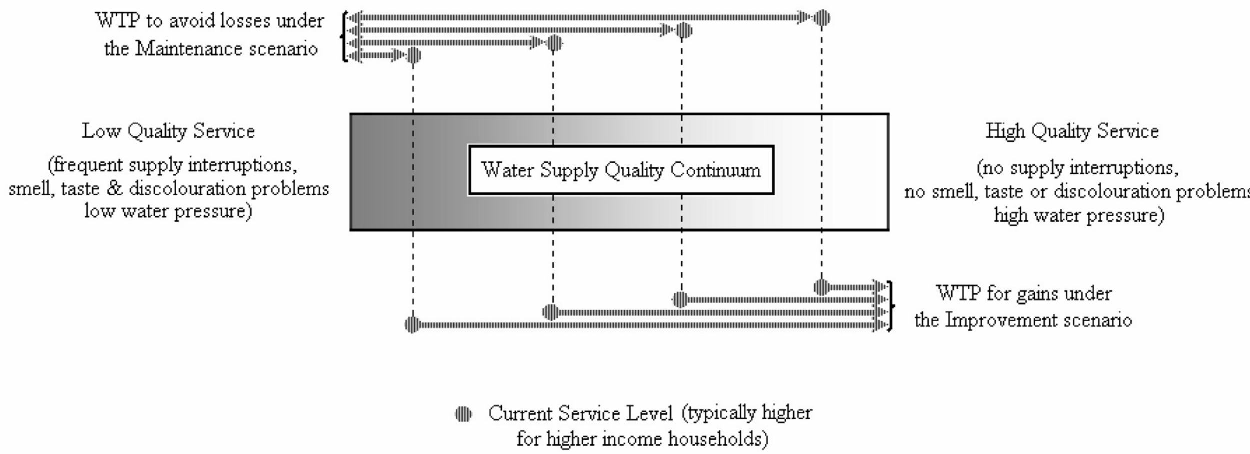

Figure 1. Water supply quality continuum and welfare measures for the maintenance and improvement scenarios showing links between initial endowments (current service level; correlated with household income level), scenario specific final service level, and corresponding WTP.

of the criteria given above would seem to suggest that WTP responses were not related to current provision and therefore did not exhibit scope sensitivity.

[12] Figure 1 provides a graphical description of H_o^1 and H_o^2. Here we see that those with lower current levels of water service quality will have higher WTP for the improvement program than for the maintenance program. Conversely those with higher initial endowments will have lower WTP for the improvement program than for the maintenance program. Accepting (as we demonstrate subsequently) the strong positive correlation between income and the initial endowment of water service quality we therefore expect H_o^1 and H_o^2 to be satisfied.

[13] Our second approach to scope sensitivity testing is more conventional. Here we selected subgroups of respondents for whom income is reasonably constant (denoted by the superscript YCON in notation below) but who exhibit some commonly perceived variation in baseline water supply quality. Following the logic of the above arguments we should expect that, as baseline quality increases so WTP for maintenance of those supplies will also rise. Conversely a similar set of (roughly) constant income respondents facing the improvement scenario will be expected to reduce their WTP responses as baseline quality increases. If we model WTP responses for a given scenario as a function of this baseline quality (QUALITY) and a matrix of other variables (X) as follows,

$$WTP_j = f\left(\beta_j QUALITY, \beta_1 X\right)$$

where j = M for the maintenance scenario and j = I for the improvement scenario, then we can formalize these expectations into a further scope hypothesis as follows:

$$H_o^3 : \beta_I^{YCON} < O < \beta_M^{YCON}$$

[14] We test these various scope sensitivity hypotheses by conducting the first CV study examining households' WTP for changes to the water supply service in Mexico City. This is both the largest city in the developing world and one whose water supply system exhibits many of the characteristics typical of water supply systems in urban areas of developing countries. In particular it has a highly intervened, subsidized tariff system and extremely heterogeneous water supply conditions which are strongly linked to income distribution. A large-scale, best practice, CV survey is conducted, collecting data for both of the design treatments outlined above. Our results confirm the importance of current service levels upon WTP and implied preference ordering of the maintenance and improvement schemes, thereby satisfying our scope sensitivity tests. Furthermore, we show how, if taken at face value, the magnitude of WTP responses favors the maintenance scheme preferred by wealthier households currently enjoying high levels of service. Because wealthy households are less income constrained, their preference for the improvement scenario over the maintenance scenario dominates a conventional BCA even though it is low-income households which comprise the majority of the population (a characteristic feature of urban areas of developing countries [*World Bank*, 1991; *Wegelin-Schuringa*, 2001]). However, applying recent BCA guidelines for the equity weighting of WTP results [*HM Treasury*, 2003], we find that, when the income constraints are equalized across all households, the priority ranking of proposed schemes changes with the improvement scheme favored by poorer households now yielding the highest net values.

[15] The remainder of this paper is organized as follows. Section 2 discusses the water supply problem in Mexico City, overviewing current water prices and the investments required for sustainable service modernization. Section 3 discusses the basis of economic welfare theory which underpins the paper and presents the empirical design of the study, detailing the two valuation scenarios and survey implementation. In section 4 we analyze the survey results both in terms of heterogeneity of the service conditions across the study area and resultant valuation responses. Models of WTP responses are presented providing theoretical validity assessments of findings. Section 5 provides formal testing of the scope sensitivity hypotheses outlined

above. Section 5 also aggregates the benefit estimates, both by including explicit incorporation of weights to address income inequality issues and by using absolute WTP figures for investment purposes. Section 6 presents conclusions and implications arising from this study.

2. Water Supply Conditions in Mexico City

[16] The Metropolitan Area of Mexico City (MAMC) is the second largest city in the world, and the biggest in a developing country, with almost 18 million inhabitants [*Instituto Nacional de Estadistica, Geografia e Informatica* (*INEGI*), 2001]. In administrative terms the MAMC is composed of two federal states: the Federal District and the State of Mexico. The rate of household connections is relatively high compared to general developing country standards with the water supply network serving 98% of the total population in the Federal District, the core entity of the city. Official information sources show that within the Federal District the amount of water supplied for domestic uses is as high as 80% [*Comision de Aguas del Distrito Federal* (*CADF*), 2001]. The MAMC consumes water at the rate of 64 cubic meters per second (m^3/s) [*Gerencia Regional de Aguas del Valle de Mexico*, 2001]. However, this supply is insufficient to meet present demand with the current deficit estimated at approximately 10 m^3/s, of which 3 m^3/s corresponds to the Federal District and 7 m^3/s to the State of Mexico [*Joint Academies Committee on the Mexico City Water Supply* (*JAC*), 1995].

[17] As in many other cities, infrastructure conditions are highly diverse throughout the Federal District. Some of the pipes in the city center were installed more than a hundred years ago and the problems of an aging infrastructure have been compounded by feedbacks from aquifer overexploitation leading to land subsidence [*INEGI*, 1999]. Such infrastructure problems have led to very significant leakage losses accounting for between 33% and 40% of the supplied water [*Direccion General de Construccion y Operacion Hidraulica* (*DGCOH*), 1997b]. This excess demand, fueled by such infrastructure deficiencies, causes a range of water supply problems such as low water pressure or shortages [*Garcia-Lascurain*, 1995; *DGCOH*, 1997a; *Schteingart and Torres*, 1997; *Ennis-McMillan*, 1998] which significantly affect up to one million households within our study area [*Bermeo*, 2002b]. Such problems have resulted in households adopting a numbers of averting measures. Storage tanks and large underground cisterns are a common feature of many households across the city [*Garcia-Lascurain*, 1995; *JAC*, 1995; *Ennis-McMillan*, 1998]. However, such poor service standards are by no means constant across the city. On the contrary a number of studies have shown that while low-income households located in the periphery often suffer poor service standards, residents of high-income areas generally enjoy a much better standard of service and consume high volumes of water [*Garcia-Lascurain*, 1995; *Schteingart and Boltvinik*, 1997; *Ennis-McMillan*, 1998]. We would expect these variations in current service standards to be a major determinant of preferences between alternatives water supply schemes and be reflected in stated WTP for such schemes.

[18] Water tariffs for households in the Federal District are determined jointly by the local congress and executive and concerns regarding access to water have resulted in high subsidies and low prices for domestic consumers [*Gobierno del Distrito Federal* (*GDF*), 2003]. The average domestic tariff of 2 pesos per 1 m^3 of water contrasts markedly with official cost estimates of 9 pesos per 1 m^3 [*CADF*, 2002]. Typically subsidies are supposed to be directed toward essential needs, which means that, considering international recommendations, for a household of five members the amount required would be 12 m^3 bimonthly [*Boland and Whittington*, 2000]. However, subsidies apply up to a consumption level of 180 m^3 bimonthly such that almost a third of all households pay less than 20 pesos (about US$2) bimonthly while the vast majority of households (91%) pay less than 200 pesos (about US$20) bimonthly for water services [*CADF*, 2002]. In contrast, nondomestic users, industry and commercial establishments pay on average 12–13 pesos per m^3. This results in the nondomestic sector contributing 80% of the total resource collection [*CADF*, 2001]. As observed in other developing country settings [*Boland and Whittington*, 2000], such a tariff structure appears to have the unstated objective of enforcing a cross subsidy from commerce and industry to domestic consumers, regardless of the income of the latter recipients.

[19] In 1992 the water authorities initiated a series of reforms in the water tariff and collection administrative system. The main actions that have been undertaken to date include the elaboration of a census of all water users, improved detection of illegal connections, digitization of the network, reduction of leakages and installation of water meters. Over 1,260,000 meters have now been installed, covering about 70% of the total users [*CADF*, 2001; *Institute of the Americas*, 2001]. Although revenues remain dominated by nondomestic consumers [*CADF*, 2002], these reforms have allowed the authorities to substantially increase domestic tariff revenues [*GDF*, 2000]. However, while much improved, collection problems have not been eliminated. In 2002 roughly two thirds of domestic consumers presented delayed payments [*Bermeo*, 2002a; *Martinez Omana*, 2002]. In part this reflects the authorities' reluctance to disconnect supplies due to late payment [*Shirley*, 2002]. This may pose a problem for a CV study. If households believe that they will not in the end have to personally pay for a good then they may overstate their WTP in an effort to secure a benefit at no extra cost [*Bateman et al.*, 1995, 2003]. Clearly, in assessing the validity of WTP responses the CV analyst would like to control for any nonpayer overstatement effects and we discuss approaches for assessing the nature and scale of this problem subsequently.

[20] The problems raised by the underpricing of water are exacerbated by ongoing growth in demand. The authorities estimate that in the year 2010, an additional 18.2 m^3/s of water will be required in the MAMC, an increase which existing sources cannot satisfy. There is a substantial literature regarding this problem [*Sanchez-Diaz and Gutierrez-Ojeda*, 1997; *Birkle et al.*, 1998; *Gonzalez-Moran et al.*, 1999; *Downs et al.*, 2000; *Secretaría del Medio Ambiente*, 2000; *Comision Nacional de Agua* (*CNA*), 2003a]. However, these studies have focused almost exclusively upon the supply side with little attention being paid to demand and no previous assessment of

WTP. The present study makes a novel and, we would argue, timely contribution to this debate by assessing households willingness to pay while explicitly considering the socioeconomic and equity concerns expressed in relevant policy documents [*CNA*, 2003b].

3. Study Design

3.1. Welfare Measures of the Value of Changes in Water Supply Services

[21] Consider individual i who consumes two goods, X and Y. In the present application we can define X as consumption of water services while Y is a composite good measured in money units which we can define as the individual's income. Suppose we wish to assess the value to the individual of a change in their consumption of good X between levels x_i^0 and x_i^1 (where $x_i^0 < x_i^1$) as expressed in terms of the amount of good Y (the income numeraire) that the individual is prepared to give up. *Hicks* [1943] defines a range of welfare change measures including some which assess individuals' willingness to accept compensation regarding changes. However, such approaches have been shown to result in responses which fail to conform to standard economic theory [*Bateman et al.*, 1997, 2000]. Therefore valuation research has focused upon the following two measures of the welfare change arising from moves between x_i^0 and x_i^1.

[22] 1. The first measure is equivalent loss (EL). Suppose individual i is endowed with the quantities x_i^1 and y_i, then $EL(x_i^0, x_i^1, y_i)$ is their maximum WTP to avoid a decrease in consumption from x_i^1 to x_i^0.

[23] 2. The second measure is compensating gain (CG). Suppose individual i is endowed with the quantities x_i^0 and y_i, then $CG(x_i^1, x_i^0, y_i)$ is their maximum WTP in return for an increase in consumption from x_i^0 to x_i^1.

[24] In the context of our present study design, the EL measure refers to our maintenance scenario while the improvement treatment yields a CG measure. Standard (Hicksian) economic theory implies that for given levels of x_i^0 to x_i^1 these two measures should be equivalent. If we accept this and accordingly denote either measure as simply WTP then we can write the utility function (1)

$$u\left(x_i^1 - \mathrm{WTP}\left[x_i^0, x_i^1\right]\right) = u\left(x_i^0\right) \tag{1}$$

which just says that the utility of the superior provision level (x_i^1) minus the maximum WTP in respect of the change in provision between x_i^0 and x_i^1 would leave the individual at the same utility level provided by the inferior provision level (x_i^0).

[25] The scope sensitivity tests formulated as H_o^1, H_o^2 and H_o^3 essentially examine the relationship between the magnitude of WTP responses and the size of the change in provision between x_i^0 and x_i^1. The research challenge for (and contribution of) this paper is to allow for the fact that, because individuals are at differing initial (baseline endowment) levels of service, then the move to endpoint levels of provision (as envisaged in the maintenance and improvement scenarios) imply differing changes in WTP. This is further complicated by the strong correlation between income levels and initial endowments (and hence the size of provision change) at the individual level. This is allowed for in H_o^1 and H_o^2 by looking at the relation between WTP and income, and in H_o^3 by examining a subset of respondents for whom income is constant yet some variation in quality endowments is observed.

3.2. Eliciting WTP for Water Supply Services

[26] As noted above, while not previously applied to the present case study area, the CV method has been widely used to assess WTP for water services in developing countries. The method typically uses survey techniques to ask a member of each surveyed household a series of structured questions designed to determine the maximum amount of money their household is willing to pay for the proposed change in service provision [*Mitchell and Carson*, 1989; *Arrow et al.*, 1993; *Whittington and Swarna*, 1994; *Bateman et al.*, 2002]. As discussed previously, in order to implement our proposed scope sensitivity tests we require valuations for changes in provision which vary according to both initial water service endowments and final endpoint service levels. Such requirements are satisfied by the use of two valuation scenarios presented using a split sample approach. Here roughly half of those interviewed value the maintenance program to avoid deterioration of supply quality to a common low level (set as the lower levels of service currently endured within the study area). The remaining survey respondents are presented with the improvement program which sets out to raise service conditions to a common high level (equivalent to the upper levels of service currently enjoyed within the study area).

3.3. Survey Questionnaire: Development and Structure

[27] The CV survey questionnaire (which is available from either of the authors in either its original Spanish form or as an English translation, the latter being reproduced in Annex 1 in Text S1 of the auxiliary material[1]) was designed following a series of four focus groups. In line with best practice [*Bennett et al.*, 1998; *American Society of Civil Engineers*, 2003], these were conducted to assist scenario construction and conveyance via a survey questionnaire. Issues such as initial endowments of service quality, tariff and billing regimes and averting behavior (e.g., through the construction of water storage facilities) were addressed and the focus groups also identified the household bimonthly water bill as the most appropriate payment vehicle. Uncertainties regarding the longevity of bill increases were addressed by adopting a single increase in bimonthly tariffs which would last for 10 years to coincide with the likely investment period. Given existing knowledge regarding implicit discount rates for public goods [*Pearce and Ulph*, 1998; *HM Treasury*, 2003], this period also facilitates ready incorporation of resultant WTP sums within subsequent BCAs.

[28] Again in line with best practice guidelines [*Mitchell and Carson*, 1989; *Arrow et al.*, 1993; *Bateman et al.*, 2002; *Murphy et al.*, 2005], the contingent market utilized a single dichotomous choice (DC) question to elicit household WTP responses. Such a design adheres to the principles of incentive compatibility set down by *Gibbard* [1973] and *Satterthwaite* [1975] and developed within the CV context by *Hoehn and Randall* [1987] and *Carson et al.* [2006]. Here the respondent is presented with a single buying price

[1]Auxiliary materials are available in the HTML. doi:10.1029/2005WR003981.

(or "bid level") for the good in question which respondents may either accept or reject. The bid level is varied across respondents defining a bid vector from which a survival function may be estimated and welfare measures, such as the mean WTP, may be obtained [*Hanemann and Kanninen*, 1999].

[29] Previous developing country water valuation studies have been criticized for using narrow bid vectors based primarily upon existing (subsidized) tariff levels [*Whittington*, 1998]. This issue was initially addressed through the focus groups mentioned previously (which confirmed that current tariff levels were artificially low relative to WTP) which provided a qualitative picture of the range of credible tariff increases. These were supplemented by a series of two subsequent pilot surveys [*Soto Montes de Oca*, 2003]. In the first of these, 37 interviews were used to test bid levels ranging from 20 to 500 pesos. These suggested that the lowest bid level was not considered sufficient to deliver improvements to the current water supply system, while the rejection rate for the upper bid level was high enough to trigger concerns regarding a possible "fat tails" problem [*Kerr*, 1996]. Accordingly, a second pilot was undertaken in which 40 interviews were used to test bid levels ranging from 50 to 1000 pesos. Findings suggested that such a range of bid levels should secure virtually unanimous acceptance and rejection at either end of the bid vector while remaining within the constraints of credibility [*Herriges and Shogren*, 1996]. This vector was implemented via ten bid levels using a typical, roughly logarithmic, distribution [*Bateman et al.*, 1995], with each respondent being randomly allocated to a single bid amount. The final round of piloting indicated that such a vector performed well against recognized criteria [*Kerr*, 1996; *Loomis*, 2005] such as the achievement of a high rejection rate at the upper bid amount.

3.4. Survey Sampling Frame

[30] The sampling frame was designed to capture the variation in current service conditions (and related socio-economic characteristics) which was a focal part of our scope sensitivity test. This diversity was provided by sampling three zones (west, north central and east) of the Federal District, the core area of Mexico City, as illustrated in Figure 2.

[31] Existing official documents and census data [*DGCOH*, 1997a; *INEGI*, 2000] indicated that in general the west area includes many high-income neighborhoods and is characterized by high-quality water supplies fed directly from external sources. In contrast the north central zone is dominated by medium income households which rely more heavily upon local wells for water and exhibits more heterogeneous service standards, with some households enjoying good levels of service while others are faced with some low water pressure problems. Finally, the eastern zone is the most populous and poorest in the Federal District. This zone relies substantially upon local wells many of which are overexploited and unable to satisfy local demand. The eastern zone is also remote from external supplies and consequently suffers frequent water pressure and shortfall problems together with poor water quality, creating the need to transport water from other localities [*DGCOH*, 1997a; *INEGI*, 2000].

[32] Given these conditions the north center zone is of particular interest for testing H_o^3 as we have higher variation in water supply quality relative to income variation than in other areas. Furthermore, by restricting our testing of H_o^3 to just the main middle income group within this zone we can further sharpen this test by holding income constant as quality varies. An additional advantage of such an approach to testing is that respondents conceptions of the quality of supplies may be relative rather than absolute i.e., what is considered a poor quality in the richer (better supplied) western zone might be considered quite acceptable or even good in the poorer (worse supplied) eastern zone. By testing within both an income group and a zone we should be examining more commonly held perceptions of service quality.

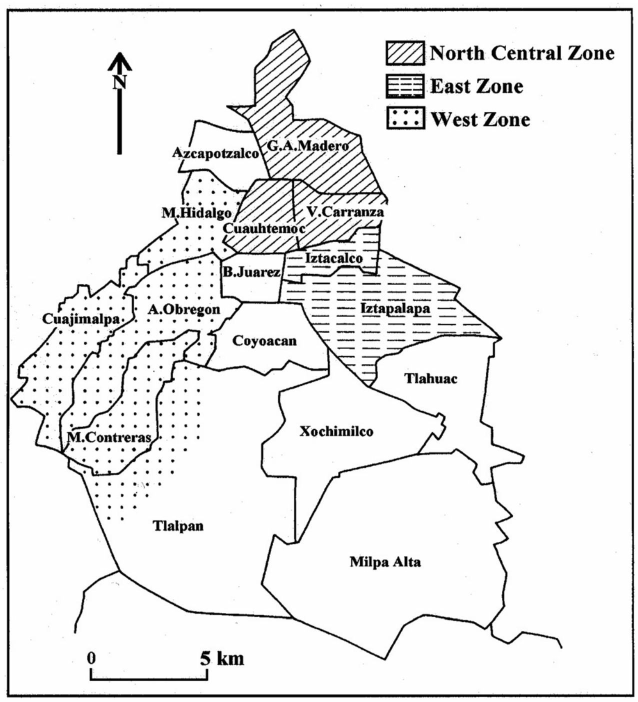

Figure 2. The Federal District and the three study zones. Location is 19°36′N, 98°57′E.

[33] Choice of survey mode was dictated by a mixture of administration costs and the importance of collecting a sufficiently large sample to operationalize the incentive compatible but statistically inefficient DC elicitation format [*Arrow et al.*, 1993]. Given these and other constraints (in particular regarding cost and interviewer safety), data was collected using a telephone survey utilizing a specified area variant of the random digit dialing method (RDD) [*Dillman*, 1978; *Sudman and Bradburn*, 1982; *Frey and Oishi*, 1995; *Ethier et al.*, 2000]. One drawback of this approach is that, despite it being the area of Mexico with the most extensive coverage, only about 66% of households in the Federal District have telephones [*INEGI*, 2001]. Given that consequent exclusions will be overrepresented by low-income households this raises the distinct possibility that unadjusted WTP measures will underrepresent the preferences of the poor. This was addressed in three ways: (1) oversampling of poorer areas within the overall study site, (2) in calculating aggregate WTP, postsurvey procedures were used to adjust for underrepresentation of different groups in our sample relative to the overall population, and (3) an equity reweighting process was incorporated within our subse-

Table 1. Service Indicators in the Three Sampled Zones (Percentage of Households) and Significance of Interzonal Differences[a]

Service Indicators	West Zone	North Central Zone	East Zone
Low water pressure (*59%*)	47% (0.0001) W-NC	58% (0.0001) NC-E	72% (0.0001) W-E
Poor water quality (*36%*)	29% (0.248) W-NC	26% (0.001) NC-E	61% (0.0001) W-E
Frequent water shortages (*33%*)	20% (0.0001) W-NC	32% (0.0001) NC-E	52% (0.0001) W-E
Bottled water consumption (*71%*)	61% (0.017) W-NC	68% (0.0001) NC-E	91% (0.0001) W-E
Water storage in cisterns (*40%*)	33% (0.005) W-NC	42% (0.008) NC-E	51% (0.0001) W-E
Monthly average income	5,981 pesos (US$598) (0.0001) W-NC	4,096 pesos (US$409) (0.0001) NC-E	3,088 pesos (US$308) (0.0001) W-E
Survey observations	566	493	365

[a]Values in italic type are percentages of the full sample reporting problems with the service indicator.
Values in parentheses in normal type are p value significance levels (from chi-square tests). W-NC indicates a test for significant differences between the west and north central zones. NC-E indicates a test for significant differences between the north central and the east zones. W-E indicates a test for significant differences between the west and the east zones. The exchange rate at the time of the survey was roughly US$1 = 10 pesos.

quent BCA to allow decision makers to examine the impact of equalizing income constraints across the population. All of these procedures are discussed subsequently.

[34] In operationalizing the RDD method, ZIP codes for neighborhoods in each of the three study zones were cross referenced between the telephone directory and a list of codes used for telemarketing purposes. This latter list allowed us to ensure a high proportion of poorer neighborhoods would be targeted, thus compensating for the underrepresentation caused by using a telephone based survey. The telephone area code was obtained from the ZIP code and remaining digit numbers were built by starting with the four root digits and then adding the exchange numbers starting from 0001. This generated a list of numbers for each surveyed area (*Bateman and Munro* [2005] examine issues arising from the conventional use of individual level surveys to proxy household responses).

3.5. Survey Questionnaire

[35] The questionnaire (which is reproduced in the work of *Soto Montes de Oca* [2003] and available from that author) was divided into various sections to elicit the following information.

[36] 1. The first section was the introduction, which described the survey to the respondent and determined their eligibility for interview.

[37] 2. The next section was general perceptions of the water supply service. This section investigated the consumers' perception of the general standards of supply across the Federal District.

[38] 3. The third section was perceptions of the current service quality (initial endowment) in the household: Indicators such as household water pressure, shortages and water quality were obtained. Averting strategies, such as water storage and the consumption of bottled water were also assessed.

[39] 4. The fourth section was program scenario and WTP question: Here the appropriate maintenance or improvement scenario was presented together with a randomly selected DC bid amount for which WTP responses were elicited together with motivations underpinning these responses.

[40] 5. The fifth section was knowledge of current water bills: Failure to recall current bill levels may be linked to WTP responses via a number of routes. It may indicate uncertainty over the bill amount or that the amount is too trivial for the respondent to readily recall it. Both interpretations might be expected to be negatively correlated with WTP. However, an inability to answer this question might also indicate a respondent who does not pay their water bill. Such nonpayers might be expected to overstate their WTP in an attempt to capture service improvements which they feel will be funded by others. Given this uncertainty of expectations, associations between this factor and WTP remain an open empirical question which we examine subsequently;

[41] 6. The final section was household socioeconomic characteristics. Here questions elicited information such as the household demographics, employment and income profiles, etc.

[42] The survey was conducted by a team of eight experienced telephonists who were given a two day training course on relevant aspects of a CV telephone survey.

4. WTP Results and Theoretical Validity Modeling

[43] Full details of the diversity of sample characteristics elicited are presented by *Soto Montes de Oca* [2003], with section 4.1 providing a summary of those pertinent to the present study.

4.1. Sample Size and Heterogeneity of Service Conditions Across the Three Studied Zones

[44] The survey was undertaken over 20 days, including weekends, during November and December 2001. Excluding nonresponses and calls to nonresidential numbers, a total of 2,908 contacts with potentially eligible respondents was made. Of these a response rate of 49% was achieved, which compares well with random first-pass, face-to-face surveys and reflects the high general levels of interest in the topic. A total sample of 1,424 household responses was collected of which 716 were presented with the maintenance scenario the remaining 708 households faced the improvement scenario.

[45] Survey findings confirmed that, when considered across the full sample, current endowments of service quality are both highly heterogeneous and strongly correlated with household income. Table 1 presents some measures of the service performance by study zone as assessed through three indicators: low water pressure (which is the most prevalent problem), poor water quality and frequent water shortages (a note concerning the definition of all variables from the responses given to the survey questions is available from the authors and reproduced as Annex 2 of the auxiliary material). A clear difference between the three zones is observed in almost all measured parameters. For example the prevalence of low water pressure is significantly lower in the West zone than in the north centre (p <

0.0001) which is in turn significantly lower than that in the eastern zone ($p < 0.0001$).

[46] This pattern of superior levels of current service endowment in the west zone, intermediate levels in the north center and lowest initial endowments in the east, is repeated across all service quality measures. This is also reflected in greater reliance upon bottled water and storage cisterns in the east where the quality and reliability of supplies are lowest. Furthermore, as Table 1 also indicates, this pattern is directly related to income distribution across the zones. The west zone enjoys significantly higher incomes than the north centre zone, which in turn has significantly higher income than the east zone ($P < 0.0001$ in all cases). In line with the previous research reviewed above, we find higher household income to be positively and significantly correlated with all collected measures of water quality including fewer water pressure problems ($p < 0.012$); less water quality problems (lower water odor incidence, $p = 0.037$; reduced occurrence of residuals in water, $p < 0.001$); fewer problems of discoloration, $p = 0.006$); and less frequent interruptions in supply ($p < 0.001$). Households with higher incomes were also significantly more likely to report that they had not experienced any water supply problems ($p < 0.001$).

4.2. Willingness to Pay: Validity Analysis and Welfare Measures

[47] Theoretical validation of DC WTP responses was achieved through the estimation of a model relating positive responses to bid amounts and a variety of variables derived from economic theory and empirical regularities. Given the binary nature of our response data we adopted a probit modeling approach estimated using maximum likelihood techniques. Such an approach is based on the cumulative normal distribution and consistent with theories of consumer utility maximization [*Cameron*, 1988]. Contrary to approaches where DC data are analyzed as ordinary unordered data [*Hanemann*, 1984], the Cameron model assumes that the range of bid values are ordered, the threshold of the latent variable are observable and their variance can be used to identify the location and the scale of the underlying censored continuous valuation variable. This approach offers the possibility of generating individual fitted values for every respondent in the sample. The conceptual framework of the probit equation describes is compatible with such a model [*Cameron*, 1988; P. Moffat, Environmental Econometrics mimeo, School of Economic and Social Studies, University of East Anglia, 2002].

[48] Explanatory variables investigated included the bid level presented; household income; whether or not the household water bill was reported (and, if so, its level); a variety of water supply quality indicators (including frequency of water pressure problems, the incidence of any shortages, perceived quality, etc.); and various household and respondent socioeconomic characteristics including respondent gender and household age composition, education level, occupation, etc. For the probit regression analysis all variables were defined as interval or binary data.

[49] Analysis of the data revealed (as expected) that, when the full data set was considered, the strong correlation between household income and measures of water supply quality prevented their simultaneous inclusion within regression models. Given the logic of causality (household income may well constrain access to higher water quality but the opposite causality does not hold) we retain the income variable over the inclusion of those highly correlated water quality measures. This approach not only produces models with higher explanatory power but subsequently also allows us to test H_o^1 and H_o^2. Table 2a presents comparable probit models for both valuation scenarios (full definitions of variables being given in Table 2b), while Table 3 and Annex 3 of the auxiliary material present details regarding the underlying raw WTP response data.

Table 2a. Probit Regression Models of WTP Responses for the Maintenance and Improvement Scenarios

	Maintenance Scenario			Improvement Scenario		
Variable	Coefficient	SE	t	Coefficient	SE	t
BID	−0.00187[a]	0.00020	−9.41	−0.00186[a]	0.00019	−9.63
LnINC	0.60824[a]	0.11324	5.37	0.21077[b]	0.10274	2.05
AGE	−0.03120[c]	0.01735	−1.80	−0.06318[a]	0.01746	−3.62
AGE^2	0.00031[c]	0.00019	1.64	0.00063[a]	0.00020	3.11
FEMALE	2.52326[b]	1.11020	2.27	0.71975	1.03198	0.70
FEM*LnINC	−0.32261[b]	0.13488	−2.39	−0.08154	0.12734	−0.64
MEMBERS	0.05239[b]	0.02440	2.15	0.00097	0.02240	0.04
DK_BILL	−0.04382	0.10892	−0.40	−0.20693[c]	0.10625	−1.95
Intercept	−4.00298[a]	0.99024	−4.04	0.25120	0.89151	0.28

[a]Here $p < 0.01$.
[b]Here $p < 0.05$.
[c]Here $p < 0.10$.

[50] The models presented in Table 2a show expected relationships with explanatory variables, exhibiting consistent signs on coefficients throughout, although significance levels vary somewhat among those variables for which we do not have prior economic theoretic expectations. We do have prior expectations for the BID and LnINC variables, both of which conform to theory, yielding negative and positive relationships respectively.

[51] Considering each variable in turn, both models show a clear and virtually identical price effect with increases in the BID variable reducing the probability of a "yes" response (this similarity of price coefficients across scenarios itself provides an important indicator of theoretical consistency; the value of money should not be context sensitive). Similarly the positive relation between bid acceptance and household income (LnINC) is as expected. Interestingly the magnitude and significance of this effect is substantially larger for the maintenance scenario than for the improvement scenario. This supports the hypothesized income/scenario preference ordering of H_o^1 and H_o^2 as low-income households are expected to be less enthusiastic about the maintenance scenario, whereas it is expected to be the more strongly preferred option for high-income households. This will strengthen the income/WTP relation above that observed for the improvement scenario where low-income households are prepared to pay relatively more than for the maintenance program whereas high-income households reverse this prioritization. We return to consider formal testing of these hypotheses subsequently.

[52] For both scenarios we observe a U-shaped relationship between bid acceptance and respondents age, with a minimum around 50 years old. It is tempting to suggest that this may reflect the health priorities of respondents with the elderly and those with young families most concerned

Table 2b. Definition of Variables

Variable Name	Variable Description	Coding	Mean Value[a]	Standard Deviation[a]
WTP	dependent variable (response to WTP question)	1 = yes, 0 = other	Maint = 0.46 Imp = 0.49	Maint = 0.50 Imp = 0.50
BID	bid amount (pesos)	50, 70, 100, 150, 200, 250, 350, 500, 700, 1000	Maint = 309.94 Imp = 305.98	Maint = 294.35 Imp = 290.85
Ln_INC	natural logarithm of household income (pesos)	Log_e of 1250, 3750, 7500, 15000, 20000	8.04	0.84
AGE	respondents age	age in years (continuous variable)	39.34	15.67
AGE^2	square of respondents age	square of age in years (continuous variable)	1793	1392
FEMALE	gender of respondent	1 = female, 0 = male	0.64	0.48
FEM*LnINC	interaction of FEMALE with Ln_INC variable	from above	from above	from above
MEMBERS	total number of family members	continuous variable	4.80	2.27
DK_BILL	respondent stated that they did not know their water bill	1 = not reported, 0 = bill cost was given	0.42	0.49

[a]Maint is maintenance scenario (n = 689; 27 cases with missing data); Imp is improvement scenario (n = 687; 21 missing cases).

with water quality, all else remaining the same. An interesting gender effect is observed for both scenarios with FEMALE respondents being generally more likely to respond positively. This may reflect a gender divide regarding experience of the consequences of poor water supply quality (for example, women may be disproportionately impacted by child health issues associated with such problems). This interpretation seems supported by the negative FEM*LnINC interaction term showing that the gender divide is eroded by increasing incomes suggesting that it is poorer women who are most exposed to the negative consequences of poor water supplies. This is further echoed in the positive effect on WTP of increased family size shown by the MEMBERS variable.

[53] The negative sign on the DK_BILL variable is interesting. Recall that this group includes both those for whom water bills are too trivial or uncertain for them to readily remember and (we suspect) those who have not paid their bills. We have different expectations regarding these two subgroups. If current bills are considered very small (too trivial to recall) then this may provide downward anchoring pressure upon WTP. However, nonpayers may view the programs either as heralding greater enforcement of payments (a negative pressure upon WTP) or that there is the prospect of a costless gain if improved services are provided without greater payment enforcement (which we would expect to inflate WTP). The negative sign on the DK_BILL variable indicates that the latter group is less dominant than the former suggesting that strategic overstatement is not a major problem in the present study.

[54] The probit models allow us to estimate the WTP of each household in the sample [*Cameron*, 1988]. Table 4 presents summary measures of WTP aggregated across all households in each of the scenarios, irrespective of their income or current service level. Using these generalizing criteria, mean WTP for the maintenance scheme is 246 pesos rising to 293 pesos for the improvement scheme. Confidence intervals are somewhat wider for the former than the latter responses reflecting in part the stronger variation with income for the maintenance scenario observed in our regression models. Nevertheless, these means are significantly different ($p < 0.001$), showing that, within our sample we have a higher WTP for the improvement program. However, we need to adjust for the representativeness of

Table 3. Response Data Underpinning the Regression Models

	Maintenance Scenario			Improvement Scenario		
Bid Level	Total	"Yes" Responses	Proportion "Yes"	Total	"Yes" Responses	Proportion "Yes"
50	73	54	74%	74	64	86%
70	77	51	63%	73	54	74%
100	79	42	53%	80	52	65%
125	73	43	59%	73	44	60%
150	74	43	58%	74	40	54%
200	70	26	37%	70	31	44%
350	69	25	36%	70	25	36%
500	68	19	13%	65	9	14%
700	68	15	22%	68	15	22%
1000	65	9	14%	61	14	23%

Overall response rates	Maintenance Scenario	Improvement Scenario
"Yes"	46%	49%
"No"	48%	43%
"D/K"	6%	8%

Table 4. Household WTP Measures for the Maintenance and Improvement Scenarios[a]

	Maintenance Scenario	Improvement Scenario
Mean WTP (pesos/bimonthly)	241	290
95% confidence interval	225–257	280–301
Median WTP (pesos/bimonthly)	213	278
WTP increment compared to average current water bill	164%	197%
WTP expressed as percentage of household average income	5.2%	6.36%
WTP plus current average water bill expressed as percentage of household average income	8.4%	9.49%

[a]Values are based upon the functions reported in Table 2a. Omitting statistically insignificant variables from these functions results in a very minor reduction in mean WTP from 246 to 241 for the maintenance scenario and from 293 to 290 for the improvement scenario.

our sample before we can say anything about the aggregate value of the two schemes. Before considering this, it is interesting to note the comparison of WTP with current tariff prices also detailed in Table 4. In both cases WTP for the proposed scenario is more than double current water bills, equating to 7–9% of income. While these may seem high, within a developed world context they fall well within the bounds suggested by previous research [*Whittington et al.*, 1991; *Briscoe et al.*, 1993; *Zerah*, 1998; *Goldblatt*, 1999]. Furthermore, we should remember that current tariff prices are kept artificially low by the substantial subsidies mentioned previously. Perhaps most persuasively, the sums stated by poorer households are of a similar magnitude to existing expenditure upon bottled water. Together these comparisons provide considerable convergent validity support for our results.

5. Scope Sensitivity, Aggregate WTP and BCA

5.1. WTP and Income Distribution: Testing Scope Sensitivity Hypotheses H_o^1 and H_o^2

[55] Table 5 reports WTP for the two scenarios disaggregated across five income groups. Tests for the significance of differences across income groups and scenarios are also reported. Results show a very clear pattern in the ranking of programs in that for the two lowest income groups (i.e., those with, on average, the poorest water supply services) the improvement scenario is accorded a significantly higher WTP than the maintenance scenario. However, this pattern is reversed for the upper three income groups. This pattern of priorities switching as incomes increase exactly conforms to the scope sensitivity tests set out in H_o^1 and H_o^2. As the test details presented in the notes to Table 5 confirm, both of these hypotheses cannot be rejected ($p < 0.05$) and therefore provide strong theoretical validity endorsement for our study.

[56] Figure 3 provides a graphical representation of these results, clearly illustrating that the impact of income upon WTP is substantially greater for the maintenance than improvement scenario. Figure 3 also confirms the switch in the ordering of program priorities given in H_o^1 and H_o^2.

5.2. WTP Holding Income Constant: Testing Scope Sensitivity Hypothesis H_o^3

[57] The strong collinearity between income and initial endowments of water service quality precluded the inclusion of both income and quality variables in the models reported in Table 2a. However, H_o^3 proposes holding income constant and looking for an expected switch in the sign of the relationship between WTP and the initial endowment of

Table 5. Household WTP Disaggregated by Income Group

	Maintenance Scenario		Improvement Scenario	
Income Group, pesos	Mean WTP, pesos	Significance of Differences Across Income Groups	Mean WTP, pesos	Significance of Differences Across Income Groups
I, <2500	57	II[a]	212	II[a]
		III[a]		III[a]
		IV[a]		IV[a]
		V[a]		V[a]
II, 2500–5000	259	I[a]	317	I[a]
		III[a]		III
		IV[a]		IV[a]
		V[a]		V[a]
III, 5000–10,000	409	I[a]	361	I[a]
		II[a]		II
		IV [a]		IV[a]
		V [a]		V[a]
IV, 10,000–20,000	578	I[a]	421	I[a]
		II[a]		II[a]
		III[a]		III[a]
		V[a]		V
V, >20,000	629	I[a]	424	I [a]
		II[a]		II[a]
		III[a]		III[a]
		IV[a]		IV

[a]Difference significant at $p < 0.05$ level. WTP differences between the two scenarios are significant at $p < 0.05$ level within each of the five income groups.

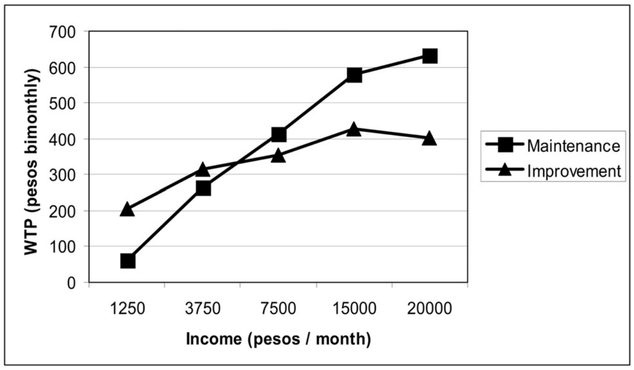

Figure 3. WTP for the maintenance and improvement programs by income group.

water service quality across our two scenarios. Essentially, with income held constant we would expect WTP for the maintenance program to increase with initial endowments of quality. Conversely, again with income held constant, we expect WTP for the improvement program to actually fall as initial endowments of quality increase. This switch in the direction of effects provides a clear and strong scope sensitivity test of the validity of our WTP responses.

[58] To test H_o^3 we first identify a suitable subsample within which income is relatively constant yet quality endowments vary. As indicated previously, the north center zone provides the best test bed for such an assessment as it is generally characterized by middle income households but exhibits a variety of current water service levels (and as noted above, restricting the analysis within a geographical zone may also have the advantage of ensuring more common conceptions of what constitutes a given level of water service quality as respondents may have greater experience of supply conditions within zone as opposed to across zones). To ensure that income is held reasonably constant we also omit those residents of this zone who did not fall into the two major middle income categories (3750 and 7500 pesos per month).

[59] The test is then performed by estimating the model of WTP responses reported in Table 6. Here we combine responses from both the maintenance and improvement scenarios and relate WTP to the current quality of service (QUALITY). Differences between the responses elicited from the two treatments are identified through the introduction of the IMP variable which denotes respondents facing the improvement scenario and is used to form interaction variables to test for response differences between the treatments (full variable definitions are given in footnotes to Table 6). The central purpose of Table 6 is to test hypothesis H_o^3 and this is achieved via the first two coefficients reported. By including both the QUALITY variable and the QUAL*IMP interaction term we ensure that the former tests the relationship between WTP and the baseline level of water service for the maintenance respondents, while the latter examines the departure from this relationship observed for the improvement respondents. The coefficient on baseline quality for the maintenance treatment (β_M^{YCON} in H_o^3) is found to be positive but insignificant. However, the QUAL*IMP interaction coefficient (β_I^{YCON} in H_o^3) is both negative, strongly significant ($p < 0.01$) and of sufficient size to ensure that the overall effect of baseline quality for the improvement respondents is negative. Therefore we observe that $\beta_I^{YCON} < 0 < \beta_M^{YCON}$ as per H_o^3, which we accordingly cannot reject.

[60] The remaining relationships of the model reported in Table 6 (which is specified from the full sample models of Table 2a, adding only those variables necessary for testing hypothesis H_o^3 and removing only those income related variables which are controlled for in the definition of this subsample) are of lesser importance but support the robustness of the relationships observed previously. The BID variable now denotes the base case (negative) attitude of maintenance treatment respondents to increases in water tariffs, all else remaining the same. The insignificant interaction term BID*IMP shows that this attitude does not differ for the improvement respondents. Its insignificance also suggests an absence of "loss aversion" effects [*Tversky and Kahneman*, 1991] across the EL and CG measures of WTP for the maintenance and improvement programs (respectively). The AGE and AGE^2 variables map out the same significant quadratic relationship as observed previously. Given the constant income nature of this subsample we omit the gender-income interaction (FEM*LnINC), retaining only the gender effect. This was of low significance previously and is statistically insignificant in the smaller subsample. For similar reasons the MEMBERS and DK_BILL variables, of mixed significance previously, prove insignificant here. Finally the IMP binary variable indicates any shift in the function intercept due to the improvement scenario, a shift which (as might be expected) proves statistically insignificant.

5.3. Conventional and Equity Weighting Approaches to Aggregation

[61] With WTP by income now calculated, aggregation proceeds by allowing for the distribution of the population across income groups. However, comparison of our sample with the characteristics of the general population showed that we had actually oversampled low-income households

Table 6. Interaction Effects Model of WTP Responses (Testing $H_o{}^3$)[a]

Variable	Coefficient	SE	t
QUALITY	0.21976	0.24507	0.90
QUAL*IMP	−0.80101[b]	0.33818	−2.37
BID	−0.00173[b]	0.00047	−3.66
BID*IMP	0.00029	0.00063	0.46
AGE	−0.06853[b]	0.02741	−2.50
AGE^2	0.00073[b]	0.00030	2.41
FEMALE	−0.20540	0.16753	−1.23
MEMBERS	0.05071	0.04082	1.24
DK_BILL	−0.12134	0.16940	−0.72
IMP	0.19874	0.27407	0.73
Intercept	1.82385[b]	0.66178	2.76

[a]Variables are defined as follows: QUALITY, 1 if household currently suffers frequent low water pressure problems (40% of subsample); = 0 otherwise (indicator of initial endowment of water supply quality); IMP, 1 if response is for improvement scenario; = 0 if response is for maintenance scenario (improvement scenario indicator); 51% of this subsample were in the Improvement scenario; IMP*QUAL, IMP variable multiplied by QUALITY variable (Quality * Improvement interaction); IMP*BID, IMP variable multiplied by BID variable (Bid * Improvement interaction). Other variables and dependent as defined previously; n = 271 (5 cases with missing data).

[b]Here $p < 0.01$.

Table 7. Aggregate WTP Values[a]

Income Group	Group Mean WTP per Household for Maintenance Scheme, pesos/bimonthly	Group Mean WTP per Household for Improvement Scheme, pesos/bimonthly	Group Population, households	Aggregate Benefits for Maintenance Scheme, million pesos per year	Aggregate Benefits for Improvement Scheme, million pesos per year	Equity Weight	Equity Weighted Aggregate Benefits for Maintenance Scheme, million pesos per year	Equity Weighted Aggregate Benefits for Improvement Scheme, million pesos per year
I, <2500	57	212	505,900	173	643	4.58	792	2947
II, 2500–5000	259	317	653,179	1015	1242	2.44	2477	3031
III, 5000–10,000	409	361	179,041	439	388	1.22	536	473
IV, 10,000–20,000	578	421	358,081	1242	905	0.61	758	552
V, >20,000	629	424	338,252	1277	861	0.37	472	319
Total, million pesos				4146	4039		5035	7322

[a]Aggregate benefits for maintenance scheme = Group mean household WTP for maintenance scheme * Group population. Aggregate benefits for improvement scheme = group mean household WTP for improvement scheme * Group population. Equity weight = (population average income/Group average income). Equity weighted aggregate benefits for maintenance scheme = Equity weight * Aggregate benefits for maintenance scheme. Equity weighted aggregate benefits for improvement scheme = Equity weight * Aggregate benefits for improvement scheme. The reweighting and equity weighting exercises were undertaken using group mean incomes approximated as follows: I, 2000; II, 3750; III, 7500; IV, 15000; V, 25000. Mean income (estimated by taking group means and reweighted by the actual population distribution) was 9158 pesos. Total population of the study area is 2,034,453 households.

(i.e., in our efforts to allow for the bias against poorer households inherent in telephone sampling we had over-compensated, targeting too many poor households). This is readily accounted for within the aggregation process. The first six columns of Table 7 undertake this adjustment, by incorporating the number of households in the population within each income group. By multiplying group mean WTP by group population and summing for all groups we obtain the aggregate WTP for each program, this being 4,146 million pesos for the maintenance program and 4,039 million pesos for the improvement scenario. This suggests that, taking the conventional WTP measure (i.e., accepting that the current distribution of income gives richer households greater ability to express their WTP), the maintenance program yields higher aggregate WTP than the improvement scheme. This ranking of programs accords with the preferences of richer households and is a common result in many BCAs.

[62] While the conventional analysis indicates that the maintenance program (favored by richer households) yields the highest benefits, as noted previously there is policy concern regarding the standards of supply endured by poorer households. The maintenance scheme would not improve these conditions. However, the higher values accorded to this option are, as clearly demonstrated above, a product of income distribution. In recent years some economic authorities have advocated alternative approaches which apply some form of adjustment to recognize that WTP may be a systematically biased representation of underlying utility in this respect [e.g., *HM Treasury*, 2003]. One approach is to apply an equity weight (EW) to all benefits constructed so as to allow more even purchasing power across socioeconomic groups. *Pearce* [1983] discusses one simple variant in which the EW for some household i is defined as follows:

$$\mathrm{EW_i} = \text{Population average income}/\text{Household i}'\text{s income}$$

[63] This formulation provides EW values which are greater than one for households with below average incomes and less than one for those with higher than average income. Specifically the adopted approach uses a particular instance of a utility weighting formula where the exponent is the elasticity of the marginal utility of income function with, in this case, the elasticity set equal to unity. This approach is adopted in the last three columns of Table 7 with $\mathrm{EW_i}$ calculated as above and then applied to the WTP values to yield an aggregate benefit value for the maintenance scheme of 5,035 million pesos compared to a total value for the improvement program of 7,322 million pesos. Therefore, as expected, the equity weighting process shifts the balance back in favor of schemes which benefit lower-income households, here reversing the previous ranking in favor of the improvement program preferred by those poorer households who currently suffer low-quality water services.

[64] Finally, returning to our unadjusted (but population reweighted) benefit values, given that different areas suffer differing problems one could imagine a hybrid scheme which offers households a choice between the maintenance and improvement schemes. Assuming WTP levels remain unchanged then using the higher of the two WTP sums expressed by each income group as a guide to preference and consequent valuation suggests an aggregate WTP of 4,843 million pesos for this hybrid.

5.4. Comparing Benefits and Costs

[65] When, through a series of subsequent elite interviews [described by *Soto Montes de Oca and Bateman* [2005]), the aggregate benefit results estimated above were presented to relevant decision makers, the latter group saw this as an extremely useful input to the policy making process. However, a major issue determining whether or not either scheme will in fact be implemented are the institutional capacity and implementation costs they entail. At present the 3200 million pesos of water tariff collected each year is supplemented by a subsidy of some 3800 million pesos [*Cruz*, 2002; *CADF*, 2001]. The authorities have estimated that an extra budget of 2,000 million pesos annually would allow the service improvement in a substantial manner [*Cruz*, 2002]. The aggregate WTP estimates indicate that these costs could be completely funded through increased tariffs which could be further raised so as to substantially decrease subsidy levels.

[66] While these results suggest ample room for reform of the present subsidy system, a degree of caution is necessary. While the equity weighting procedure may indicate which scheme yields the highest net utility, it still needs to be financed. This may impose long-term, dynamic problems, particularly in the face of projected population growth. A scheme which guarantees a given albeit modest level of supply to all households may result in unsustainable costs in the face of demographic change, i.e., the equity weighting decision could, in the long term, make the investment problem worse, not better. While we did not have access to the cost data details necessary to undertake such an analysis, decision makers should always be mindful of the long-term consequences of adopting any given strategy when certain of the long-term determinants of scheme viability are not under their control.

6. Conclusions

[67] A gap exists in the research literature associated with households' WTP for water services in urban areas of developing countries. This study contributes to bridging that gap through an application to the developing world's largest urban area: Mexico City. Our survey confirms that service levels are highly heterogeneous in its core entity, the Federal District. Importantly, our results clearly show that service deficiencies disproportionately affect low-income households while richer households enjoy high-quality services.

[68] A CV study was undertaken to investigate households' WTP for two programs; the maintenance and improvement scenarios. This allowed the formulation of three hypotheses testing the validity of WTP responses through novel variants on the scope sensitivity test. H_o^1 and H_o^2 explicitly acknowledge the correlation of income and current service levels in determining WTP. Here theoretically driven expectations are clearly fulfilled with higher-income households (those which tend to enjoy better current endowments of water supply quality) being willing to pay higher amounts to avoid service deterioration than for improvements. In contrast, low-income households, which currently endure poor level of service, have higher WTP for the improvement than the maintenance scenario. These expectations underpin H_o^3 which controls for income to directly show the influence of current endowments upon WTP; those with higher endowments report higher WTP for maintaining those levels but lower WTP for further improvements than those suffering lower current service levels.

[69] We feel that the major contribution of this paper is to highlight the vital importance of incorporating heterogeneous current service conditions, their correlation with income and impact upon WTP, within valuation studies of water provision in urban developing country contexts. The novel scope sensitivity tests proposed in this study provide a validity criterion which brings together these related issues and permits the analyst to examine the extent to which findings are consistent with theoretically driven expectations. In broader policy terms, this WTP information provides an input to the process of defining more equitable and economic efficient tariff schemes, identifying the priorities of different groups of households while adjusting for the varied income constraints which they face.

[70] In calculating aggregate WTP we adjust for an oversampling problem so as to better represent the underlying population. Using the prevalent income distribution to conduct a BCA we find that the maintenance program favored by richer households delivers higher aggregate benefits values. However, using an equity reweighting formula to equalize the income constraint across society reverses priorities such that the improvement scheme favored by poorer households yields higher net benefits. That said, both the unweighted and equity weighted BCA show that the benefits of either scheme (or a hybrid combination of the two) were sufficient to cover the costs of implementation while still permitting a substantial reduction in subsidy levels and consequent efficiency gain.

[71] Analyses such as that outlined in this paper remain information inputs to the decision process and are no substitute for the decision itself. Nevertheless, the positive reaction to this study observed through our elite interviewing process gives us encouragement that the explicit incorporation of issues such as water supply heterogeneity, income distribution and equity impacts which form the basis of this study may provide a template for further studies and encourage their wider use within the decision making process. Armed with such information policy makers may feel emboldened to reject the continued reliance upon inefficient subsidies and instead adopt economically efficient strategies for tackling long-term problems of sustainability, while still ensuring that the water supply needs of poorer households are not overlooked.

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I. J. Bateman and G. Soto Montes de Oca, CSERGE, School of Environmental Sciences, University of East Anglia, Norwich NR4 7TJ, UK. (i.bateman@uea.ac.uk)