WILLINGNESS TO PAY FOR WATER

IN

KERALA, INDIA

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ABSTRACT

Large quantities of financial and human resources have been devoted to improving rural water supplies in developing countries over the past two decades. Many projects have been successful, but many have failed to meet the needs of the intended beneficiaries. Evidence of the failures lies in the unused and poorly maintained systems that are scattered throughout rural areas. In this paper we explore one of the main reasons for problems in rural water supply -- inadequate attention to clients' needs, willingness to pay for yard taps, and the economic characteristics that are designed into water systems.

We analyze contingent valuation data collected in three areas of Kerala State, India. One area has abundant traditional sources of water; in the second, traditional sources tend to dry up in the summer; and the third has abundant water but has begun to experience salt water intrusion into traditional sources. Households that currently own yard taps, households that have access to yard taps but have chosen not to purchase one, and households in areas that do not yet have public water systems were sampled. Our interest is to understand the determinants of both actual demand for existing yard taps and responses in the bidding games that were administered. The bidding games were designed to find out how much people would be willing to pay for yard taps (both the monthly tariff and the connection charge), and how much they would be willing to pay on a monthly basis for improved water service.

The conventional wisdom in Kerala is that the low quality of service (low pressure, intermittent flow, and maintenance problems) and the cost of connecting are the major impediments to the installation of more yard taps. We find that respondents in the bidding games are very sensitive to both the monthly tariff and the connection cost. However, their responses on connection cost are consistent with treating it as the cost of a durable good, and one of our major discoveries is that it is probably not the connection cost per se but credit market conditions that turn it into an impediment. We show that the water authority has considerable scope within which to solve this problem because it almost certainly faces much lower credit costs than do its customers. Our simulations indicate that at a monthly tariff of about 10 rupees for reasonable use, many more connections could be accommodated, the connection costs could be paid for as a component of the tariff, and a large increase in the quantity of connections demanded as well as the water authority's revenues would result. Our estimates suggest that a large increase in welfare would result from reducing the constraints on yard tap ownership implicit in the current system.

In contrast, we find that only current connectors are willing to pay substantially more for improved service, and residents of the scarce water area in particular would pay a large premium for better service. Given the apparent high latent demand for yard tap connections, we speculate that this large and virtually untapped source of revenue may make service improvements feasible even at low monthly tariffs. The fact that current connectors are interested in better service suggests that if more households connect, their primary concern after doing so will be better service.

We have less success in explaining and drawing inferences from actual patterns of demand for yard taps among households that could hook up now. However, owning a yard tap appears to reduce the impact of many socioeconomic variables on the quantity of water used, which suggests that having a yard tap can reduce or eliminate the negative effects of low income and low educational attainment on demand among the poor. Increased yard tap connections would thus allow the poor to behave much like the rich in consuming water, a benefit that is rarely emphasized. Thus it is little wonder that almost half the poorest quintile in both the abundant and water scarce areas are predicted to choose yard taps at a monthly tariff of 10 rupees, twice the current rate, if the cost of connections is reduced or eliminated.

INTRODUCTION

Substantial financial and human resources have been devoted to solving the technical problems associated with supplying water to rural communities in developing countries. Less attention has been paid to the behavior of the populations intended to benefit from those systems, which in the end is what determines whether they will be maintained, used, and have a positive impact on the health and welfare of the targeted populations. Designers have relied on rules of thumb, such as a maximum percentage of income that people are thought to be able to pay for water, when factoring in the contributions and tastes of the population to be served by a new rural water system. The result has often been water systems designed to provide minimal levels of service at the lowest possible cash cost to users. Water system planners emphasize the health benefits of water systems while users are seeking reduced time costs, better tasting water, or more reliable service (as well as health benefits).

This study examines willingness to pay for hookups to central water systems in several areas of northern Kerala State in India. A large number of rural piped water supply schemes have been constructed over the years in Kerala by the Public Health Engineering Department, which is now incorporated into the Kerala Water Authority. In most cases these schemes were partially or fully funded from central government sources. The central government targets funds to problem villages including those having no access to good quality water within a depth of 15 meters or a distance of 1.5 kilometers; where the incidence of water-borne diseases is high; and where traditional sources of water contain excessive chlorides, fluorides, iron, and other toxic elements. All such projects must conform to inflexible design criteria specified by the central government, which include the following: a capacity of 40 liters per capita per day to the beneficiary population, capital costs no higher than 200 rupees[1] per beneficiary, and (for the most part) no house connections.

By official estimates, between 50 and 70 percent of rural water systems in India at any given time are in a state of disrepair. Only 50 percent of the population with access to an improved water source are in fact using it. The quality of service through both public taps and house connections is poor, with water usually available for only a few hours a day at unpredictable times. Revenues from these schemes usually cover only about 30 percent of the operating costs and none of the capital costs.

When water systems are planned in villages of Kerala, it is usually assumed that 90 percent of the population will be served once the system is operational, and simple multiplication of the 200 rupee limit by the served population provides a capital budget for the system. A water system is then constructed within this budget that will provide some water to each of the served wards. Because of the central government's policy prohibiting private connections to publicly financed systems, the systems are designed to provide water volumes adequate only for a limited number of public taps. However, once the schemes are commissioned, applications for household connections are accepted and connections are given. The payment to the Kerala Water Authority for the connection is modest, but the connecting household bears the full cost of running the pipeline from the water main to the house, plus a water meter, plus in-house plumbing if it is installed.

There is now a broad consensus among donors and governmental officials that generation of revenues through domestic connections is a cornerstone to sound development in the water sector

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[1] In this paper all currency denominations are in rupees. In 1988, at the time of the survey work, 14 rupees exchanged for US$ 1. Thus a 200 rupee capital expenditure was equivalent to US$ 14.29. A 5 rupee tariff for water from a yard tap, the typical cost for reasonable use every month, was US$ 0.36.

in Kerala. These concerns pose a research question in the sense that an empirical base of knowledge is required to ascertain how rural people in disparate social, economic, and environmental settings respond to different system configurations (yard taps or public taps), levels of service, tariffs, and connection costs. The underlying policy question is whether it is possible to generalize about the consequences of these social and economic variables for policy options, such as tariff structure and cost recovery targets, and whether inexpensive and feasible methods exist to better understand clients' desires during the planning process for a new water system. If system design is changed to provide more yard taps with adequate cost recovery to maintain the system, the question of the equity implications of such a system arises in the sense that greater reliance on the price system to finance water supplies might exclude poorer segments of the population from the associated health benefits or convenience.

This study examines the actual behavior of households in deciding whether to hook up to the water system in several areas where piped water is currently available. In addition, bidding games were conducted in those areas and in other areas where water systems are being built but are not yet operational in order to assess hypothetically the determinants of why people will or will not choose to hook up. The goal of the bidding games is to assess the sensitivity of potential clients' hook-up decisions to changes in the cost of a connection, the monthly tariff for reasonable use, improved performance of the system, and exogenous conditions of traditional water scarcity or salinity

The remainder of the paper is organized into six sections. The next (second) section discusses the data and the setting. The third section analyzes the results of the bidding games. In the fourth section, the validity of the findings are considered. The fifth section examines the actual experience of connectors and nonconnectors in the A sites, explaining both the determinants of connecting and the demand for water. Finally, the overall conclusions of the analysis are summarized.

KERALA, INDIA: SETTING AND DATA

Background

Six sites in northern Kerala are covered by the survey. There are two sites from each of three types of environments: one with relatively abundant traditional sources of water, one with adequate quantities of water from traditional sources but of poor quality due to salt water intrusion, and one which has traditionally suffered from a scarcity of water. As shown in Table 1, the Panchayats in each area include an A site, where the improved water supply has been in existence for a few years and where a number of house connections have been made. For each A site, the table shows the number of connectors and nonconnectors in the population as well as the sample drawn for each type of household. The B sites, in contrast, are currently without improved water systems but were chosen to be similar to the A sites in other ways, such as social, economic, and environmental factors, including the characteristics of traditional water sources. All of the B sites have been targeted for improved water supply systems within the near future

In the A sites, the improved water service is mainly through public standposts. Most of the schemes are small in size, with ground water or surface water serving as the source of raw water. Service problems with the systems include leaking standposts (which are sealed by maintenance crews and not restored to service for several months), damage to pipes that requires several months to repair, poor quality meters that require frequent service, and pump repairs that are required on average more than once a month. Pump failure is the most important problem and is attributed primarily to fluctuations in voltage. The pump in Ezhuvathuruthy, for example, failed on fifteen separate occasions in 1987. The water flow in these systems and, in fact, the national norm of 40 liters of water per capita per day, are considered low by the standards of water use in Kerala. Few of the improved water supply schemes provide water for eight hours a day, and most maintain a flow of water for no more than four or five hours a day.

Public taps are located at specified distances along the main pipe; every 200 meters is a common spacing. The public taps may thus fall too close to households that would not use a public tap (if they have a private well) and too far away from households that have poor alternatives. Some standposts may serve as many as 70 to 80 households while others are used by only 5 or 6 households. Occasionally public taps are located in areas that are flooded, hence inaccessible, during the monsoon season.

The inevitable result of these factors is long queues, which were observed by the survey team at the public standposts. Rationing methods have evolved that limit the total amount of water per household per day, such as two to four pots per day. Although households with connections can get more water, only 15 to 20 percent of the households in each area are located where a connection to the water main is feasible. The next section provides quantitative information on some of these factors for the households covered in the survey.

Descriptive Information

The sampling framework should be clear from Table 1. The entire population of connecting households in the A sites was sampled because there were so few of them. 100 nonconnecting households in each of the A sites were sampled, and 200 households in each of the B sites were sampled. The total sample size is 1150 households.

Household Characteristics. Table 2 displays information on the households in the sample by A or B site. Average household population is about seven members in all sites, and about a fourth of the households are headed by women. Annual per capita income for connecting households is 71 percent higher than for nonconnectors in the A sites and 37 percent higher than for households in the B sites. Nearly all of the connectors have electricity compared to less than half of the other groups. Almost 60 percent of the connectors contain men who work in government, compared to 32 percent for nonconnecting A site households and 22 percent for B site households. A similar pattern exists for female employment. The coding of the schooling variables in the survey prevent identification of the schooling of any particular person, so the figures in the table refer to maximum levels of schooling for all adults in the household. The average maximum schooling for adult men and women among connectors, at 12 and 11 years respectively, represents essentially secondary school completion. Average maximum schooling levels are about 25 percent lower for the nonconnecting households and 58 percent lower for the B site households.

Table 3 displays weighted means by the type of site -- traditional water sources with abundant quantities of good water, those with abundant water but with intrusion of salt water, and those with traditional scarcity of water. The characteristics of traditional water sources are highly correlated with specific household characteristics. For example, households in the abundant-water sites have average incomes almost three times those in the salty water sites and double those in the water-scarce site. Abundant-water households are also more likely to have electricity and to have completed several more years of school than are households in either of the other types of sites.

Water Source Characteristics. Table 4 contains information on water source characteristics for the sample. Connectors in site A are, of course, the only ones using piped water, and for them it is the primary source. First a few statistics that are not included in the table will be discussed. Of the

250 connectors, 31 percent bring the piped water into the home; the rest simply have running water in the yard. For about two-thirds of the connectors, consequently, the yard tap connection is equivalent in convenience to a well in the yard. About 25 percent of the connectors had some type of maintenance problem with their water system during the year previous to the survey. Water meter problems were the most common, accounting for 43 percent of the reported problems during the summer (low water) season.

Table 4 shows the distribution of the primary *alternative* water source for connectors (if they were to disconnect or to supplement the yard tap) and the primary source for nonconnectors and B site households. Only 5 percent of the connectors in the A sites would turn to the public tap if they could no longer afford the yard tap connections; 61 percent would use their own well and another 27 percent would use their neighbor's well or tap. In contrast, 37 percent of the A site nonconnectors currently use the public tap, and almost all of the remaining households use a private well. The proportion using a well in the B sites is similar, and the remaining 30 percent use either a public tap (even though their own area is not served directly by a public tap), a public hand pump, or a public well.

Connection charges for the entire sample were estimated based on the distance from the house to the actual or planned water main. In addition, actual connection charges were reported by connecting A-site households. Using the estimated connection charges, it is clear that on average, households that were connected faced the highest connection charge (or were farthest from the water main). Actual reported connection cost for the site A connectors were about 2.4 times the estimated charge, suggesting that reported hook-up charges may cover considerably more plumbing work than just the connection to the water main.

Distances to water sources are relatively short, on average no more than 50 meters. Queuing time is also short, on average not more than a quarter of an hour.

Connectors are relatively dissatisfied with both the yard tap and the secondary source of water. While approximately 80 percent of the nonconnectors and B site residents claim that their water tastes good and is of good quality,[2] only about 40 percent of the connectors are happy with the taste and quality of either their piped water or their alternative source. Overall satisfaction[3] is lower for all sources but extremely low for households owning a yard tap.

Table 5 contains weighted means for the sites, classified by water source characteristics. The first group of numbers shows the distribution of water sources used by households in each site. Households in the abundant sites depend primarily on their own wells, while those in the scarce-water sites are heavily dependent on public sources (58 percent) or on a sharing arrangement with a neighbor (24 percent). The saline-water households' use patterns lie between these limits. Average distance to the primary water source is longest in the scarce water sites (11 times longer than in the abundant water sites) and the quantity per capita is lowest. However, average queuing time is about 12 minutes in both the saline and scarce water sites.

Households in the abundant water sites are almost completely satisfied with their traditional sources of water. Saline-site households are quite dissatisfied (relative to the other sites) with all

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[2] "Good" is the highest possible recommendation. The categories in the relevant questions are "good," "not bad," and "bad."

[3] Categories for this question are: "satisfied," "somewhat satisfied," and "not satisfied." Only "satisfied" is reported here.

characteristics of their water. Scarce-site households are satisfied with the taste and quality of the water but indicate low overall satisfaction.

Bidding Games. Table 6 shows the bidding games that were conducted in each site. For the A1 households, for example, the first game varied the tariff, raising it from the current 5 rupees for reasonable use per month to 50 rupees per month, and asking if the household would still connect to the system at the new price. Intermediate levels of 20 and 30 rupees were also asked in order to ascertain a narrower range for the tariff at which the household would disconnect. The second game for the A1 households was the same as the first, but an improved system with plentiful, clean, good-tasting water and reliable service was first described. The same range of tariffs was quoted for this system. In addition to these two games, a game reducing the connection cost was played in the A2 and B sites. The improved service game was not administered to the B site households.

Table 7 shows average maximum willingness to pay derived from the various bidding games for A and B households. In the first game, for which the tariff was varied, the mean bid was 19.3 rupees for A site connectors, falling to 8.7 rupees for A site nonconnectors and 5.5 rupees in the B sites. The average maximum bid exceeds the current tariff of 5 rupees for reasonable use, by from 0.5 rupees to 14.3 rupees. The second row of numbers shows that 56 percent of the A connectors would pay more than their current tariff for the existing system. However, only 43 percent of the connectors and 34 percent of the B households would pay anything for a yard tap.

In the second game, when the connection charge was varied from 100 rupees to 700 rupees, the average maximum bid falls near the middle of the range, at 355 rupees, for the A site nonconnectors and well below the midpoint, at 267 rupees, for households in site B. The average maximum bid also falls well below the average cost of connection for those households, as shown in Table 4. However, 78 percent of the currently unconnected A households and 62 percent of the B households are willing to pay something for a connection. The third and final game in the table is for the improved service described above. About 85 percent of the currently connected households are willing to pay, on average, 30 percent more than for the unimproved service and 400 percent more than is currently charged. However, nonconnectors would pay only 11 percent more, and less than half of them would pay anything.

Overall, these descriptive statistics show little willingness to pay substantial increases in the monthly tariff by households that are currently not connected to a water system. Yet a large proportion would make a contribution for the connection charge, although the contribution they would be willing to make is, on average, less than 60 percent of the actual cost of connecting. These low bids contrast with those of currently connected households, which are willing to pay an average of nearly four times the current tariff for an unimproved system and about five times the current tariff for an improved system.

Similar statistics provided in Table 8 by water characteristics indicate that scarce water households approximately match the abundant water households in willingness to pay the tariff for the current system and for the connection cost. However, they will pay a large premium for an improved system. Saline water households display low willingness to pay in all three games.

Users of Public Taps. Table 9 displays descriptive statistics for users of public taps.[4] Users of public taps are slightly poorer than average and are less likely to have electricity; otherwise, they are similar in most respects to other households in the sample. Waiting time at the public taps is

[4] For connectors, households in this table are those that would use a public tap if they disconnected.

longer than the means for the whole sample shown in Table 4, but reported quality and taste is good. Overall satisfaction with the public tap is low. Flows from public taps may be low, but users of public taps are able to reach about the same total daily quantity from *all* sources as is achieved by the sample as a whole. Willingness to pay by users of public taps in the B villages is low, but close to the mean for the site A nonconnectors. There appears to be little systematic difference between the whole sample and users of public taps.

Summary

The "stylized facts" quoted earlier about the water systems are not entirely borne out by the survey data. The population appears to be generally content with the quality and taste of water from traditional sources, although this situation varies. Users of traditional sources are much more satisfied with them than are owners of yard taps. Actual water consumption levels are about the same as the 40 liter-per-capita design criterion.[6] While yard tap-owning households do have repair problems, the systems appear on the whole to be operable. These inferences are of course based on descriptive data and to some extent on responses to opinion questions (satisfaction-quality-taste). It should be kept in mind that expectations among the population may be very low, which may be reflected in the low willingness-to-pay responses in the bidding games, even for the promise of an improved system. The estimations to be carried out next control for a number of different factors in an attempt to find how differences in prices and system characteristics alone affect the probability of hooking up.

PROBABILITY OF CHOOSING A YARD TAP IN THE BIDDING GAMES

Referring to Table 6, three bidding games were conducted. Only the simple tariff game was administered to all households. The connection charge game was not appropriate for the A1 households, which are already connected, and the improved service game was not appropriate for the B households, which have no public system to improve. Thus the a major analytical hurdle is how to combine the information contained in these games in a way that allows generalizations about the important variables (new water system characteristics, traditional water source characteristics, and household variables) across sites.

Probit Estimates

Two different methods could be used to analyze the bidding game responses. One, which is used in this section, is to treat the bidding games as supplying to the respondent a description of the improved water source characteristics, with the respondent indicating whether, given those characteristics, he or she would choose a yard tap. Under this interpretation, the dependent variable is a 0/1 response, and the tariff, connection charge, and improved service variables are determinants of the response. In such a problem, the classical regression model is inappropriate, and the probit (based on the normal distribution) or logit (based on the logistic distribution) regression model is used. Either of these approaches transforms the dichotomous dependent variable into a continuous variable on the 0,1 interval. They generally give similar results unless the predicted probabilities for most of the sample lie near the endpoints of the interval. We use the probit model in our analysis. A second approach is to treat the final "yes" response in each game

[6] Of course this statement is not meant to imply that 40 liters per capita is the optimal amount or that the entire 40 liters is gotten from the public water system. In fact, households with yard taps get, on average, only 18 liters per capita per day from the tap. It appears that households with yard taps do consume more water, in total, from all sources. See Table 4 and a more detailed discussion later in the paper.

as the maximum willingness to pay for a yard tap, which can then be analyzed using the ordered probit statistical model. It will be discussed briefly in a subsequent section.

Modeling the Choice of Water Source The underlying economic model for the probit is the random utility model, in which the respondent's choice is, almost tautologically, taken to reveal the highest level of indirect utility possible for that person, given the available choices. Econometrically, implementing the probit model to analyze the bidding game responses can be problematic. First, we would like to include information from all bidding games in the estimates, yet the bidding games differ and each bidding game was not conducted at every site. We overcome this obstacle by assuming that if a specific game was not conducted, the respondent made a choice as if the characteristic changed in the unadministered game was not changed for that respondent. For example, in the connection cost or simple tariff game, the dummy variable for whether the service is improved is set to 0 even though no mention of improved service was made. A related problem is what to do about the connection cost for the A1 households, which are already hooked up. The connection cost variable is never less than 100 rupees for the other sites, because that was the minimum quoted in the bidding games. We treated connection cost as a sunk cost for the A1 households, so it is always 0 for them.

A second econometric problem is the proliferation of observations created by coding each bid as a 0/1 variable. Each of the three bidding games had four possible responses, so each household appears twelve times in the data used for the probit estimates. As an example, consider the single household appearing in Table 10. The top four observations correspond to the simple tariff game. The respondent would not choose a yard tap at any of the prices quoted. The middle four observations correspond to the improved service game. In this game, the respondent would choose the yard tap at a tariff of 10 or 20 rupees. The bottom four observations indicate that the connection game was not conducted. The respondent's maximum willingness to pay in the simple tariff game is 5 rupees (the current charge for an A1 household) and 20 rupees in the improved game. Because we treat each price quote as a separate response, each household in the sample has 12 observations for the probit analysis, giving rise to 13,800 observations for the 1150 households.

The resulting coefficient estimates are unbiased, but because of the correlation of the errors across observations for the same household, the standard errors are biased downward. To correct the standard errors we used a bootstrapping method, drawing one observation randomly from each group of 12 and re-estimating the probit on these 1150 observations. This sampling (with replacement) was done 100 times, and the average standard error for each coefficient from those 100 probits is reported.[8]

Independent Variables. We include improved water system characteristics (from the bidding game), characteristics of the current source, household characteristics, traditional water characteristics, and bidding game dummies as independent variables in our analysis. The list of variables in Table 11 shows the categories, provides a definition, and indicates the expected sign for each variable. Referring to that table, the price variables associated with the improved system (tariff and connection charge) are expected to reduce the probability of connecting. The quality variable (improved service) is expected to raise the probability of connecting. The time cost variables associated with the primary traditional source used by the household (distance and queuing time) are expected to increase the probability of hooking up to the improved system. The basic

[8] The standard errors for the probits based on the full 13,800 observations tend to be about a third smaller than those we report, resulting in t-statistics about 3 times too large. The means of the coefficients from the 100 probits, as expected, are almost exactly the same as those reported for the large sample.

household variables (income, electricity, number of rooms in the house, and adult education) measuring income, wealth, and human capital are expected to increase the probability of hooking up. The occupation variables (government employment by females and males) are intended to capture the effect of modern sector employment in raising the opportunity cost of time; hence, they are expected to raise the probability of hooking up to the water system. The religion variable (Hindu) is a control variable for which we have no expectation as to the sign. Sex of both the respondent and the household head is included because many observers speculate that females benefit more from yard taps and thus are more likely than men to provide positive hook-up responses. Dummy community variables differentiate community water characteristics (abundant, scarce, saline), with the expectation that households in scarce or saline water areas will provide higher bids, everything else equal. Finally, dummy variables distinguishing the type of household (A1, A2, B) are included to measure the bidding game bias for households that are not currently connected.

Results for the Full Sample

Table 12 contains the estimation results for the full sample, using the information from all three bidding games. As in all subsequent tables, the following information is reported: the estimated coefficients, standard errors, and asymptotic t-statistics; an asterisk indicating whether each coefficient is statistically significant for a two-tailed test at the ten percent level; the elasticity estimated for continuous variables at the means of all independent variables[7]; and the mean of each variable in the sample used for the estimation. Table 12 contains coefficients for two models -- the full model containing all variables discussed in the previous paragraph and a simple model in which the only household variable that appears is per capita income. The discussion below refers to the full model.

Characteristics of the Improved Water Source. The price variables -- tariff and connection cost -- have the expected negative effects on the probability of hooking up, and they are statistically significant at less than the one percent level. The tariff elasticity is quite large: a 1 percent increase in the monthly cost reduces the probability of choosing a yard tap by 1.5 percent. The connection cost elasticity is substantially smaller: a 1 percent increase in the cost of hooking up reduces the probability of doing so by 0.3 percent.[8] Thus a small percentage change in the connection cost appears to have less effect on the probability of connecting than does an equal percentage change in the tariff. This finding is counter to the popular impression that connection cost is the major impediment to hooking up to the modern water system and in fact is counter to the responses of the A2 respondents, 58 percent of whom reported that the cost of connecting was a reason they had not already connected to the existing system.[9]

In fact, the apparent large difference in elasticities is illusory because the scale and time horizon for the tariff and connection charges are different. If the two charges are made economically

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[7] The reported elasticity is the change in the probability of hooking up for an infinitesimal change in the independent variable.

[8] It should be noted that the connection cost game was introduced by telling the respondent that the maximum connection cost being quoted (700 rupees) was smaller than they would otherwise pay, which was not generally true given the estimated connection cost reported in Table 4.

[9] Respondents were allowed to make multiple responses to this question. Out of 300 respondents, there were 324 responses. 58.3 percent of the responses cited the cost of connection. Another 34.3 percent cited other reasons, including that they already owned a well or that a public tap was nearby. The remaining 7 percent either had or would like to apply for a connection.

equivalent, there should be no difference in how rational economic agents react to the actual rupee cost, no matter what label is put on the charge. Table 13 illustrates this idea Column 1 contains the mean value of the tariff and connection charge from the bidding games. In a sense, these values are unrealistic in that the tariff is probably much higher than would actually be charged, and the connection charge is much lower than the actual cost for most households However, the elasticities in Table 12 are calculated at these means, and this example is designed only to show the potential for behavioral equivalence by the consumer in evaluating the two charges Column 2 shows the rupee value of a ten percent increase in the tariff or in the connection charge. Column 3 shows the implied reduction in the probability of hooking up, given these changes and the elasticities in Table 12.[10] Columns 2 and 3 illustrate the peculiar result that a 1.8 rupee change in the tariff causes a 5 times greater reduction in the hook up probability than does a 21.9 rupee change in the connection charge. In column 4, the increase in the tariff is multiplied by 12 to get an annual increase in expenditure, and the increase in the connection charge is amortized over 6 years at a 5 percent real rate of interest to show the implied increase in annual cost.[11] On an annualized basis, it turns out that the change in the connection charge is about a fifth as costly as the change in the tariff.

Column 5 is included to reorient the reader: suppose we abandon the idea of equal percentage changes in the tariff and connection charge and instead vary them so that the absolute increase in the annual expenditure is equivalent, at 4.2 rupees per year? To achieve this equivalence would require a 0.4 rupee increase in the monthly tariff a 21.9 rupee increase in the connection charge (column 6). These increases correspond to a 2 percent in increase in the tariff and a 10 percent increase in the connection charge (column 7). Column 8 shows that this equivalent change in expenditure through either the tariff or the connection charge would reduce the probability of hooking up by the same percentage no matter which of the two charges is chosen for the fee increase.

What does this information mean? The respondents have simply revealed that they made rational responses to the bidding game questions; they showed that they discount the cost of a durable good (the connection charge) over a period of year in trading off between the connection fee and the monthly tariff. Thus, at some interest and amortization schedule, the connection charge and tariff can be made equivalent to the household. This finding implies that, given the credit market conditions facing each household, it is possible to find whether it would prefer to fold some of the connection charge into the tariff or vice versa. For example, if the real rate of interest a household faces is an annual rate of 100 percent and the maximum term for which it can borrow money is 12 months (those terms might exist for a poor rural household), the connection charge increase (21.9 rupees) shown in Table 13 would be equivalent to 3 rupee increase in the monthly tariff (about 35 rupees). In such a situation, if the real borrowing cost of the water authority is only 5 percent on long term bonds of 30 years, it could provide the same credit to the household for only a 0.1 rupee increase in the monthly tariff, reducing the cost to the household by 97 percent while still recovering its costs.

In other words, if the connection charge is viewed by households as a major barrier to connecting, it must be an impediment primarily because of poorly functioning credit markets. If the water authority faces credit market conditions that are less costly than those faced by its potential customers, which would be the expectation in rural India, it could use its borrowing power to fold

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[10] Although the elasticities are calculated for infinitesimal changes in prices, it is unlikely that we are making an excessively large error by assuming a constant elasticity for a ten percent change in price in this illustration

[11] The term and interest rate were chosen arbitrarily.

some part of the connection charge into the monthly tariff, thereby increasing the coverage of the system and its revenues. Abandoning the incremental examples used above, suppose 900 rupees of a 1000 rupee connection charge were folded into the tariff. If the water authority could borrow 900 rupees at 5 percent real interest for 30 years, the cost would be 58 rupees annually. If it charged the household 7 percent interest for 30 years, the result would be a net addition of 6 rupees per month to the tariff. The equivalence of the behavioral reaction by the respondents to the tariff and the connection charge suggests that the water authority's treatment of the two fees should depend primarily on credit market conditions.

These calculations suggest that viewing the connection charge per se as a major impediment to choosing a yard tap is an illusion. The households responding to the bidding games suffered from no such illusion; their responses to the two types of games can be reconciled at a reasonable discount rate and amortization schedule. Policy should be based not on the presumed difficulty of paying the connection charge (and thus not making yard taps an integral part of the planned water system) but on a careful assessment of credit market conditions and whether a reasonable substitution could be made between small increases in the tariff and large decreases in the connection charge. Respondents to the bidding game imply that households would readily understand a new pricing strategy that included some or all of the connection cost in the monthly fee.

The other water service characteristic, whether the system's reliability is improved, apparently has no effect on the probability of hooking up, which is surprising given that poor service is one of the most common criticisms of the modern water systems now in place. This issue is explored further in the sensitivity analysis that is presented later.

Characteristics of the Current Water Source. The variables measuring characteristics of the primary traditional source -- distance and queuing time -- are not statistically significant. While this result is contrary to our expectations, if household location is partially determined by characteristics of the traditional water sources, the behavioral impact of those characteristics may be blunted by adjustments that have already taken place in the household.

Household Characteristics. The household income and asset measures -- per capita income, whether the household has electricity, and the number of rooms in the house -- all have statistically significant positive effects on the probability of choosing a yard tap. However, the female government occupation dummy is negative and statistically insignificant, while the male government occupation dummy is positive but also fails our significance test (it is significant at the 15 percent level in a two-tailed test).

The religion variable -- whether the household is Hindu -- has a negative effect and is significant at the 13 percent level in a two-tailed test. Whether the household head is female is not significantly different from zero. Whether the *respondent* is female has a statistically significant negative effect on the probability of choosing a yard tap, which is the opposite of the expectation in the literature.

All of the adult education dummies have statistically significant positive effects. The excluded education variable is no schooling. If we disregard the other variables in the equation and just calculate the change in the hook-up probabilities associated with each education dummy, it is possible to see how each level of schooling increases the probability of hooking up relative to the previous level.[12] The results are organized in Table 14. The two largest increments in probability

[12] This approach probably understates the true change in probability because it disregards the combined effect of a number of correlated variables, such as income, that change as education changes.

come at the lower levels of schooling: finishing primary school raises the probability of hooking up by 5.9 percent over having some primary schooling, and finishing middle school raises it by another 13.1 percent. Adding secondary or college further increases the probability, but at a declining rate

The table also shows the percentage of A-site nonconnectors and B-site households falling into each education category. The effects in the table are approximately cumulative, so that a household containing someone who went to college is (other things equal) nearly 30 percent more likely to choose a yard tap relative to a household with maximum schooling of some primary.[13] While adults' maximum schooling levels are slow to change, education is probably not a major impediment to choosing a yard tap. About 61 percent of the A-site nonconnectors and 33 percent of the B-site households are in the two top education groups.

Traditional Water Supply Characteristics. Households in the scarce water area are substantially more likely to choose a yard tap (other things equal) than are those in the excluded abundant water site.[14] The magnitude of the effect, which is statistically significant at about the one percent level, is approximately the same as having electricity or completing middle school instead of stopping at primary school.

In contrast, bids from the saline water area are significantly lower than in the excluded abundant water site, a result that is unexpected. The negative effect of this variable on the probability of choosing a yard tap is only about seven percent smaller than the positive effect of the scarce water dummy.

Bidding Game Bias. The bidding game bias detected for either the A2 or B households is not statistically significant at acceptable levels, although the B coefficient is significant at about the 15 percent level for a two-tailed test. Both coefficients are negative.

Illustrated Summary of the Major Results. Overall, the estimates for the combined bidding games follow our expectations. The price variables have strong negative effects on the probability of choosing a yard tap. Apart from the price variables, the important determinants of choosing a yard tap are the income/wealth variables, education, and scarcity of traditional water. Saline water conditions seem to reduce the probability of choosing a yard tap.

The interplay of the important variables is clearly shown in simulations. Figures are provided here to illustrate the effect of the tariff on the probability of choosing a yard tap in each site. For each simulation, all variables are held at their mean values except the one that varies (tariff or income). How the independent variables are held constant is important to the interpretation of the graphs, so the procedure is carefully explained below.

Figure 1 shows average differences in hookup probabilities based on "community-level" averages. The unchanging variables, including the dummy variables, are held at the average for each site rather than at the overall averages for the whole sample or for a particular household. For

[13] The effects are not exactly cumulative because the denominator changes at each step. For example, according to the table, going to college raises the probability of choosing a yard tap by 27.2 percent over finishing primary school. The actual change is 29.8 percent.

[14] The excluded category includes a household with the following characteristics: no improved service, no electricity, no one in government service, not Hindu, male head and respondent, no schooling, and an A-1 household in an abundant water site. Such a household probably does not exist. It is an oversimplification to discuss the excluded category as a single variable, as is done in the text, but it would be ponderous to precisely identify the full list of exclusions that are lumped into the constant.

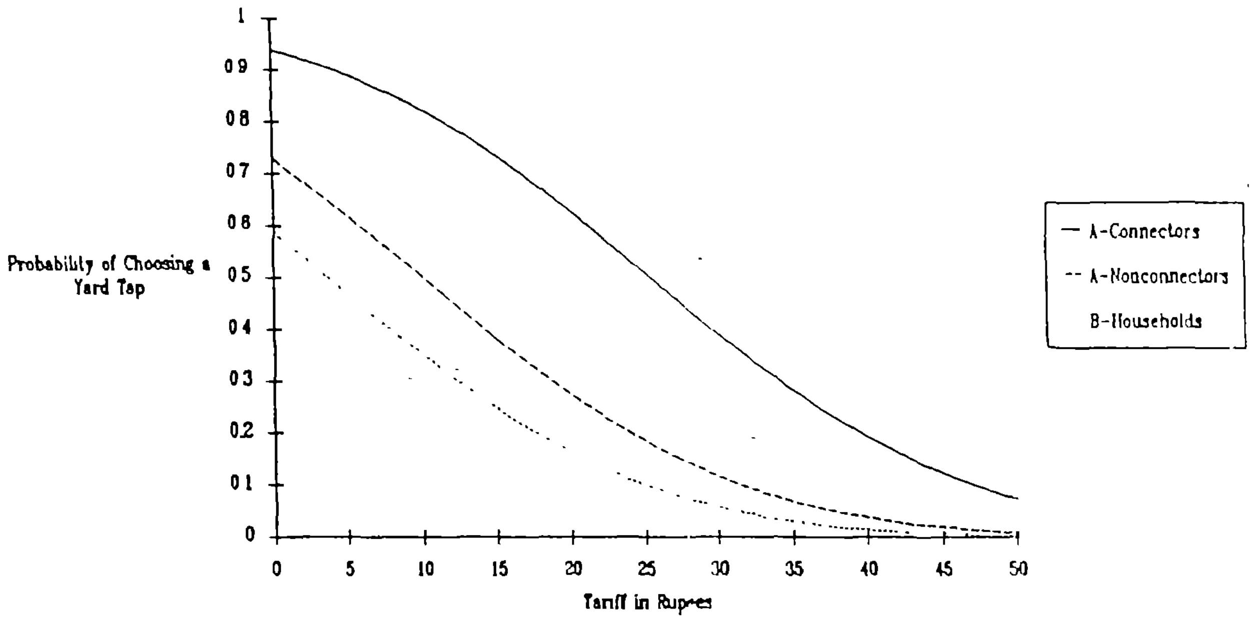

Figure 1. Effect of Bidding Game Bias and Household Characteristics on the Probability of Choosing a Yard Tap. Derived from Table 12.

example, income for the A1 connectors is held at 3533.27 while income for the B households is held at 2652.53, which are the means for those two types of households.[15] Thus the lines reflect differences in the means of the independent variables as well as the site dummies included in the probit model. All lines use the same coefficients from Table 12.

Figure 1 confirms that the connectors are most likely to connect, hardly a finding that requires economic analysis! The value added of the analysis is to show in quantitative terms how much more likely they are to connect. If we take 0 5 as the cut-off for choosing to connect,[16] the "average" A1 household would hook up at any tariff below 25 rupees, suggesting significant leeway in setting the monthly tariff once a household is connected.

The approximate tariff below which A2 households would connect is 10 rupees, and it is 5 rupees for the B households. An obvious question is why the A2 households are not already hooked up at the current 5 rupee tariff if the analysis suggests they would hook up at a higher tariff. The answer lies in footnote 16: the reduction in the tariff by 5 rupees increases the probability of connecting from 0.50 to 0.65, which is apparently not enough to actually move the average A2 household into the connector category. On the other hand, raising the tariff to 10 rupees does not alone cause a substantial decline in the hook-up probability. Other factors, such as income, education, or water scarcity, are also important.

[15] These means are slightly different from those in Table 2 because they are the means for the observations used in the analysis, after those with missing values for any of the independent variables were dropped.

[16] We have transformed a yes/no decision into a continuous probability on the assumption that there is some underlying continuous variable that characterizes the propensity to choose a yard tap. For some households, the underlying probability might have to rise to 0 99 before they decide to take a yard tap. For others, the decision might occur at a 0 76 underlying probability, for other it might occur at a 0.25 probability. Our choice of 0 5 as the threshold is arbitrary.

The results for the A2 and B households suggest that there is little room for maneuver in setting the initial tariff if the hope is to encourage private connections. Yet the huge difference between the hook-up probabilities for the A1 households relative to the others also suggests that there are strategic pricing opportunities available to the water system. For example, a strategy of low initial prices to encourage hook ups, coupled with slowly rising tariffs to reach cost recovery targets, may be feasible. It is often not essential to fully recover costs at the outset. Using the A1 responses as a guide, it seems reasonable to expect that as users become more familiar with the system over time they will become willing to pay more.

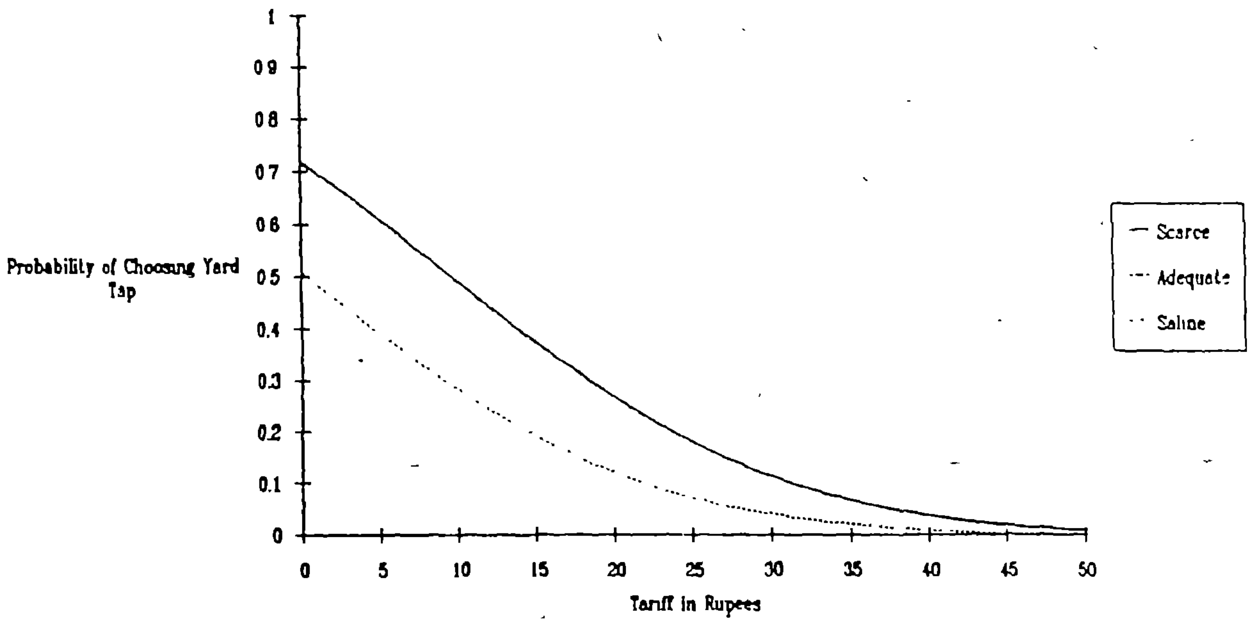

Figure 2. **Effect of Traditional Water Conditions on the Probability of Choosing a Yard Tap. Derived from Table 12.**

Figure 2 shows differences in hook-up probabilities by traditional water source characteristics. The same simulation method is used here as for Figure 1, but the means used are for the abundant, scarce, and saline sites. It is impossible to distinguish the adequate-site line from the scarce-site line in Figure 2 because they are superimposed on each other.

The effect of being in a scarce water area on raising the probability of hooking up is very strong. The average per capita income in the scarce-water area is about half that in the abundant-water area, and a quick perusal of Table 3 reveals other large differences between the two sites in some of the variables that matter in the hook-up decision -- availability of electricity, males in government service, and educational attainment. All of these differences are completely offset by the scarcity of water in determining the average household's hook-up probability.

In contrast, the even larger differences between the saline and abundant water sites in these same variables is reinforced by the negative effect of salinity on the bids. Although those living in the saline water areas rate the taste and quality of traditional water relatively low (see Table 5), those views do not translate into a higher willingness to pay for tap water. It makes one wonder if they expect to get the same salty water from a yard tap as they do from their current sources, an issue that should be addressed in any subsequent survey.

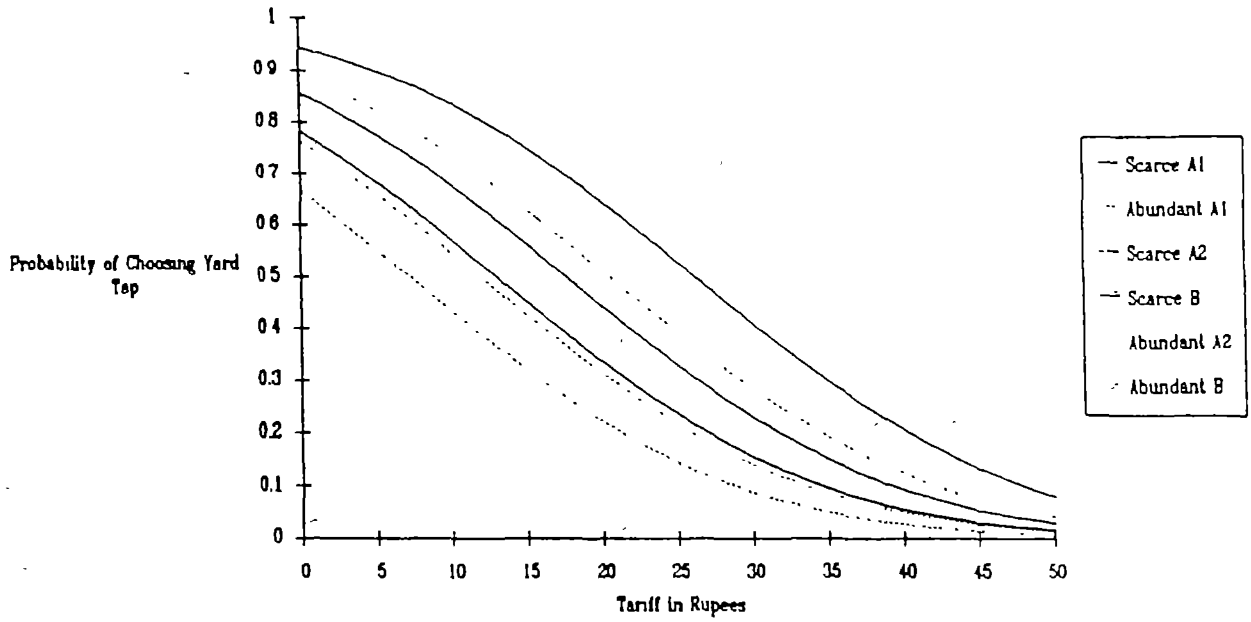

Figure 3. Effect of Traditional Water Sources and Bidding Game Bias on the Probability of Choosing a Yard Tap for Specific Household Characteristics. Derived from Table 12.

Figure 3 takes a different approach to the means that are held constant. Rather than using overall community averages, the independent variables are set to characterize a specific type of household. As in the previous figures, a number of variables are held at the community average, including distance to the current source, queuing time, per capita income, and number of rooms in the house. Tariff is allowed to vary, but connection charge and improved service are held at zero The household-specific variables are set at the following values: no one in government service, Hindu religion, male head of household, female respondent, and secondary school completion. The site dummies are set to a value appropriate for each line. Assuming that the reader is familiar with the previous two graphs, both types are combined into a single graph for this simulation. Each type of household (A1, A2, B) appears twice -- those in scarce sites (solid lines) and those in abundant sites (dotted lines). The ordering of the lines is given in the legend. The highest one is an A1 household in a scarce site; the next one is an A1 household in an abundant site The bottom line is a B household in an abundant site.

For the specific type of household characterized by these lines, willingness to pay for water is high A horizontal line drawn from the 0.5 probability level corresponds to a minimum of about 8 rupees in the abundant B site and nearly 30 rupees in the scarce A1 site. The positive effect of scarce site location is also clear from the graph, with the scarce site lines lying above all but one of the abundant site lines.

Other graphs showing hook-up probabilities for income and connection cost could be shown, but they provide little additional information. Given the numerous assumptions required to draw the graphs, they should be taken as no more than illustrative of the major findings in Table 12

The Simple Model. Would a quick-and-dirty survey that does no more than collect household income and perform the bidding games provide adequate information to plan the economic characteristics of a water system? Many of the household variables are highly correlated with income, so it is possible that while we are knowingly mis-specifying the model by dropping variables, the resulting biases may be small. In one such model, the simple specification in Table 12, only one sign changes -- the intercept -- but there are several changes in the size of the estimated effects. Both the tariff and connection cost elasticities, for example, are underestimated by about 20 percent in the simple model. The effect of per capita income is increased by about 67 percent. Although the implicit biases in the coefficients are large, the basic qualitative inferences for these important variables, would not change.

However, the misspecification eliminates the positive effect of living in a scarce water area and increases the negative impact of living in a saline water area. It also approximately doubles the negative bidding game bias detected for the A2 and B households, and it makes those effects strongly significant. The probable cause of these errors is the systematic difference in household characteristics across sites. Those characteristics cause differences in bidding game responses that would be attributed to traditional water source attributes or to strategic bidding game behavior in the simple model because the variables actually causing the responses are not measured directly

A simple survey would create few problems in this example if the only item of interest is the reaction of households to the characteristics of the new water system. The combination of the intercept and household income are probably adequate proxies for most of the household characteristics. However, unless the households are fairly homogeneous across sites, the site characteristics themselves do not provide valid information in the simple model. Because the few variables required to estimate the full model in Table 12 are neither difficult nor onerous to collect, a further simplification is probably not warranted, given the errors it may create.

Summary

Respondents are quite sensitive to the monthly tariff for water and to the price of a connection. They provided responses to the connection cost game that suggest the major impediment to hooking up may not be the connection cost per se but the cost of credit. Despite the sensitivity of the sample to the monthly tariff, we showed that small increments to it could remove completely the credit market impediment to getting a connection. We do not know anything about the supply side, such as whether there are significant economies of scale to systematically providing universal yard taps at the same time a system is installed. If such economies exist, they would allow the water system to reduce the cost of a connection significantly. The credit/connection charge issue and the possibility of rolling some credit costs into the tariff should be treated as a hypothesis that merits further work, including actual experiments in which water companies provide credit for some portion of the connection charge either implicitly or explicitly through the monthly tariff.

Improved service does not significantly affect hook-up probabilities. This finding is quite surprising given the conventional wisdom, affirmed by descriptive statistics for this sample, that connectors are dissatisfied with the quality of the service. Connectors may be dissatisfied, but the quality of service is not an important issue to households that are currently not connected.

Income, asset, and schooling variables have strong positive effects on hook-up probabilities, as does living in a scarce water area. We do not find evidence that female headed households are more likely to hook up, and we find that female respondents consistently report lower hook up probabilities than men.

SENSITIVITY ANALYSIS

Several possible problems with the bidding game results are listed below with a discussion of additional estimations designed to test the sensitivity of our results to each one In each case the estimation is identical to that used for Table 12 except that two variables -- females in government service and some primary schooling[17] -- were dropped, and other changes described below were made.

The Inclusion of Bidding Game Variables for Samples to Which The Games Were Not Administered

Table 15 is a subset of Table 12 in two ways. First, the sample includes only the A2 and B households. Second, it includes information from only the tariff and connection cost bidding games. The improved service game is excluded because it was not administered to the B households. The A1 households are excluded because the connection cost game was not administered to them.[18] The question to be answered by this estimation is whether our inferences are affected by the change in sample and specification.

The simple answer is no. The coefficients on tariff, connection cost, and income are virtually identical to those in Table 12. The elasticities change slightly not because of the coefficients but because the means at which they are calculated are different for this subsample. Although there are some minor differences in the size of some of the other coefficients, most are almost exactly the same as in Table 12. Significance levels tend to be slightly lower, but that is to be expected for a smaller sample.

Table 16 is also a subset of Table 12 in two ways. First, the sample includes only the A1 and A2 households. Second, it includes information from only the tariff and improved service games. The connection cost game is excluded because the A1 households are included. The B households are excluded because the improved service game was not administered to them. Again, the question is whether our inferences are affected by these changes.

There are two sign changes in Table 16 (improved service dummy and males in government service), but neither is statistically significant in either this table or in Table 12. The coefficient on the tariff drops by about a third, and that on per capita income doubles. However, none of the important inferences derived from Table 12 changes. In fact, it is surprising that there is not more variability in the results. As indicated by the means, this sample is quite different from those used in either Table 12 or Table 15, especially the mean of the dependent variable. The positive sign on improved service is consistent with our expectations for the first time, but the coefficient remains statistically indistinguishable from zero. This issue is discussed further in the next section.

In summary, our *qualitative* conclusions -- the signs of the independent variables and their statistical significance -- are virtually unchanged across the different specifications and samples. The *quantitative* effects of the variables, especially those of greatest interest in the bidding game -- income, education, and site variables -- are remarkably stable across estimations. Although there is some variation in the coefficients and sample means across Table 12, Table 15, and Table 16, the tariff elasticity, for example, varies only from -1.5 to -1.7. Our inference of a high price elasticity is not affected by this 0.2 range in the estimate.

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[17] Smaller samples were used in each case reported below, and there was not enough variation in these two variables, preventing the maximum likelihood estimator from converging when they were included.

[18] Recall that in the previous estimation, connection cost for the A1 households was treated as a sunk cost (set to zero)

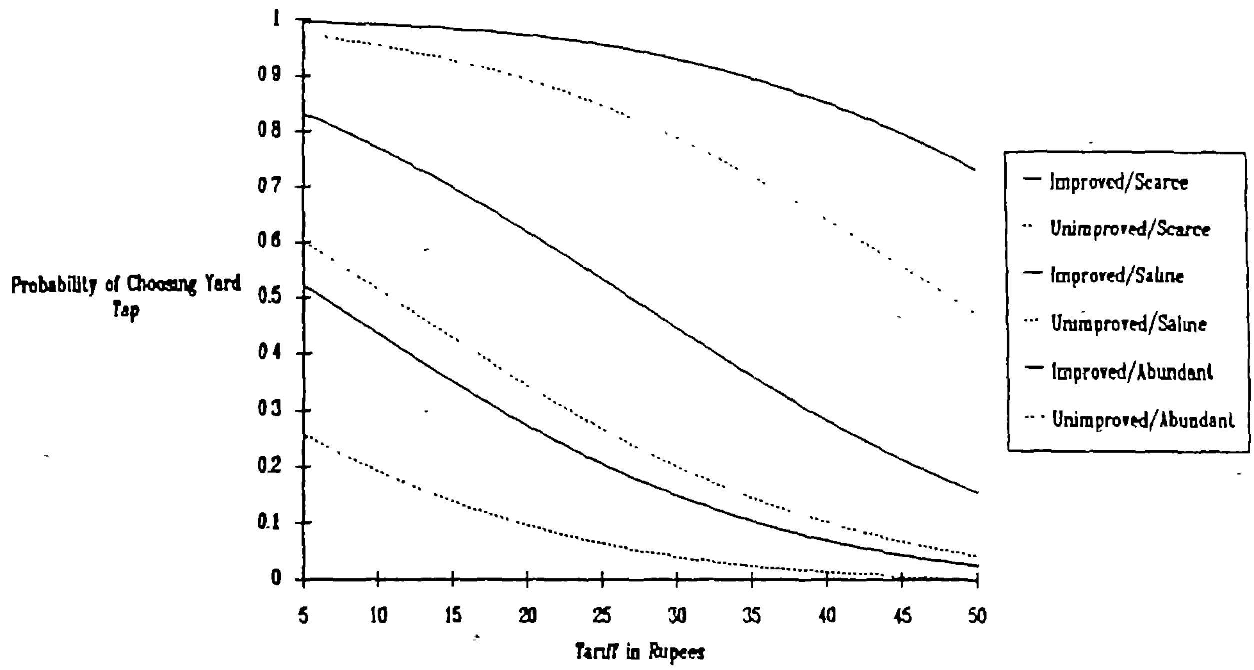

Figure 4. **Effect of Improved service and Traditional Water Conditions on the Probability of Choosing a Yard Tap for an A1 Household. Derived from Table 17.**

The conventional wisdom of great dissatisfaction with rural water systems among those with yard taps in Kerala is confirmed by the descriptive statistics in Table 4. The A1 connectors express extremely low levels of overall satisfaction with their water service. Yet in none of the estimates already discussed do we find that respondents are willing to pay more for an improved water system -- the dummy variable for that characteristic is statistically insignificant in estimates for both the full sample (Table 12) and the smaller A1-A2 sample (Table 16). What is the cause?

One hypothesis is that households that currently do not have yard taps are unaware of what an improved system would mean. Alternatively, the concept of an improved system, even if well understood, may be too hypothetical to affect their bids, or people may have no confidence that higher tariffs would result in a better system. We examine this issue by estimating the model only for the connecting (A1) households. Table 17 reports the results. Tariff, improved service, college, scarce water, and saline water are the only variables that are statistically significant. In contrast to the previous results, improved service has a large positive effect. Figure 4 shows the combined effects of the tariff, improved service, and traditional water conditions on the probability of choosing a yard tap for this sample.[19] The probability of choosing a yard tap increases substantially for improved water systems, and the traditional water characteristics have the expected effects. In the scarce water area, the probability of choosing a yard tap does not fall below 0.8 until the tariff rises almost to 50 rupees, although without improved service, the

[19] Figure 4 is drawn using the average distance, queue, per capita income, and number of rooms for the A1 sites. The dummy variables as set to reflect the most common type of household, according to the means shown in Table 17: males in government service, yes; Hindu, yes; household head, male; respondent, male; college, yes.

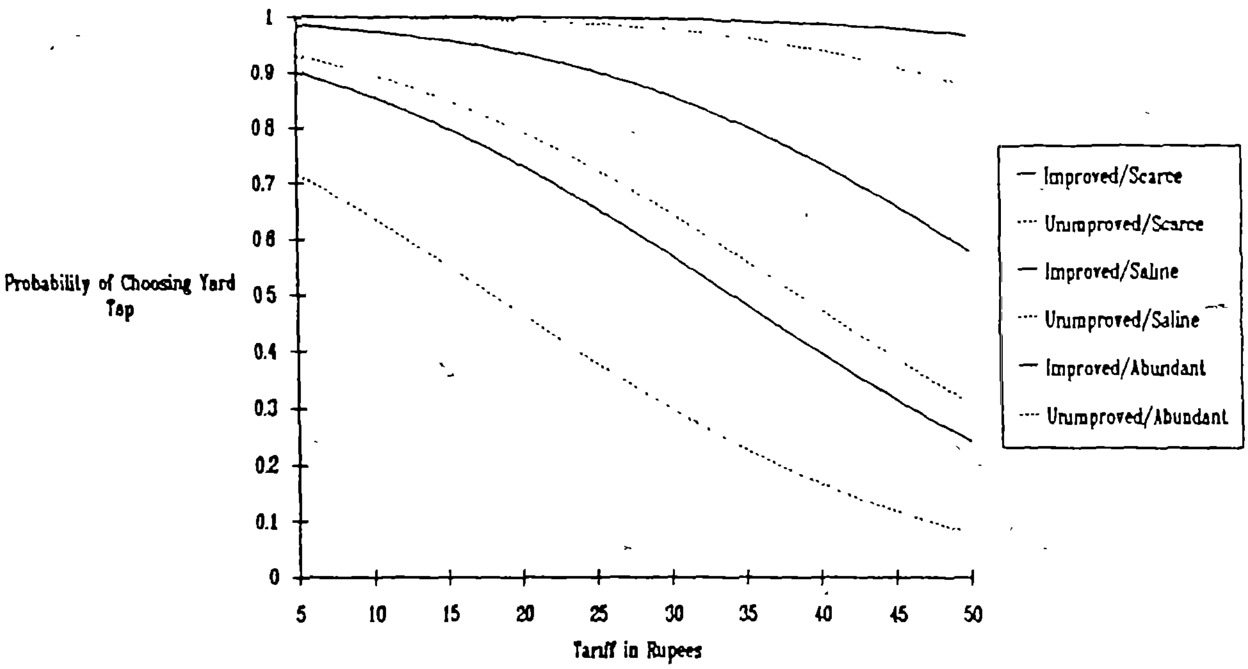

Figure 5. **Effect of Improved Service and Traditional Water Conditions on the Choice of a Yard Tap for an A1 Household. Derived from Table 17; Insignificant Variables Coded to Zero.**

probability of hooking up drops below 0.8 at about 30 rupees.

All of the households represented in Figure 4 already own yard taps, so the probability of hooking up even in the unimproved/abundant sites should be greater than 0.5, at a 5 rupee tariff, which it is not. This result is caused by the large number of negative but insignificant coefficients in Table 17 that enter into the simulation. Figure 5 shows what happens when the insignificant variables are not allowed to affect the simulation. If Figure 4 errs in underestimating hook up probabilities, Figure 5 errs in overestimating them, but the two figures together provide a feeling for the limits because the true relationship must lie somewhere between.

Even at the extremes, the inferences for the scarce water site do not change. Because the probability of choosing a yard tap is bounded by one, the overall probability that the scarce water households will hook up is about the same in Figure 5, although the unimproved line gets pushed up against the improved line. For the other two sites, the overall probabilities rise, but the implicit premium that would be paid for an improved system is unchanged.

Have We Censored the Choices?

The only choice analyzed in the bidding games is whether the respondent would take a yard tap. Have we censored the choices actually available to the sample by eliminating the free public tap as one of the options in these questions? The answer appears to be negative. In the B sites, respondents were asked at each tariff and connection cost whether they would choose a yard tap, continue to use their current sources exclusively, or use the public tap. The distribution of responses is tabulated in Table 18. In the sample as a whole, only 1 3 percent of the respondents chose the public tap. An attempt was made to analyze these responses using all three alternatives for the dependent variable in a logit model, but the resulting estimates are too imprecise to provide meaningful information and are not reported.

Apart from these observations, we would argue on deductive grounds that we are not censoring the dependent variable. In measuring willingness to pay, we are only interested in whether households will or will not choose a yard tap. It is not feasible to charge for public taps, so whether households would use them is not relevant to the willingness-to-pay analysis. The only oddity is the low response rate for public taps because B site households have a strategic incentive to provide high positive response rates for public taps in the hope that more free public taps will be provided.

Checking the Estimation Procedure -- Maximum Willingness to Pay Analysis

One of the most important potential criticisms of this work is the estimation method, in which we combined the information from all three bidding games, treated bids as yes/no responses to price quotations, and used multiple observations from the same households. We can check the consistency of our results with a more conventional willingness to pay analysis in which the maximum bid in the game is treated as the dependent variable, and each game is analyzed separately.

The estimation problem is that the dependent variable, the maximum bid, falls into an interval. In other words, we do not know the exact amount that people would pay, only the interval in which they fall. The relevant intervals are shown at the bottom of Table 19 for each of the three bidding games. The appropriate estimation method in this case is the grouped regression model (Stewart 1983), which is also known as an ordered probit with known thresholds. The results are shown in Table 19.

There are some major differences between this approach and the one we used. First, each bidding game must be analyzed separately. We could not, for example, combine the tariff and connection cost games because the metric of the dependent variable is completely different in the two games. Second, price does not appear as an independent variable because it is the dependent variable (to be precise, the dependent variable is the maximum price that the respondent would agree to pay). As a consequence, no price elasticities can be calculated. We could show how many households would choose to hook up at each price by manipulating predicted willingness to pay, but such an exercise would probably not provide much more information than is available in the distribution of the dependent variable. Third, the central difference in interpretation of the coefficients under this approach relative to our probit method is that by estimating separate regressions for each game, we are implicitly assuming that the structure of the model varies by bidding game, and that it is not enough to include dummy variables to distinguish the elements that differ across the bidding games. If we were to use the same approach in our earlier model, we would have interacted each right side variable with the dummy (connection cost or improved service) identifying the bidding game.

Despite these differences, the results Table 19 do not contradict those in Table 12. Looking first at the tariff and connection cost results in Table 19, there are no qualitative differences in the inferences for the two different dependent variables. All signs are exactly the same, and significance levels are similar. We cannot compare the quantitative inferences because the dependent variables are different. T-statistics in Table 12 are for the most part slightly smaller than their counterparts in Table 19, suggesting that we have been conservative, as expected, in judging significance levels in our inefficient estimation procedure.

We do get some additional information on the differences between bids for the simple tariff game and the improved service game, but this is due to the separate estimations for each game rather than to the estimation method itself. The education variables and the dummy for scarce water have impacts on the maximum bid in the improved game that are much larger than their effects in the simple tariff game. Living in the scarce water area, for example, has an impact that is about four times larger than its effect in the tariff game. Households with males in government service would pay more for an unimproved service but would pay less for an improved service, other things equal.

The results in these standard willingness to pay equations, for which the statistical properties are well understood, are completely consistent with the approach we used. We believe that our approach provides much more useful economic information by pooling the bidding games and using prices as independent variables. The statistical properties are less well understood, however, so the fact that the estimates are consistent with those from the grouped regression model and that the estimated t-statistics are more conservative suggests that our pursuit of the additional information did not come at a cost of accuracy.

Summary

We have reviewed different approaches to analyzing the data to discover whether we have partially predetermined our results by mixing the bidding games, looking only at the yard tap decision, or using price variables on the right side. Our single equation approach produces results that are consistent with the fragmentary approaches that look at each issue separately, plus we get more information than can be gleaned from a large number of separate estimations. We find that improved service does not cause higher bids in the A2 sites, but households that are currently connected, especially those in the scarce water areas, would pay substantially more for an improved system than would other households that currently are not connected.

ACTUAL BEHAVIOR IN AREAS WITH MODERN WATER SERVICE AVAILABLE

One method for taking user's characteristics into account in planning new water systems is the so-called indirect approach, in which actual use patterns in an area with an existing modern public water system are examined. Once equations are estimated explaining actual use in those sites, the same coefficients could be used to predict the probable water use patterns after a modern water system is constructed in another village that is currently without one. This approach assumes that people in the new sites are not radically different in unmeasured characteristics that affect water use patterns, so that the coefficients based on the actual experience in another town accurately capture the main determinants of water use patterns in all environments.

Choice of Water Source in the A Sites

Table 20 presents multinomial logit estimates explaining the choice of primary water source in the A sites, where households can choose a yard tap, a public tap, or a well.[20] Table 20 is difficult to

[20] The actual sources in the survey are grouped as follows: yard tap: only those currently connected (the A1 households); public tap: public tap, public well, public hand pump; well: own well with bucket, own well with motor, neighbor's well, neighbor's tap. A number of other options are listed in the survey instrument: trough (kulam), river, canal, tanker, and other. Only one household in the A sites reported that the primary source was from this last group, and that household was dropped from the estimations in this section. The estimation assumes that the sources used are mutually exclusive, which in fact is not true. We are therefore not explaining complete water use patterns but the choice of a primary

interpret because the results are stated in terms of log odds ratios (the natural log of the probability of choosing either a yard tap or a well relative to the excluded category, public tap). To make the results more understandable, Table 21 has been constructed showing the marginal effects of the independent variables on the probability of choosing each of the three sources at the mean values of the dependent and independent variables. Inferences derived from Table 21 are accurate only around the means. The following discussion refers to Table 21.

Two different models were estimated, one which includes current source characteristics[21] and one which excludes those characteristics. In the full model we get some strange results. Estimated connection cost, which is based on the distance from the house to the water main, has an unexpected positive impact on using a yard tap. Waiting time at the current source has a spurious positive effect on using the public tap because current users of the public tap report the longest waiting times (see Table 4 and Table 9). Distance to the current source has no statistically significant effect on use patterns, and the signs are generally the opposite of the expectation (they should all be positive).

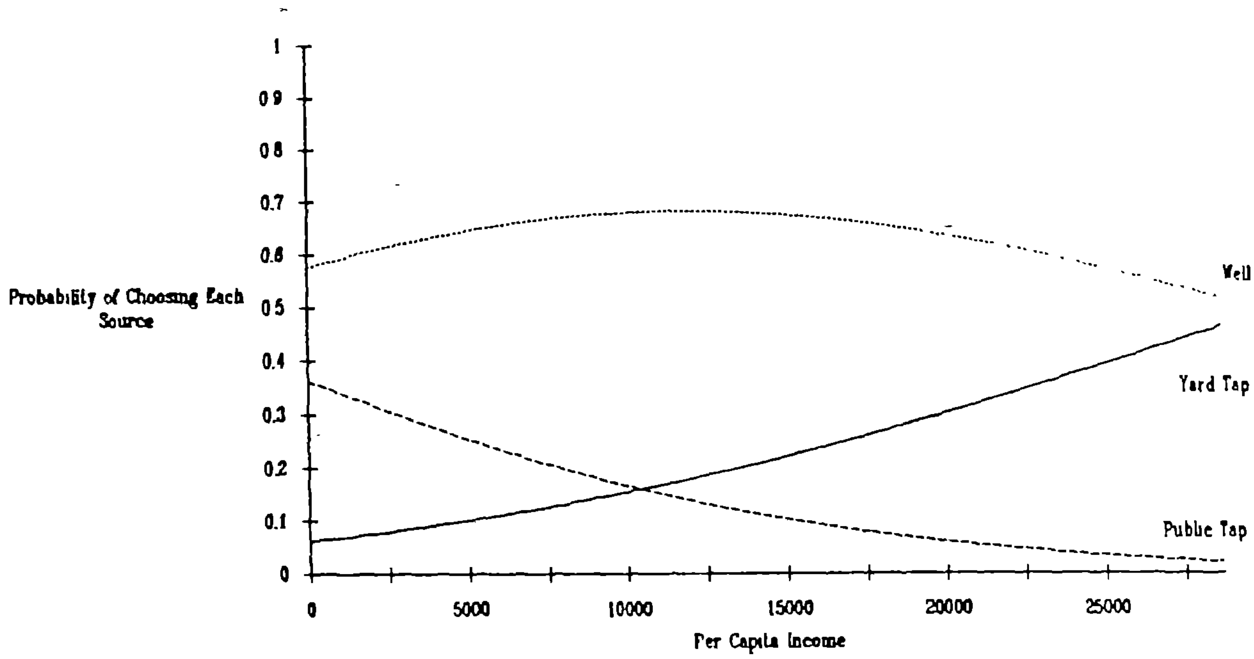

Figure 6. Average Over All Traditional Water Areas: Effect of Income on the Actual Choice of Primary Water Source in the A Sites, at the Means for All Variables. Derived from Table 20.

In order to correctly model source characteristics in this logit model, we would need to measure source-specific queuing time and source-specific distances in the same manner for each household

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source of water.

[21] Whenever we refer to traditional source characteristics for households that have yard taps, we actually mean the characteristics of the primary alternative source to the yard tap, as reported by the household.

for each source.[22] As the variables exist in our data, they are not exogenous to water source choice but are endogenously determined along with the source.

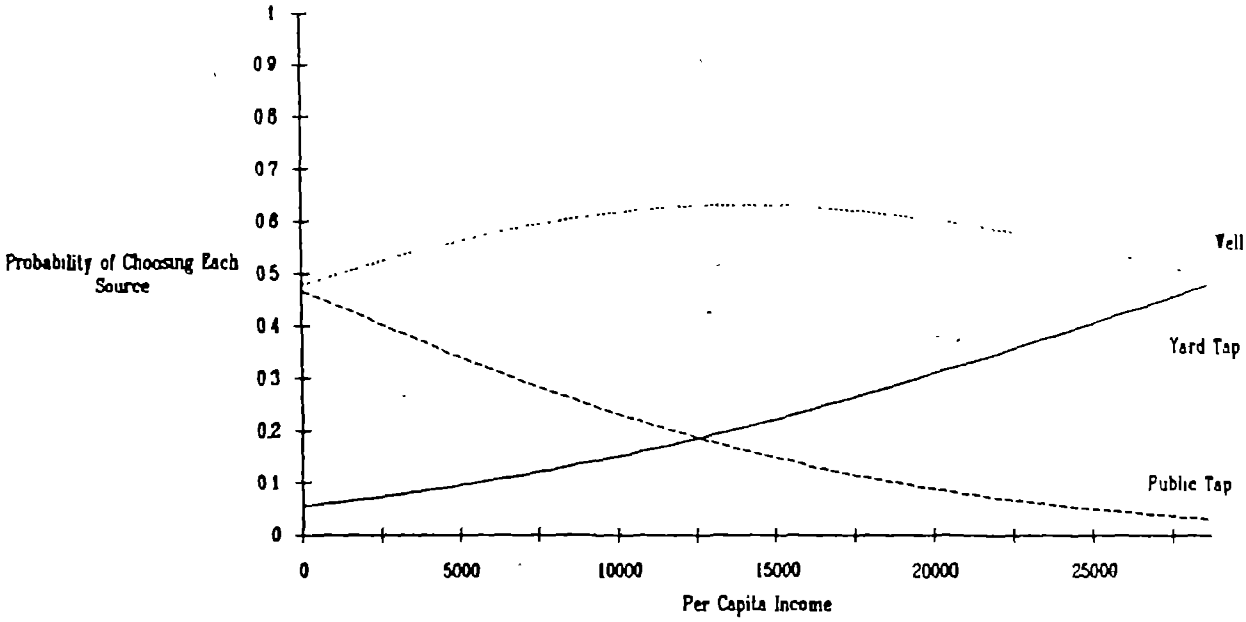

Figure 7. Water-Scarce Area: Effect of Income on the Actual Choice of Primary Water Source in the A Sites, at the Means for All Variables. Derived from Table 20.

One thing is clear from both models in Table 21 -- we do not satisfactorily explain current water use patterns. Focusing on the marginal effects of the variables in the model that excludes water source characteristics, only the income and the asset variables have a consistent impact on choices -- both significantly reduce the probability of using a public tap, raise the probability of choosing a yard tap, but have little effect in the choice of a well. In addition, higher levels of education tend to reduce the probability of choosing a public tap and raise the probability of choosing a private tap. The effect of income alone is shown graphically in 7. Mean per capita income for the sample lies just below the first tick mark (2500 rupees); 65 percent of the sample has per capita incomes below that amount. The top ten percent of the income distribution lies above the third tick mark (7500 rupees). The graph demonstrates a monotonically decreasing probability of using a public tap and monotonically increasing probability of using a yard tap across the income distribution in the sample. In general, households favor the private alternatives (well and yard tap) as income rises. At the higher incomes that characterize the richest ten percent of the sample, households begin to substitute yard taps for wells. At income levels that characterize 90 percent of the sample (below 7500 rupees per capita), there is a low probability that a yard tap will be chosen, yet there is quite a strong probability of shifting from a public source to a private well.

The only other variables of interest that are also statistically significant in Table 21 are those that characterize local water conditions. Living in either the scarce water or saline water areas

[22] For each household, we would need to calculate a distance-based measure of connection cost irrespective of whether they are currently hooked up, plus distance and waiting time associated with the nearest public tap or well that the household could use, notwithstanding whether it does use the source

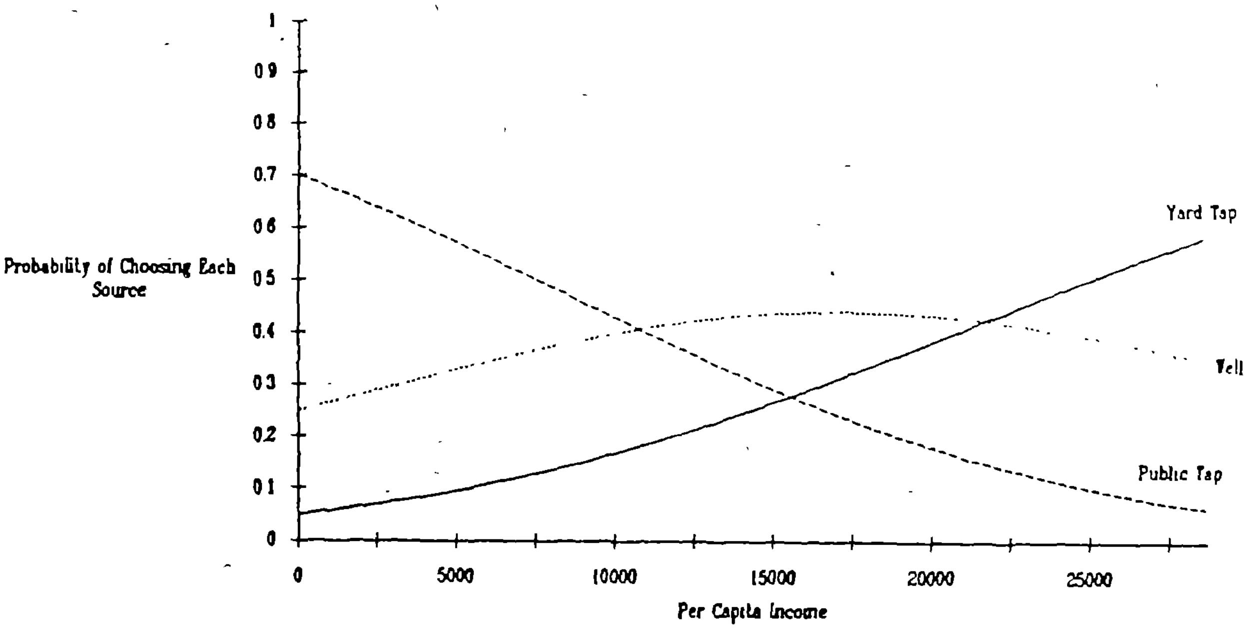

Figure 8. Saline Water Area: Effect of Income on the Actual Choice of Primary Water Source in the A Sites, at the Means for All Variables. Derived from Table 20.

increases the probability that a public tap will be chosen as the primary source.[23] The effect of both variables on the use of a well is negative. The combined effects of these variables and income are shown in Figure 7 (water-scarce sites) and Figure 8 (saline water sites). There is a fairly high probability of using the public tap in both the scarce and saline water areas at low levels of income, but in both cases people readily substitute away from that source as income rises. In scarce water areas, they shift to wells primarily; in saline water areas they shift to yard taps.

These results are at variance with those from the bidding game, where scarce water households indicated relatively high demand for yard taps, while saline water households indicated the opposite. However, Figure 7 and Figure 8 show how households behave in an environment where the availability of connections is constrained, while in the bidding games we are getting responses as if there were no supply constraint.

Quantity of Water Consumed in the A sites

We are also interested in the quantity of water consumed in the A villages, for two reasons. First, we would like to understand the determinants of the demand for water and how those determinants change when a household connects to the water system. Second, we would like to predict the demand for water under the counterfactual that the A2 households own yard taps.

Demand for Tap Water. Explaining the demand for water from the yard tap is a censored dependent variable problem. The reason is clear from the model shown below. We observe only the first equation because all values for the dependent variable in the second equation are missing (it is a counterfactual -- the quantity of tap water is not observed if there is no yard tap). Thus the tap water variable is missing for households that do not have a yard tap, even though all

[23] These comparisons are all relative to choices in the abundant water areas.

households have observations on the independent variables that explain demand.

This is a straightforward sample selection problem, which is well understood (e.g., Maddala 1983), and there is no reason to reproduce the formal econometric model here. Instead, the simplified model shown below is explained. Our interest is in estimating equation 1, but we implicitly take equation 2 into account because people self select into the yard tap category according to equation 3, which determines the probability of having a yard tap based on both equations 1 and 2. This model can be estimated by a two-step procedure in which a probit is run first to determine the probability that a household is included in the yard tap subsample (equation 3), then the inverse of Mills' ratio is calculated and used as a regressor in equation 1, which is estimated by ordinary least squares with a corrected covariance matrix.

$$(\textit{Daily quantity from yard tap} \mid \textit{yardtap}=1)_i = X_{1i}\beta_1 + \sigma_{1u}\left(\frac{\phi(Z_i\alpha)}{\Phi(Z_i\alpha)}\right) + \varepsilon_{1i} \quad (1)$$

$$(\textit{Daily quantity from yard tap} \mid \textit{yardtap}=0)_i = X_{2i}\beta_2 - \sigma_{2u}\left(\frac{\phi(Z_i\alpha)}{1-\Phi(Z_i\alpha)}\right) + \varepsilon_{2i} \quad (2)$$

$$P(\textit{Yard tap} = 1) = \Phi(Z_i\alpha) = \Phi(X_{1i}\beta_1 - X_{2i}\beta_2) \quad (3)$$

where

X_{1i}, X_{2i} = *possibly overlapping sets of explanantory variables for household i*

β_1, β_2, α = *coefficients to be estimated*

σ_{1u}, σ_{2u} = *covariance between quantity and yard tap decisions*

$\left(\frac{\phi(Z_i\alpha)}{\Phi(Z_i\alpha)}\right), \left(\frac{\phi(Z_i\alpha)}{1-\Phi(Z_i\alpha)}\right)$ = *inverse of Mills' ratio appropriate for truncation of the error*

The inverse of Mills' ratio corrects for the truncation of the error caused by the censoring of the dependent variable; as can easily be seen in the first equation above, it is just a correction factor to center the mean of the tap quantity variable. It is also obvious from equation 1 that if the estimate of σ_{1u} is not statistically different from zero, the model collapses to a classical regression model, with no evidence of a correlation between the decision to purchase a yard tap and the quantity of water drawn from it.

The two-step estimates are consistent but not efficient. We use maximum likelihood on the full model to gain efficiency as well. Estimates are reported in the left half of Table 22 for both ordinary least squares (OLS, not accounting for selection) and for the selection model (MLE). The same basic variables that have been used up to this point should also explain water demand, because it is a reduced form. Household population is added to the right side because it is believed to be an important determinant of water demand. A number of exclusions are explained in the table. The probit estimates for whether a household owns a yard tap are not reported; they provide essentially the information as the logits already reported.[24]

[24] In other words, we do not explain the hookup decision well.

The coefficients are almost identical under both the simple OLS and the selection-corrected approaches. The reason lies in the insignificance of the coefficient on the inverse of Mills' ratio, which is reported at the bottom of the table as "Covariance· choice and quantity." There is no evidence that the distribution of observed tap water quantities for those owning a yard tap is truncated, so the OLS estimates are unbiased.

However, our model essentially fails to explain the quantity of tap water used. Only two variables scarce water conditions and household population, are statistically significant, and both increase the demand for tap water. The adjusted R-squared for the OLS estimates is only .06 (the model explains only 6 percent of the variance in quantity), and both the OLS and MLE equations barely meet the test of overall significance at the 2 percent level.

Our inability to explain the demand for tap water has two interpretations. Either the households are so supply-constrained (which is unobserved) that there is little room for their characteristics or preferences to have an effect on use, or the availability of water from a yard tap reduces the impact of income, education, and other household variables on demand.

Demand for Water from All Sources. Despite the lack of a systematic explanation for *tap water* demand, owning a yard tap may affect the *total* demand for water. We can model the demand for water from all sources as a switching regression in which the structure of demand is assumed to differ for those with a yard tap from those without a yard tap. Quantity from all sources is observed for the full sample, but it is determined by two regimes, depending on whether the household owns a yard tap. Equations 4 and 5 are directly analogous to equations 1 and 2, and they share the criterion equation 3. The difference is that we actually observe the dependent variable in both equations 4 and 5.

$$(\textit{Daily quantity from all sources}|\textit{yardtap}=1)_i = X_{1i}\beta_1 + \sigma_{1*}\left(\frac{\phi(Z_i\alpha)}{\Phi(Z_i\alpha)}\right) + \varepsilon_{1i} \qquad (4)$$

$$(\textit{Daily quantity from all sources}|\textit{yardtap}=0)_i = X_{2i}\beta_2 - \sigma_{2*}\left(\frac{\phi(Z_i\alpha)}{1-\Phi(Z_i\alpha)}\right) + \varepsilon_{2i} \qquad (5)$$

The estimates for this model are presented in the right half of Table 22. The coefficients are estimates of the "direct" effects of each variable on water demand in the sense that they measure the effect given that a household is selected into each regime. There is also a "total" effect that takes into account the additional impact of the variables through the probability of being in the regime (the inverse Mills' ratio). For example, per capita income has a direct negative impact on the total quantity of water if a household owns a yard tap. Yet it raises the probability that a yard tap will be owned in the first place, so the total effect of income may be positive in the existing environment. The direct effect shown in the table would not change as more people purchase yard taps assuming that the structure of demand remains the same, but the indirect effect could be reduced or eliminated by policies that make connections universal.

It is apparent, however, that owning a yard tap eliminates the direct positive effect of income on consumption (the coefficient is -0.004 for those owning a yard tap and +0.022 for those not owning a yard tap). In contrast, household population has no direct effect on demand without a yard tap, but it has a strong positive effect with a yard tap. This finding is consistent with the effect in the previous regression, which showed that household population increases quantity from the yard tap. Presence of a yard tap apparently allows households to adjust more readily to the demands created by a larger family.

Another finding is that the effect of education on quantity appears to be eliminated for families owning a yard tap. For households without a yard tap, each level of education above the primary level has an approximately equal, strongly positive impact on water demand.[26] Similarly, yard tap ownership eliminates the positive effect of civil service employment. Length of queue at the traditional or current source (or alternative source, for yard tap owners) has a negative effect in both cases.

These findings are consistent with the second possibility cited above in speculating about our lack of ability to explain demand for tap water. The modern water system appears to reduce significantly the impact of income, education, and regular employment on a household's demand for water.

Traditional water conditions have interesting effects. Both "scarce" and "saline" reduce demand for water from all sources for yard tap owners. Living in a scarce water area increases the demand for water from the tap (see the left side of Table 22), so even though scarce water households consume less water in total, they get more from the yard tap. Those living in saline areas consume less water but about the same from the yard tap as do households in the abundant water sites For households without yard taps, scarce conditions cause no difference in demand, but saline conditions raise demand.

Table 23 displays summary information on the simulated effect of a yard tap on per capita consumption. First we will review the findings for owners of yard taps. The top row shows actual per capita consumption from the yard tap, and the high relative demand in the scarce water area is confirmed. The second row shows predicted yard tap consumption for each type of household using the selection model in Table 22. Although the model does not explain quantity used very well, its predictions are on average close to the actual quantities. The next row shows actual use from all sources. Again, as expected, total consumption in the scarce water site is lower than in the abundant water site.

The final row reports average predicted values from the switching regression using equation 6 for the conditional expectation of quantity, where the hats refer to estimated coefficients. These predictions take into account both the direct and indirect impacts of the right-side variables. The results are more variable than for the yard tap predictions. We systematically underestimate total demand by a large margin on average, especially for saline areas.

$$E(\textit{Daily quantity from all sources} \mid yardtap = 1)_i = X_{1i}\hat{\beta}_1 + \hat{\sigma}_{1\epsilon}\left(\frac{\phi(Z_i\hat{\alpha})}{\Phi(Z_i\hat{\alpha})}\right) \qquad (6)$$

Next we will discuss the results for households that currently do not own yard taps. We are interested in how much water these households would use *if they were connected*. The first step is to estimate the quantity of water they would use from the yard tap. In general, we predict that they would use about the same quantity of water as the connectors currently use. This finding is no surprise given the lack of selection bias in the estimates for the connector households. In contrast, our predictions for total consumption (using equation 6) are substantially higher than for

[26] This effect is, of course, relative to the excluded category of schooling below the primary level.

the households currently connected except in the scarce water area. This finding may seem implausible because it would mean that having tap water would actually increase consumption on average from current sources. Yet that would have to be the case to be consistent with the experience of the yard tap owners, who consume more from their alternative sources than do the nonconnectors (on average). Note that the difference between predicted total and tap quantities for the households without yard taps almost exactly reproduces the actual differences for the yard tap owners.[28] The implication is that on average, the yard tap does not substitute for water from traditional sources but is treated as a complementary good.

We have seen that owning a yard tap would increase demand for water from non-tap sources for households that currently do not own one. The numbers on the right side of the table, which are standardized relative to the abundant area, show that consumption in the scarce and saline areas would begin to catch up with the abundant area if yard taps become available. For example, average consumption for nonconnectors in scarce water areas currently stands at 56 percent of that in the abundant area. It would rise to 66 percent after installation of yard taps.

Summary

While these results for the quantity of water consumed are interesting, they must be viewed as largely speculative. They are imprecise point estimates based on equations that do not explain water use well, and they require the construction of counterfactuals, such as predicted quantities from yard taps for households that currently do not own them. Our findings are best viewed as hypothesis generating, which should lead to careful survey efforts directed at accurately measuring the use of water from all sources before and after a water system is installed.

Although the water systems in the survey areas are reputed to operate poorly and the survey reveals that owners of yard taps are not very happy with them, they do have significant effects on consumption patterns. We find that yard tap ownership, even though the yard tap supplies on average no more than 36 percent of total per capita water needs, tends to eliminate the effects of income, occupation group, and schooling on water demand. It also allows households to better adjust to the physical size of the dwelling and household population when they consume water. We predict that on average households currently without yard taps would consume about the same amount from them as do similar households that are currently connected, that wider availability of yard taps would increase water demand in all sites (abundant, scarce, and saline), and that the latter two would gain relatively more than the abundant site. Wider availability of yard taps would allow households in those areas to reduce the gap in consumption that currently exists. Finally, we predict that water consumption from non-tap sources would rise on average if yard taps were to become more widely available.

We do not know to what extent public taps have similar effects. We would expect them to have weaker effects on quantity, if any, because they have few of the economic characteristics of a yard tap (which is closer to a deep well in terms of convenience and other economic characteristics). Almost 40 percent of the nonconnecting households already use a public tap and report average water use of 26 liters per day, compared to 117 for the connecting households (see Table 9 and Table 4), which suggests that the effects discussed in this section would not be forthcoming from a public tap-based system.

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[28] For example, yard tap owners in the scarce site consume 87 liters per capita on average from all sources and 31 liters from the yard tap, a difference of 56 liters. For households without yard taps, we predict 80 liters total and 25 liters from the yard tap, a difference of 54 liters.

POLICY SIMULATIONS

In this section we use the probit results in Table 12 to estimate demand for water connections and system revenue across the range of tariffs quoted in the bidding games. This simulation is done for the minimum and maximum connection cost quoted in the bidding games for the A2 and B households. In addition, the effect of bidding game bias is demonstrated, and we show potential gains in welfare if the supply of private water connections is expanded. For the A1 sites, where hypothetical improvements in the quality of the water system had a strong positive effect on bids, demand and revenue projections are shown for the current system and for an improved system. We also provide some rudimentary information on the income distribution aspects of changes in tariffs and availability of connections.

Effect of Changes in the Tariff for the Whole Sample

The simulation method is simple and is illustrated by this first example, in which only the tariff is varied. Using the coefficients in Table 12, we estimate the probability that each household would hook up at each price from 0 to 50. If the probability exceeds 0.50, the household is counted as connecting.[27] For each price the total number of hook ups is counted, which is our measure of total demand. Only the policy variables -- tariff, connection cost, and improved service -- are varied in these estimates. Connection cost is set to 100,[28] and whether service is improved is set to zero. The other independent variables are the actual values for each household.

Figure 9 shows the result. The monthly tariff appears on the horizontal axis, the number of connections (quantity demanded) appears on the left vertical axis, and the implied monthly revenue of the water system appears on the right vertical axis. At a zero tariff, we estimate that 848 out of 1,129[29] would connect, including 100 percent of the A1 households, 83 percent of the A2 households, and 61 percent of the B households.

Figure 9 illustrates some basic truisms of economics. First, prices are often artificially driven to zero by public policies in order to protect the poor. However, doing so does not guarantee that 100 percent of the poor will hook up because prices do not completely determine behavior. In this simulation, driving the monthly tariff down to zero, even with only a nominal connection cost, does not result in 100 percent of the sample hooking up, and the subsidy captured by those hooking up will not necessarily favor the poor, because the highest income households will be the first to hook up. Under existing conditions in our sample villages, the top 40 percent of the income distribution, accounting for 78 percent of the income, also accounts for 67 percent of the 5 rupee per month connections. In our simulation, we estimate that there will be more connections with a tariff of 20 rupees (about four times the current fee for reasonable use) than there are today. Charging such a high tariff, and using the resulting profits to subsidize well maintained public taps might actually have a more equitable result than would driving yard tap prices down (see Briscoe et al. 1990). In other words, judging the effects of a pricing strategy on equity is an empirical issue.

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[27] The criterion for hooking up can be made arbitrarily tight. For example, the water company may want to be extremely conservative and plan the system on the assumption that households would hook up at an 80 percent probability

[28] We realize that setting the connection cost to 100 rupees for the A1 households is counterfactual, and the result is to slightly underestimate the actual demand curve.

[29] The full sample is 1,150; we lost 21 households because of missing values for one or more of the independent variables.

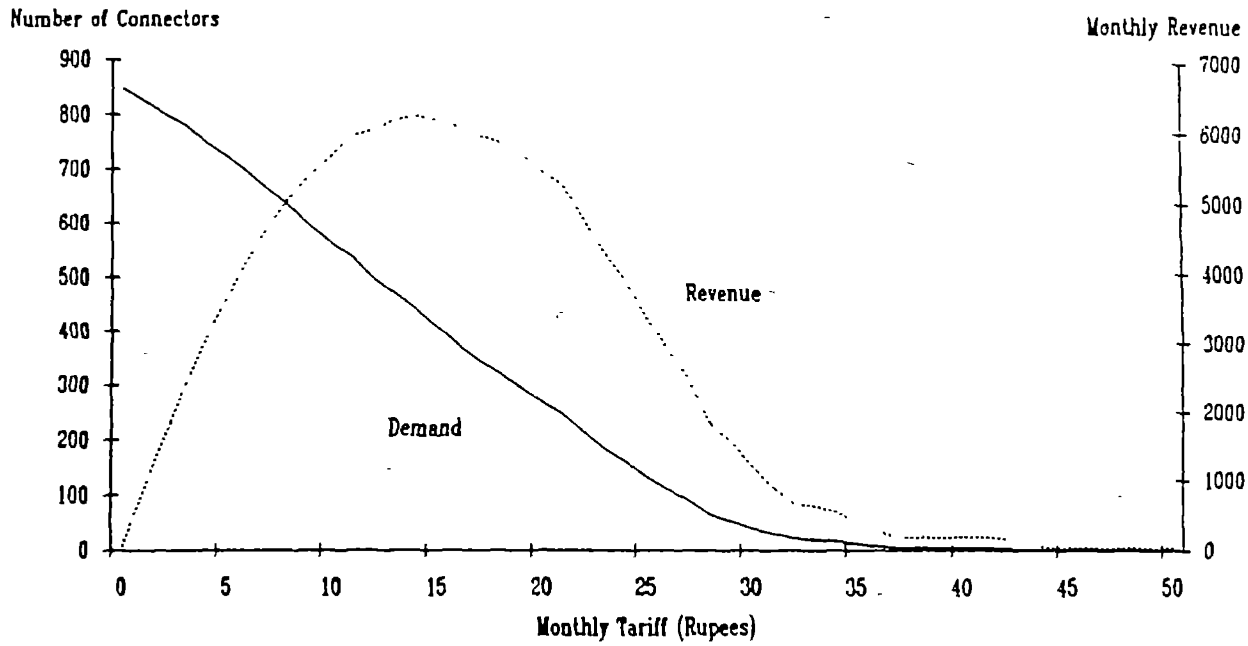

Figure 9. **Simulated Demand and Revenue at Each Price Quoted in the Bidding Games, with Connection Cost = 100 and No Improvement in the Water Systems. Derived from Table 12.**

Second, revenue is a nonlinear function of demand, which creates opportunities for making small tradeoffs of revenue for large increases in connections. The monthly tariff that maximizes revenues in Figure 9 is 14 rupees, corresponding to 445 connections and monthly revenue of 6,230 rupees. However, revenue climbs steeply for small increases in the tariff. At a tariff of 5 rupees (722 connections), monthly revenue is 3,610 rupees, 58 percent of the maximum. At a tariff of 10 rupees (565 connections), monthly revenue is 5,650 rupees, 91 percent of the maximum.

Third, from a demand or revenue standpoint, there is no sense in charging a tariff higher than 14 rupees. The same revenue would be forthcoming at lower charges.[30]

How does this scenario compare with the current situation, and would people be better or worse off with the higher charges that they seem willing to pay? In Figure 10, we draw the demand curve alone in the normal economic fashion, with quantity of connections on the horizontal axis and price on the vertical axis. This is the same demand curve that appears in Figure 9. However, the number of connections has been scaled up to the whole population. The current supply of connections is shown as a vertical line at 250. The supply curve crosses the demand curve at slightly more than 25 rupees, which by our estimates is the monthly tariff the water authority *could* charge for the few connections currently provided. The current price appears as a horizontal line at 5 rupees. At that tariff (and a 100 rupee connection charge) about 3,500 households would

[30] In these simulations, unless stated otherwise, we treat our sample as the universe. If the graph were to accurately reflect predicted behavior for the whole population, revenue and demand would higher, but the shapes would be exactly the same. Furthermore, any statements about percentage differences in revenue or connections demanded would be the same for our sample or for the whole population.

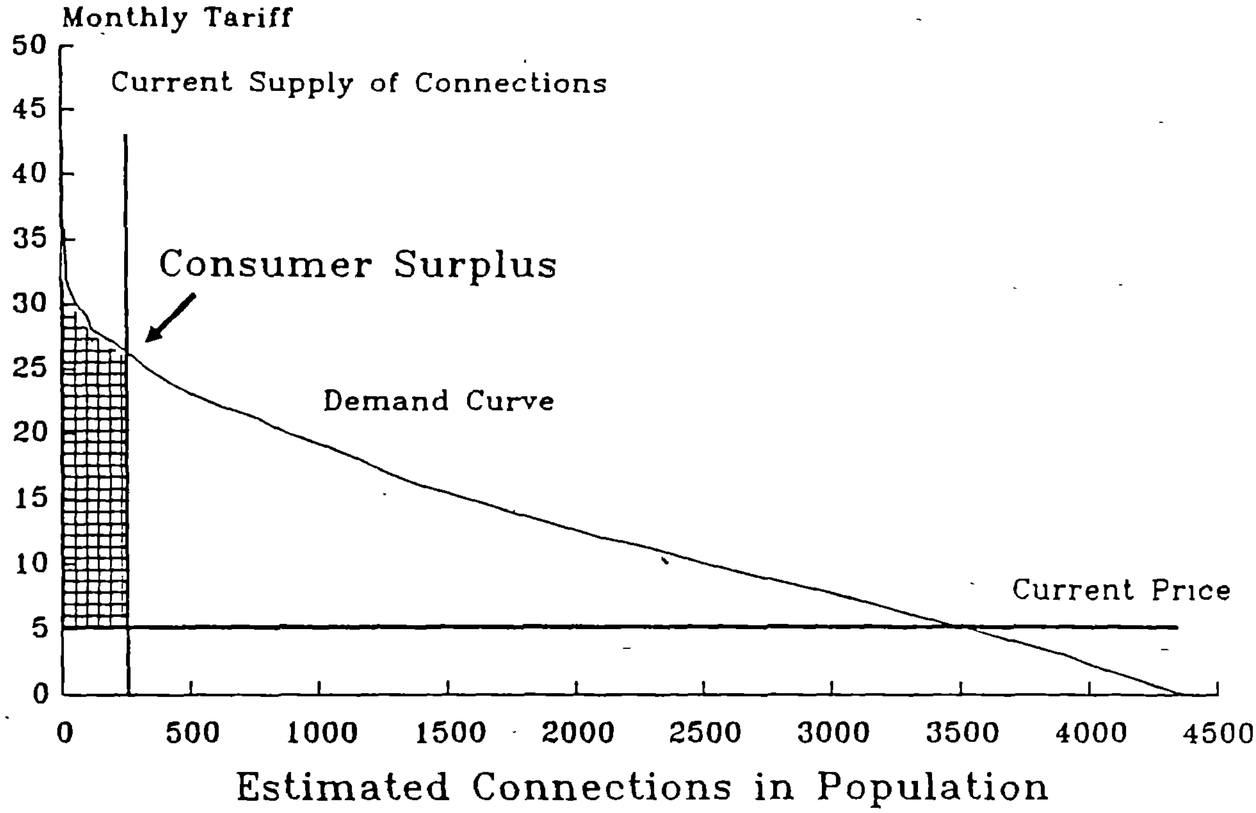

Figure 10. Current Availability of Yard Taps and Its Economic Consequences, Given the Estimated Demand Curve in Figure 9

connect,

Some readers may criticize Figure 10 because it assumes that there are no indivisibilities and that any household willing to pay the monthly tariff could be served. In fact, this is the case. All households in the sample either now or in the near future could connect; it would not be necessary to build a water system that is not already in the ground (or nearly so). All that would be required are pipes from the main to the connecting house. It may be true that at a price of 25 rupees, the same 250 households would not be connected as are currently connected; nevertheless, by our estimates there are 250 households that would connect. Obviously, we estimate tremendous unmet demand for private connections at the current tariff.

Consumer surplus, a measure of economic welfare, is shown as the crossed area above the 5 rupee price in Figure 10. This amount, if added to the small area showing existing water system revenues, shows the revenue that would be collected if current connectors were charged the price that people are willing to pay for the few connections that are available. Because they actually pay only 5 rupees each, the water authority is essentially providing a gift to current connectors equivalent to the shaded area. We can compare what happens to this consumer surplus under different scenarios.

How could private connections be expanded to meet estimated demand and what would be the result in terms of welfare? One strategy, of course, is simply to subsidize connections at the current tariff so that the additional 3,250 households could hook up. That would be expensive, but

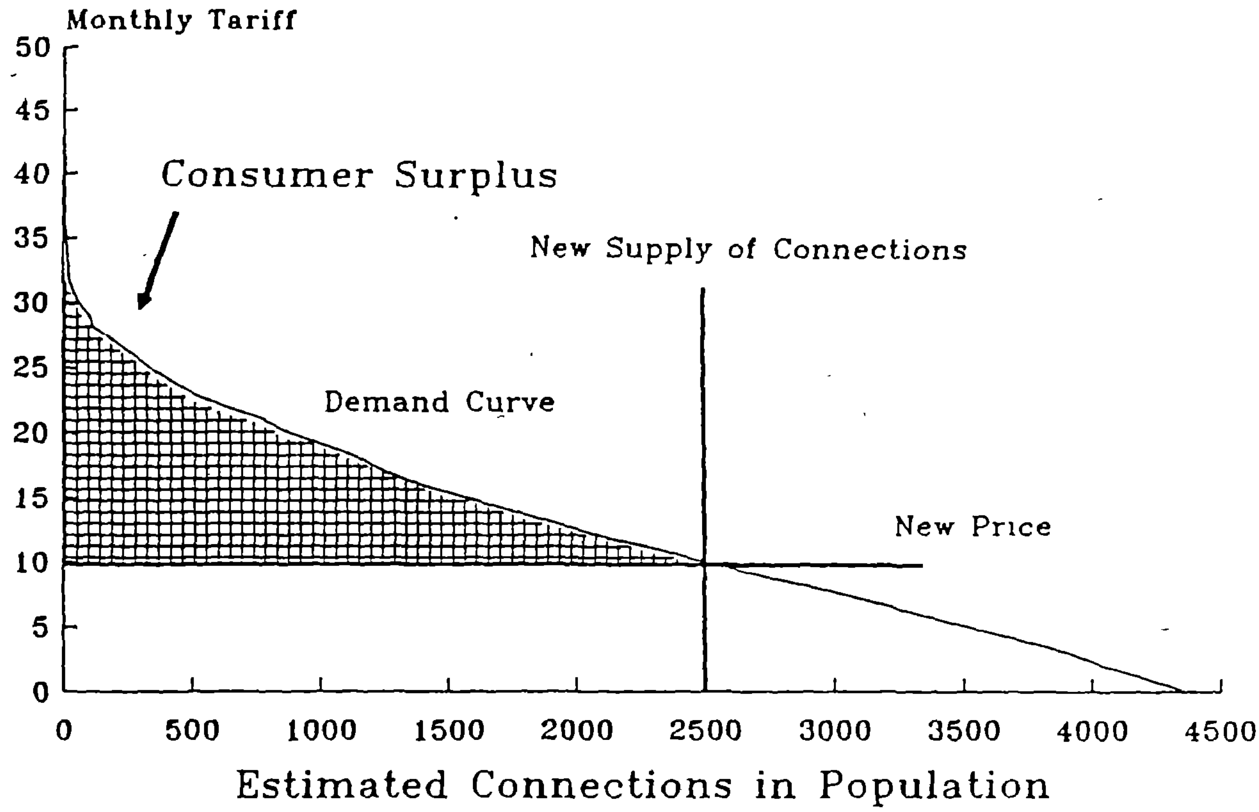

Figure 11. . Simulated Change in Welfare with a Higher Price and Unconstrained Connections

it would result in 17,500 rupees a month in revenue, 14 times current monthly collections. Suppose, instead, that the water authority raises the tariff to 10 rupees per month. This situation is shown in Figure 11 as the "New Price" line. Suppose further that the supply of connections is expanded to 2,500, which clears the market at that price.[31]

How could the water system expand connections at a 10-rupee tariff? Under the existing set up, we estimate monthly revenues of about 1,250 rupees (250 connectors times 5 rupees per month). Suppose that the water authority would be happy to increase revenues from operations to 6,250 rupees per month (2,500 connectors times 2.5 rupees). This policy would leave 7.5 rupees per month to "subsidize" connections. The water authority could borrow 3,492,780 rupees for 30 years at a real interest rate of 5 percent if it could make monthly payments of 18,750 rupees. This loan would allow it to "subsidize" connections for the 2,250 new customers at an average of 1,552 rupees per connection, about triple the estimated average cost for the A2 and B households in the sample (and we assume that each household pays 100 rupees of the cost, so our estimated availability of funds may be almost 4 times more than what would be needed). It appears that some capital would be available to upgrade service, or some of the capital could be diverted to monthly operations and maintenance, which may be the equivalent to upgrading the service. The revenue effect of the tariff hike and expansion of connections, no matter how the extra revenues are spent, is an estimated 25,000 rupees per month, about 90 percent of the maximum feasible

[31] If the tariff is raised current connectors are worse off than they are today. This result can easily be seen in Figure 10, as the rise in price would eliminate the area of consumer surplus between 5 and 10 on the vertical axis.

revenue, according to our estimates. The water company benefits through a twenty-fold increase in revenues, and more people are hooked up, but what happens to welfare?

Those who previously were connected are worse off because they are now paying double the current monthly tariff. However, this small loss of consumer surplus is more than offset by the large increase in households who benefit from private connections. The new consumer surplus is shown in Figure 11 as the shaded area. We estimate roughly that consumer surplus in Figure 10 is 5,500 rupees, compared to 25,000 in Figure 11, a gain of 450 percent. Consumer surplus by those who previously were connected falls by 1,250 rupees even though overall consumer surplus increases so much. Such a large increase in welfare could be used as justification for subsidization if the new system could not be self supporting; under any circumstances it suggests that the expansion of the water system will make people much better off even if it costs them 10 rupees per month. The increase in welfare is such that there is also room to compensate existing connectors for their loss of welfare. One approach would be to pay them cash rebates equal to the average connection cost for the new connectors, so they would not feel unfairly treated by the "subsidization" of new connectors.

We are frankly surprised at the strength of these findings. The number of connections and resulting revenue corresponding to the estimated demand curve are far higher than we would have expected. Have we made any dangerous errors? We doubt it. Suppose only 1000 households actually hook up at a 10 rupee tariff. The same revenue would be available for subsidizing connections on a per household basis, so our example would not change in that respect. However, the 2.5 rupee fee going to recurrent costs would yield only a doubling of monthly revenue over the current level. In total, the water authority would receive 10,000 rupees per month compared to 1,250 today, so there is plenty of room for reallocations between capital and recurrent costs. The basic principle remains intact: there are many people who would pay more than the current tariff for a yard tap, and this fact creates a number of opportunities to serve them better.

Effect of Connection Cost in the A1 and B Sites

In Figure 12, we show the effect of connection cost on the demand curves for A2 sites (dotted lines) and B sites (solid lines). The position of the A2 and B lines relative to each other has little meaning because it is affected by the sample size. The higher pair corresponds to a 100 rupee connection charge, and the lower pair corresponds to a 700 rupee charge. Figure 13 shows the water authority's monthly revenue curves corresponding to each demand curve, assuming that the sample is the whole population. As we would expect, connection cost has a drastic effect on demand and monthly revenues.

In the spirit of the previous section, we would argue that the proper way to look at the problem of connection cost is to view some portion of the increase in revenues at the lower connection charge as money available to finance the connections. In the B sample, at a connection cost of 700, a 5 rupee tariff would maximize revenues (500 rupees per month) with 100 connections. At a connection cost of 100, a 10 rupee tariff would maximize revenues (1,860 rupees) with 186 connections. The water authority could "subsidize" connections costing an average of 1000 rupees each for the 186 connectors at a monthly cost to service the debt of 1000 rupees (assuming the same terms as before -- 30 years at 5 percent real interest). The field workers for the survey estimated connection costs averaging 523 rupees for the B site households; if that is

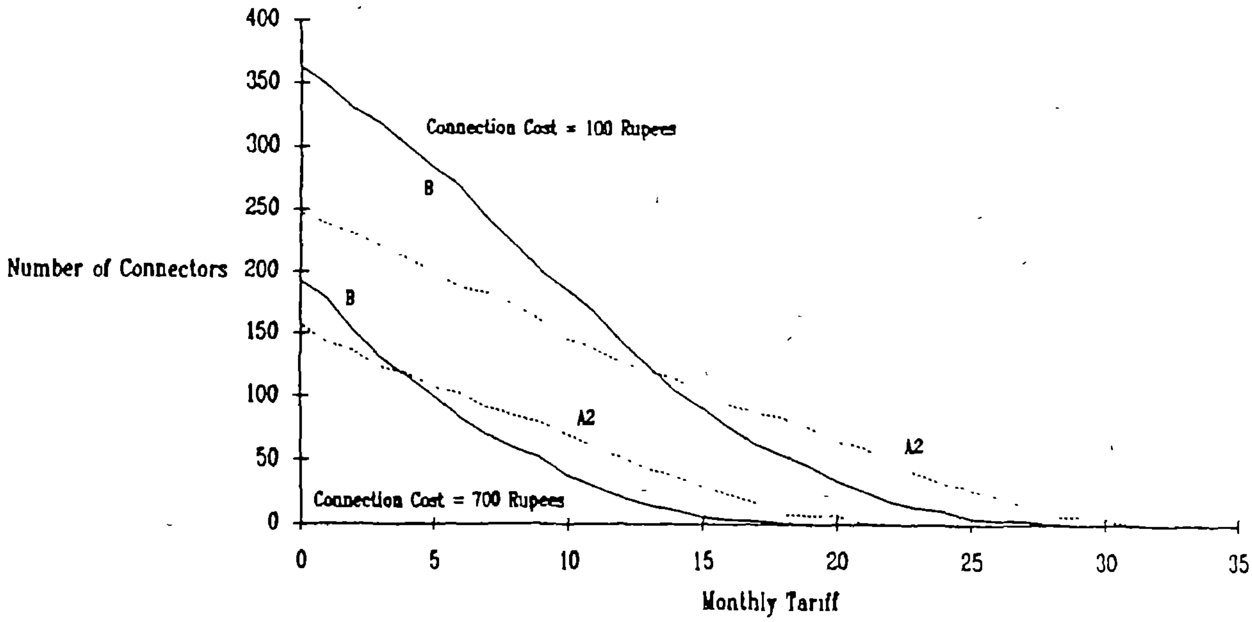

Figure 12. Simulated Demand in the A1 and B Samples at the Minimum and Maximum Connection Cost Quotes in the Bidding Games

accurate, and assuming that the households pay 100 rupees toward the connection,[32] the monthly

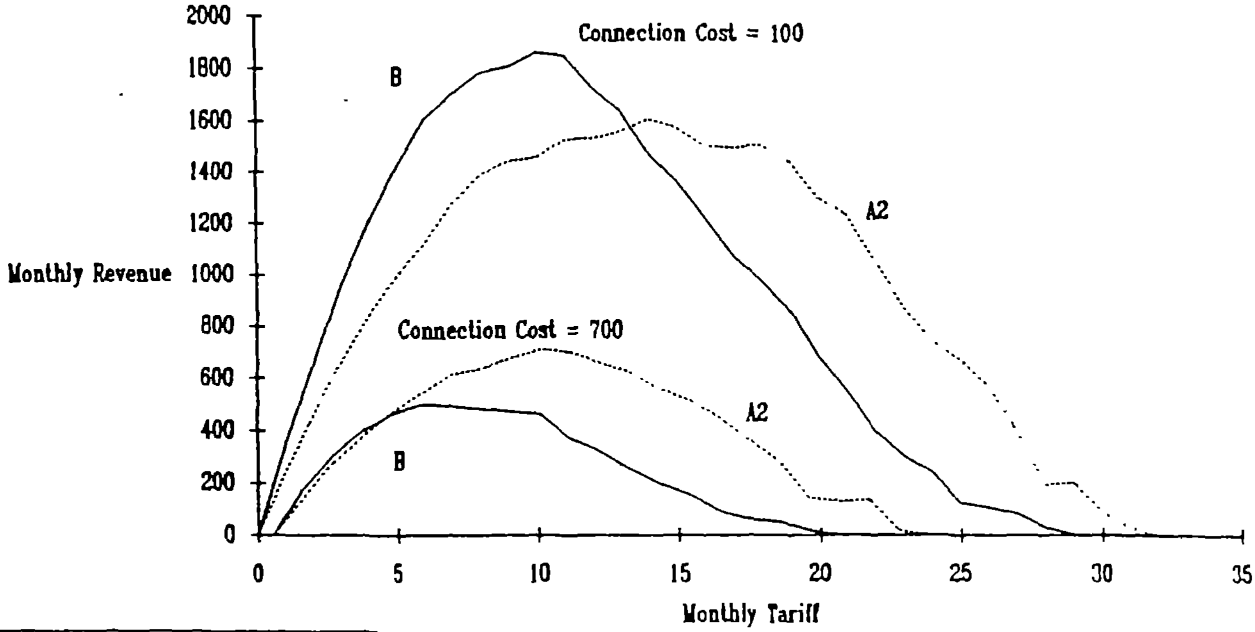

Figure 13. Simulated Monthly Revenue for the Water System for the A1 and B Samples at the Minimum and Maximum Connection Cost Quotes in the Bidding Games

[32] We are not recommending that the households pay anything directly, but 100 rupees is the lowest quote in the bidding game. Given the figures developed in this section, there is no obvious financial reason to charge anything for the connections, given that they can be completely financed by the tariffs.

cost to service the debt would be less than half our estimate. A similar calculation could be performed for the A2 households.

Effect of Bidding Game Bias on the Simulations

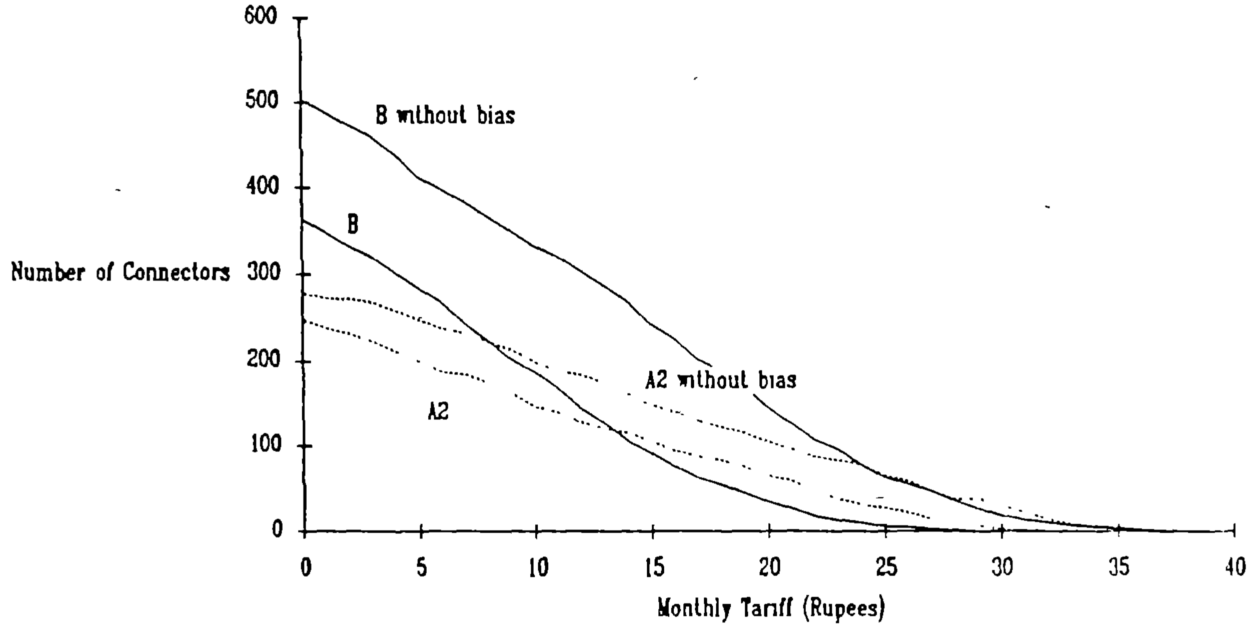

Figure 14. **Simulated Demand for Yard Taps for A2 and B Households with and without Bidding Game Bias**

Respondents from the A1 (connecting) households had a strong incentive to underestimate the price at which they would disconnect because there is a reasonable expectation that the water authority would analyze the data, find that they would pay more for the service, and charge them more -- just as we are suggesting here. Respondents in the other sites might not have such a strong incentive to underestimate their willingness to pay for the taps. In fact, it could be argued that those in the B-sites might overestimate willingness to pay in the hope that they would be provided greater access to yard taps in the new systems being built. These are unobservables. In Table 12, we find that bids in the A2 and B sites are actually lower than those in the A1 sites (measured by our site dummies), but the effects are not statistically significant. In this simulation we set the coefficients of those two variables to zero. We assume that zeroing out these effects removes the additional negative bias beyond that measured for the A1 households, although we cannot be sure that these variables only measure bidding game bias. The simulated demand and revenue curves with and without the excess bias are shown in Figure 14 and Figure 15.[33] Because we believe the A1 households have an incentive to underestimate demand, we would expect that the "no bias" curves, which simply remove the additional bias measured for the A2 and B households, continue to underestimate actual demand and revenues.

Removing the bias increases simulated demand substantially for the B sites and somewhat less so for the A2 sites. The fairly constant differences in demand across the price range have large nonlinear effects on estimates revenues. The maximum estimated revenue with bias for the B

[33] The curves are for a connection cost of 100, using the same procedure as before.

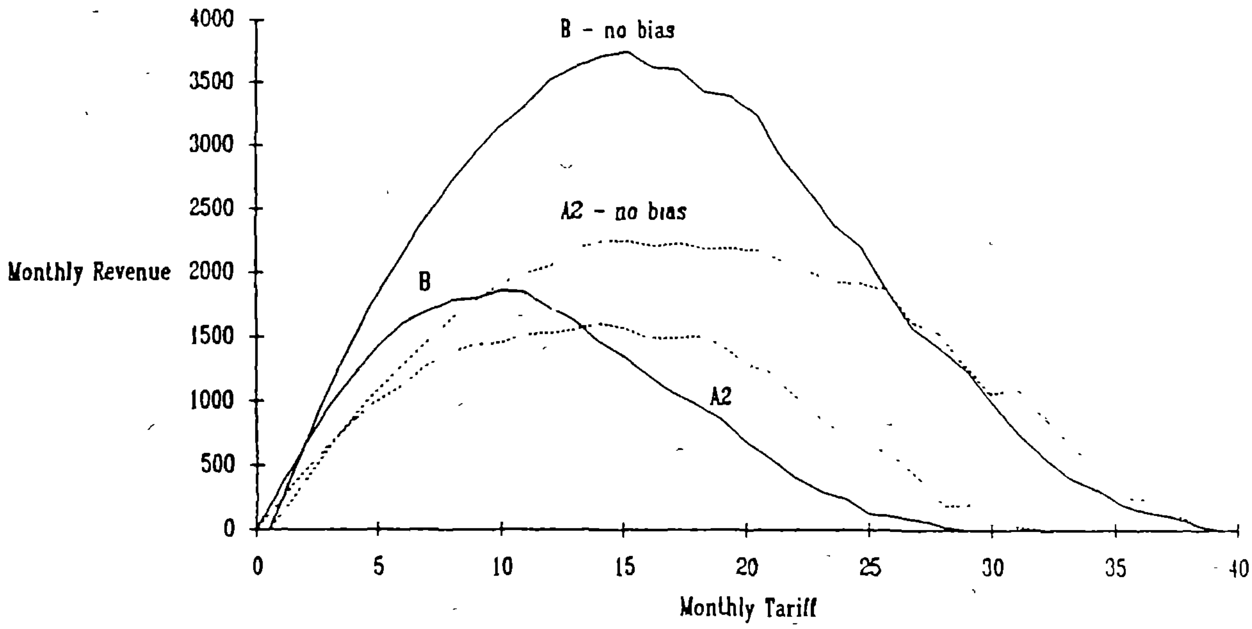

Figure 15. - Simulated Monthly Revenue for the Water System for A2 and B Households with and without Bidding Game Bias

households is 1,848 rupees per month at a tariff of 10 rupees; without bias, estimated revenue at the same price is 3,320, 80 percent higher. This result is another reason to believe that our demand projections -- but even more so, our revenue projections -- are conservative.

Effect of Improved Service for the A1 Households

We do not explain well the actual behavior of the A1 households, and we do not do much better in explaining their bidding game responses in isolation from the rest of the sample. In Table 17, only the policy variables, college education, and traditional water characteristics are significant in explaining bids. Nevertheless, we use the coefficients in that table to simulate demand for the A1 households in order to illustrate the effects on demand and revenue of improving the quality of water service.

Figure 16 shows estimated demand for the existing system and for an improved quality system. Although it cannot be seen in the figure, we significantly underestimate connectors in the *abundant* site, with only 3 out of 66 actual connectors being counted as connecting in the simulation under current conditions -- tariff = 5 rupees and no improvement. All 76 connectors in the *scarce* site are counted as connecting in the simulation, but only 72 out of 96 in the *saline* site are so classified. Some of this error is due to the low predictive power of the model, but it may also be indicative of bidding game bias.

Figure 17 shows estimated revenues for an improved system. The persistence of high revenues even at very high tariffs *for improved service* is caused by the high predicted demand in the scarce water site for improved service even at high tariffs, as is discussed in more detail below.

Quite simply, the question of improved service comes down to one of cost. We have demonstrated in the previous simulations that there is considerable willingness to pay for yard taps

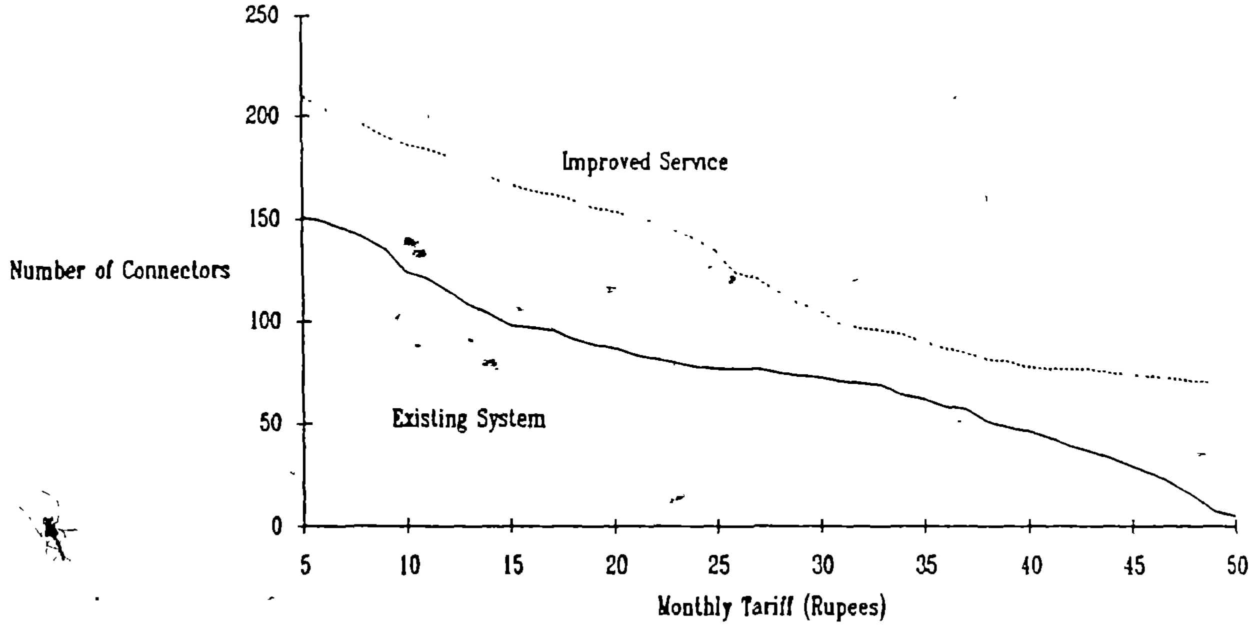

Figure 16. Simulated Demand for Yard Taps for the A1 Households with and without Improved Service

among the population if the connection cost hurdle can be overcome. It makes sense for the water authority to estimate how much an improved service would add to the capital and recurrent costs of the water system and whether the additional revenues that would be forthcoming just from expanding the number of household connections would cover the costs. There may be no need to charge a higher tariff to improve the service given that total revenues would rise substantially as the unmet demand for yard taps is satisfied. To the extent that improved service requires higher capital costs, the question is whether the additional debt could be serviced. To the extent that improved service implies higher recurrent costs, the issue is whether a plan could be formulated for gradually adding those recurrent costs over time as more households hook up and revenues rise.

A second issue is how to make priorities in providing improved service, especially if the costs are substantially higher for a better system. One straightforward method is to consider rate structures that vary by traditional water source characteristics. Figure 18 shows "survival rates" for A1 households that would hook up to the improved service at a 5 rupee tariff. In the abundant water area, 50 percent of those who would pay 5 rupees for the improved service would also pay 10 rupees. None would pay 40 rupees. In the scarce area, 100 percent of those who would pay 5 rupees are estimated also to pay willingly 40 rupees. In the saline area, 95 percent of those who would pay 5 rupees would also pay 10, 78 percent would pay 20, but only 2 percent would pay 40.

Clearly the scarce-water connectors value an improved service much more than do households in the other areas, and they are willing to pay much more to get better service. It makes sense to target the scarce water area for better service first, and the saline water area second. We did not need this simulation to discover that. However, the simulation indicates that it is also feasible to charge differentially in those sites to finance the improved service. If it costs more in the water scarce area to improve service, which seems likely, the same conditions that give rise to the higher costs also give rise to higher willingness to pay. Some might argue that differential charges are tantamount to extortion in water scarce areas, but that disregards the fact that people in poor

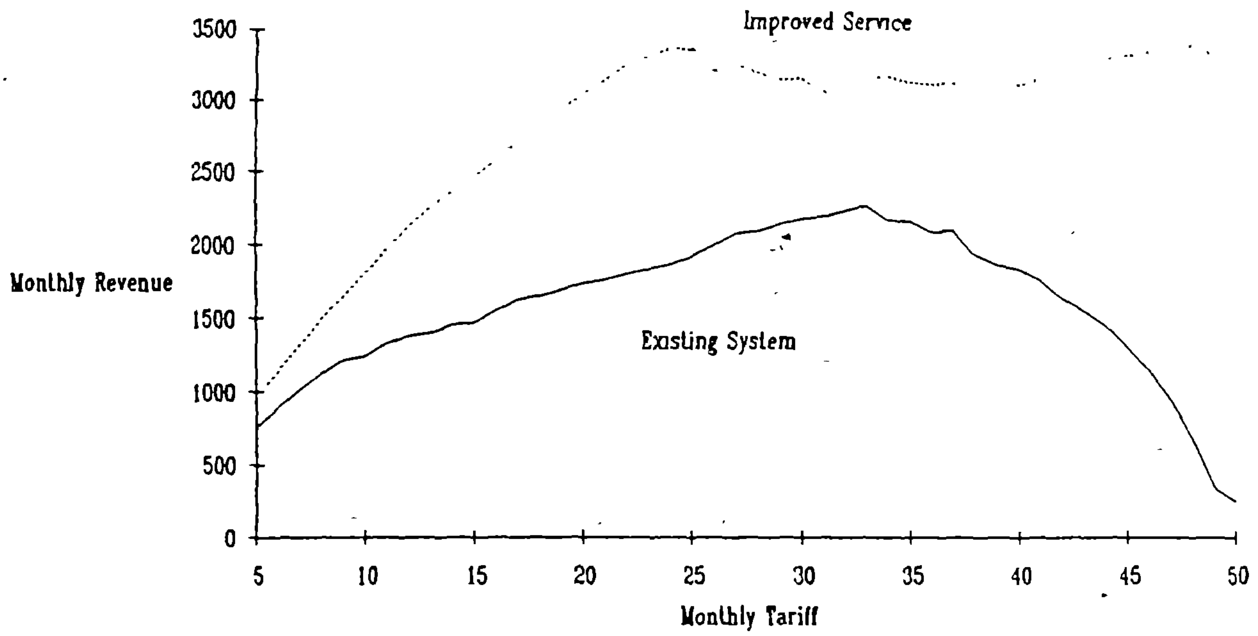

Figure 17. Simulated Revenue for the A1 Households with and without Improved Service

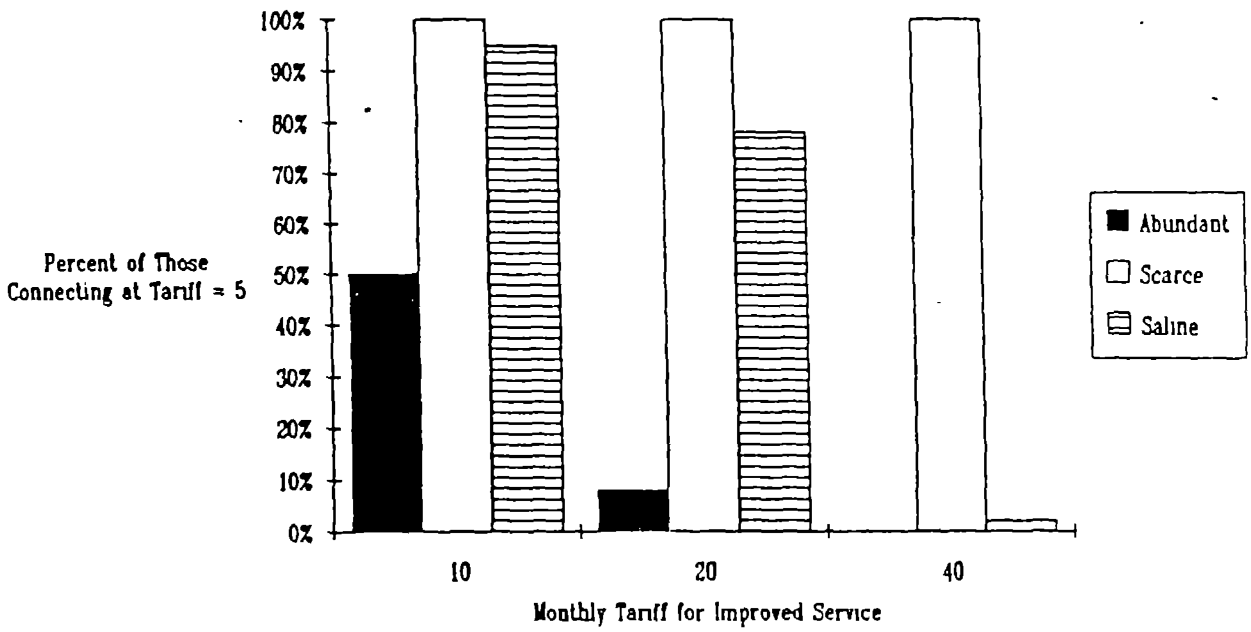

Figure 18. Interaction of Traditional Water Source Characteristics and Demand for Improved Service for the A1 Households

water areas want better service and are willing to pay for it. Cross subsidies from abundant or saline water areas are probably not feasible given the relatively higher apparent elasticity of demand in those areas.

Yearly Water Costs and Income Distribution

Table 24 contains cross tabulations of connections and the mean percent of household income spent on water by quintile, for each water area. These statistics are reported for simulations in which tariff is set at 5, 10, and 15 rupees (connection cost=100). The bottom three rows show the experience for the full sample. At a tariff of 5 rupees, the highest percent of yearly income being devoted to the yard tap is 3.5 percent, for households in the poorest quintile in the scarce water area. The richest households in that area would spend 0.3 percent of income on the water from the tap. The range seems well within the bounds of acceptable burdens.

How do the poor adjust to higher tariffs? They primarily choose not to connect. For the abundant site, 67 percent of the poorest group would connect at a tariff of 5 rupees, as would 89 percent of the richest group. But at a tariff of 15 rupees, only 12 percent of the poorest group would connect, compared to 55 percent of the richest group. The poor who would still hook up would spend 6.1 percent of their incomes on water at the 15 rupee price, compared to 0.5 percent for the richest group.

The most interesting result is for the scarce water area. As the tariff increases from 5 to 15 rupees, the percent connecting among the poorest group falls from 58 to 31 percent; for the richest group the percentage drops from 85 to 65. The poor who still connect at 15 rupees would pay a whopping 11.6 percent of their incomes for water, and the rich would spend 0.8 percent. Scarce water imposes such a burden on the poor that some of them would prefer to devote a relatively large share of cash income to overcome it.

There are two policy options to reduce the burden faced by the poor. If they live in different geographical areas, which is likely, there may be some scope for price discrimination -- charging more in wealthier areas and less in poorer areas for the same service. Even if this is not done, it is likely that the poorer neighborhoods would reach a solution on their own, such as sharing a yard tap. That solution points up the importance of metering the connections, but it also suggests that subsidies may not be essential. Another form of price discrimination is to accompany yard taps with serviceable public taps so that the poorer households that do not connect have access to a free alternative. Policy makers would be less worried about the possible social inequity of not having an equal distribution of yard taps if poorer neighborhoods were well served by a public tap system. The most important lesson, however, is that low income should not be viewed as a reason to under-design a system. Some of the poor would connect even at the 15 rupee tariff, and any of the solutions just discussed for widening access to water for the poor would require a system that is designed for private taps.

Summary

Our basic finding is excess demand for yard taps at the current tariff. Connection cost is a major impediment to connecting, but the fact that excess demand is so high provides opportunities to solve the connection cost problem in a manner consistent with our earlier finding that the underlying problem, given responses to the bidding games, is unobserved credit conditions.

CONCLUSION

Discrete choice models of bidding game behavior as well as households' actual water source and water quantity decisions have been estimated. The analysis indicates that bidding game responses and household's source choice decisions are systematically affected by source and household characteristics. The results support the basic framework and agree with a priori expectations on the signs of the variables.

Descriptive Information

We presented in the introduction a typical set of "stylized facts" about rural water systems in India, and in fact, in most parts of the developing world. Some of these ideas are supported by the data collected in rural Kerala, but others are not. The population appears to be generally content with the quality and taste of water from traditional sources, although the accuracy of that generalization varies by water source characteristics. Users of traditional sources are much more satisfied with them than are owners of yard taps. While yard tap-owning households do have repair problems, the systems appear on the whole to be operable. On average, willingness to pay responses are about 4 times the current monthly tariff of 5 rupees for reasonable use for connectors, 1.7 times above that figure for nonconnectors, and about 1.1 times higher in villages currently without piped water systems. Average responses on connection cost are well below actual costs. Willingness to pay for improved quality of service is also low overall, although it is high among households that are already connected, especially among those in scarce water areas.

Analysis of the Bidding Games

Our analysis of the bidding games provides some extraordinary information. We find low estimated connection cost and high estimated tariff elasticities. This result seems odd, but it is understandable if we take into account the fact that connection cost is the price of a durable good. We find that the real constraint in preventing hook-ups by respondents who cite the high cost of a connection as an impediment is probably credit market conditions rather than the connection cost itself. The water authority can play an important role in solving this problem. A useful by-product of these responses is that they are consistent with rational behavior and suggest that respondents gave sensible answers to the bidding game questions.

The schooling and income variables have strong positive effects on the probability of choosing a yard tap in the bidding games. The schooling effects have a positive but decreasing impact, so that the strongest impact is below the secondary school level. Living in a scarce water area strongly increases the probability that people will hook up to the water system at every price.

One common belief is that, apart from the connection cost impediment to hooking up, people also do not choose to purchase yard taps because the current level of service is so poor. However, improved service does not strongly affect hook-up probabilities. We find that only households currently hooked up (and again, especially those in scarce water areas) are willing to pay significantly more for an improved system. Given the fact that households currently hooked up are exceptional in a number of ways -- well educated, high income, a high percentage of government employees -- investing in improving their service would not have a broad impact and might be an activity that should be fully paid for by the beneficiaries. However, another perspective is that if yard taps become more widely available, greater familiarity with them will result in high levels of dissatisfaction among the broader base of users and willingness by new users also to pay more for better service.

The findings of significantly higher willingness to pay by current users both for the current system and for an improved system also introduces a temporal dimension. Early investments by the water authority may sensibly be devoted to providing yard taps at low cost to a much wider base of users, especially in the scarce water areas, and later investments might be devoted to upgrading the system as new customers become willing to pay for better service. The question that arises is the cost differential between a minimal quality system and a high quality system, and what portion of the costs are capital or recurrent.

Actual Behavior

We found it difficult to explain the actual choice of primary water source in the A villages, but we had more success in explaining the amount of water used. Although the water systems in the survey areas are reputed to operate poorly and the survey reveals that owners of yard taps are not very happy with them, they do have significant effects on consumption patterns. The major effect is to reduce the impact of socioeconomic variables (such as income and schooling) on the household's demand for or ability to procure water. We also find that connectors use more water on average from all sources, an odd result indeed.

Policy Simulations

Our simulations show the strong negative effect of connection cost on demand for yard taps. However, they also demonstrate that the connection cost impediment is a relatively easy one for the water authority to eliminate. The primary reason is that we estimate a large unmet demand for yard taps at the current tariff if the connection cost is low. Satisfying this demand would greatly increase the water authority's revenues and ability to finance connection costs (as well as service improvements).

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Table 1. Location and Types of Survey Sites, with Sample Size

Area	A sites: Improved Water Source Available		B sites: No Improved Water Source Available
	Connectors	Nonconnectors	
Water-abundant area			
Panchayat	Ezhuvathuruthy	Ezhuvathuruthy	Nannamukku
Households	66	819	1497
Household Sample	66	100	200
Water-scarce area			
Panchayat	Elapully	Elapully	Elapully
Households	86	723	876
Household Sample	86	100	200
Water-abundant but saline-intrusion area			
Panchayat	Ezhuvathuruthy	Ezhuvathuruthy	Vallikkunnu
Households	98	768	1313
Household Sample	98	100	200
Total Household Sample	250	300	600

Table 2. Descriptive Information (Means) on the Sample by Site

Household Characteristics	Unit	A Sites: Improved Water Source Available — Connectors	A Sites: Improved Water Source Available — Nonconnectors	B Sites: No Improved Water Source
Per capita income	Rupees	3602	2107	2620
Household Population	Number	6.5	6.8	7 2
Electricity	Percent	96	47	43
Rooms in house	Number	5.1	3.8	2 8
Any females in government service	Percent	16	6	4
Any males in government service	Percent	57	32	22
Hindu	Percent	68	69	40
Head of household female	Percent	28	25	24
Respondent female	Percent	50	70	57
Maximum adult education				
No education	Percent	0	5	11
Some primary	Percent	1	7	14
Primary complete	Percent	7	18	21
Middle complete	Percent	10	9	21
Secondary complete	Percent	40	33	22
More than secondary	Percent	42	28	12
Maximum female schooling	Years	11.0	8.3	6 5
Maximum male schooling	Years	11.7	9.3	7 4

Table 3. Descriptive Information (Means) on the Sample by Traditional Water Source Conditions

Household Characteristics	Unit	Abundant	Saline	Scarce
Per capita income	Rupees	4149	1524	1973
Household Population	Number	6.8	8.1	6.4
Electricity	Percent	65	27	45
Rooms in house	Number	3.3	3.0	3 0
Any females in government service	Percent	10	2	3
Any males in government service	Percent	35	14	25
Hindu	Percent	46	13	82
Head of household female	Percent	25	27	21
Respondent female	Percent	60	62	57
Maximum adult education				
No education	Percent	3	5	20
Some primary	Percent	3	18	13
Primary complete	Percent	12	30	17
Middle complete	Percent	28	18	9
Secondary complete	Percent	33	17	26
More than secondary	Percent	22	11	17
Maximum female schooling	Years	9.1	6.7	5.9
Maximum male schooling	Years	10.2	7 3	7.4

Note: These statistics are weighted by the population in each sampling unit.

Table 4. Water Source Characteristics (Means and Frequencies) by Site

Water Source Characteristics	Unit	A Sites		B Sites
		Connectors	Nonconnectors	
Primary water source				
Piped water (yard tap)[1]	Percent	100	0	0
Public tap	Percent	5	37	6
Public hand pump/well	Percent	4	5	24
Own well	Percent	61	41	42
Neighbor's well/tap	Percent	27	18	25
Trough (kulam)	Percent	2	0	3
Estimated connection charge[2]	Rupees	672	593	522
Actual connection charge	Rupees	1604		
Distance to water source	Meters	20	10	50
Mean queue time over seasons	Minutes	2	16	6
Taste is good[3]	Percent	43/46	83	79
Quality is good[3]	Percent	40/44	86	78
Satisfied[3]	Percent	17/31	62	58
Average Daily Quantity[3]	Liters	117/195	232	255
Average Daily Quantity per Capita	Liters	48	34	35

1 For site A connectors, piped water is the primary source. The other sources shown for connectors are those that would be used if they did not have a tap. For these households, distance and queuing time are also for the main alternative source.

2 For site A connectors, connection charge is actual. For others it is estimated based on the distance from the house to the distribution line.

3 For site A connectors the two numbers shown are for yard tap/alternative primary source, respectively. In each the "taste," "quality," and "satisfied" questions, the proportion shown is for the highest level of three possible response categories.

Table 5. Water Source Characteristics (Means and Frequencies) by Traditional Water Source Conditions

Water Source Characteristics	Unit	Abundant	Saline	Scarce
Primary Water source				
Piped water (yard tap)[1]	Percent	2.8	4 7	5.4
Public tap	Percent	4.2	14.7	21 8
Public hand pump/well	Percent	0	19.2	36.2
Own well	Percent	83.0	34 3	11 8
Neighbor's well/tap	Percent	12.8	31 6	24 4
Trough (kulam)	Percent	0	0 3	5 9
Estimated connection charge[2]	Rupees	534.3	610.3	478 7
Distance to water source	Meters	6.6	33.9	73 5
Mean queue time over seasons	Minutes	0.04	12.5	11 8
Taste is good (traditional source)	Percent	96	51	92
Quality is good (traditional source)	Percent	96	52	90
Satisfied (traditional source)	Percent	92	37	45
Average Daily Quantity (not from tap)	Liters	332	244	168
Average Daily Quantity from tap	Liters	117	112	123
Average Daily Quantity per Capita	Liters	49	30	26

1 The yard tap number is the true population proportion of site A connectors in each group. Each connector also reported the alternate source that they would use if they did not have a yard tap. That source is included in the other sources listed below yard tap. Thus, excluding the first row, the frequencies for water source used add up to 100 percent in this section of the table.

2 Based on distance to the ditribution line or planned distribution line.

Note: These statistics are weighted by the population in each sampling unit.

Table 6. Description of Bidding Games for Each Site

Survey Site	Bidding Game	Water System Characteristics Varied in the Bidding Games: Tariff	Service	Connection Cost
A1: currently connected to an existing scheme, with a yard tap	Tariff game	Range up (10-50 rupees)	Current service level	NAP
	Improved game	Range up (10-50 rupees)	Better service described	NAP
A2: with access to the same scheme as the A1 households, but not currently connected	Connection cost game	Current (5 rupees)	Current service level	Range down (700-100 rupees)
	Tariff game	Range up (10-50 rupees)	Current service level	Held constant at 100 rupees
	Improved Service game	Range up (10-50 rupees)	Better service described	Held constant at 100 rupees
B: new scheme planned or under construction — will have access in the future	Connection cost game	Current (5 rupees)	Current service level	Range down (700-100 rupees)
	Tariff game	Range up (10-50 rupees)	Current service level	Held constant at 100 rupees

Note: "Range up" means that the existing price (5 rupees) is the minimum, and bids ranged up from that level. "Range down" means that connection cost was started at 700 rupees and reduced in increments to the final option of 100 rupees.

Table 7. Average Maximum Willingness to Pay by Site in the Bidding Games

Bidding Game	Unit	A sites: Improved Water Source Available		B sites No Improved Water Source Available
		Connectors	Nonconnectors	
Average Maximum Willingness to Pay: Monthly Tariff Game	Rupees	19.3	8.7	5.5
Percent of respondents with a bid greater than zero	Percent	56	43	34
Average Maximum Willingness to Pay: Connection Charge Game	Rupees	NAP	355	267
Percent of respondents with a bid greater than zero	Percent	NAP	78	62
Average Maximum Willingness to Pay: Monthly Tariff for Improved System Game	Rupees	25.0	9.7	NAP
Percent of respondents with a bid greater than zero	Percent	85	43	NAP

Table 8. Average Maximum Willingness to Pay by Traditional Water Source Conditions

Bidding Game	Unit	Abundant	Saline	Scarce
Average Maximum Willingness to Pay: Monthly Tariff Game	Rupees	7 7	4 5	8 3
Percent of respondents with a bid greater than zero	Percent	51	25	39
Average Maximum Willingness to Pay: Connection Charge Game	Rupees	378	197	301
Percent of respondents with a bid greater than zero	Percent	69	60	68
Average Maximum Willingness to Pay: Monthly Tariff for Improved System Game	Rupees	7.8	6 0	19 6
Percent of respondents with a bid greater than zero	Percent	42	35	66

Note: These statistics are weighted by the population in each sampling unit.

Table 9. Household and Source Characteristics (Means) for Users of Public Taps

		A sites: Improved Water Source Available		B sites: No Improved Water Source Available
Variable	Unit	Connectors	Nonconnectors	
Household Characteristics				
Per capita income	Rupees	2011	1728	1833
Household Population	Number	6.2	6.9	6.2
Electricity	Percent	92	34	32
Rooms in house	Number	4.7	3.4	2.6
Maximum female schooling	Years	12.2	8.6	5.2
Maximum male schooling	Years	9.8	7.5	5.3
Water Source Characteristics				
Distance to public water source	Meters	63	16	11
Mean queue time over seasons	Minutes	18	43	25
Taste is good	Percent	55	92	97
Quality is good	Percent	63	92	97
Satisfied	Percent	13	45	39
Average daily quantity from all sources	Liters	121	181	217
Average daily quantity from all sources, per capita	Liters	NAP	26	35
Bidding Game				
MWTP: tariff	Rupees	23.6	8.2	2.6
MWTP: Connection charge	Rupees	NAP	360	186
MWTP: Improved, tariff	Rupees	27.3	8	NAP
Sample Size of Households Using the Public Tap	Number	13	110	38

Table 10. Reproduction of Twelve Observations for a Single (A1) Household

Hook up?	Tariff[1]	Connection Cost	Improved?	Game
0	50	0	0	Tariff
0	10	0	0	Tariff
0	30	0	0	Tariff
0	20	0	0	Tariff
0	50	0	1	Improved
1	10	0	1	Improved
0	30	0	1	Improved
1	20	0	1	Improved
.	.			Connection Cost
.	.	.	.	Connection Cost
.	.	.	.	Connection Cost
.	.	.		Connection Cost

Note: "." means missing value – game not administered
Maximum willingness to pay in the tariff game. 5 rupees (current tariff)
Maximum willingness to pay in the improved game: 20 rupees

Table 11. List of Variables Used in the Analysis of the Bidding Games

Category	Variable	Expected Sign[1]	Description
Characteristics of the improved water source, given in the bidding game	Tariff	-	Tariff quoted in the bidding game
	Connection charge	-	Connection charge quoted in the bidding game
	Improved Service	+	Whether the bidding game indicated that the service would be improved (0/1)
Characteristics of the current water source or alternative to a yard tap	Distance to current source	+	Distance to the current source of water or, if hooked up, distance to the primary alternative source
	Queue at current source	+	Average queuing time over seasons at the current source; if hooked up already, queuing time at the primary alternative source
Household characteristics	Per capita income	+	Estimated household income divided by household population
	Electricity	+	Whether the household has electricity (0/1)
	Number of rooms	+	Number of rooms in the house
	Females in government service	+	Whether any females in the household are employed by the government (0/1)
	Males in government service	+	Whether any males in the household are employed by the government (0/1)
	Hindu	?	If the household's religion is Hindu (0/1)
	Sex of HH head	+	If the household head is female (0 = male/1 = female)
	Sex of respondent	+	If the respondent to the survey is female (0 = male/1 = female)
	Some primary school	+	If the maximum education of adults in the household is some primary school (without finishing) (0/1)
	Primary school complete	+	If the maximum education of adults in the household is completion of primary school (0/1)
	Middle school complete	+	If the maximum education of adults in the household is completion of middle school (0/1)
	Secondary school complete	+	If the maximum education of adults in the household is completion of secondary (0/1)
	More than secondary	+	If the maximum education of adults in the household is at least some college (0/1)
Traditional Water Supply Characteristics	Scarce water area	+	Household is in a scarce water area (0/1)
	Saline water area	+	Household is in an area where salt water has intruded into traditional sources (0/1)
Dummy Variables to Account for Bidding Game Bias	A2 household	-	Household is a nonconnector in villages with improved water already available (0/1)
	B-village household	-	Household is in a village without an improved water source (0/1)

[1] Expected sign: the effect -- positive (+), negative (-), or unknown (?) -- on the probability of choosing a yard tap

Table 12. Probit Estimates of Choosing a Yardtap in the Bidding Games; Information from All Games Combined, Including Tariff, Connection Cost, and Improved System Bidding Games

	Full Model					Simple Model			
Variable	Coefficient	Std Error	t-statistic	Elasticity	Mean	Coefficient	Std Error	t-statistic	Elasticity
Dependent Variable. Hook up?					0.302				
Constant	-0.301	0.472	0.637		1.000	1.357	0.347	3.910 *	
Tariff	-0.060	0.006	10.184 *	-1.465	17.633	-0.053	0.005	9.654 *	-1.202
Connection charge	-0.001	0.000	4.020 *	-0.289	218.747	-0.001	0.000	3.699 *	-0.232
Improved Service	-0.058	0.204	0.286		0.114	-0.049	0.193	0.253	
Distance to current source	0.00002	0.0004	0.039	0.001	31.597	0.00006	0.0004	0.167	0.003
Queue at current source	0.003	0.003	0.895	0.032	8.412	-0.002	0.003	0.560	-0.018
Per capita income	0.00002	0.00001	1.823 *	0.083	2613.400	0.00004	0.00001	3.462 *	0.138
Electricity	0.335	0.115	2.915 *		0.461				
Number of rooms	0.086	0.031	2.799 *	0.377	3.188				
Females in government service	-0.100	0.206	0.485		0.054				
Males in government service	0.166	0.115	1.447		0.262				
Hindu	-0.191	0.124	1.539		0.463				
Sex of HH head	0.057	0.117	0.487		0.240				
Sex of respondent	-0.275	0.102	2.696 *		0.595				
Some primary school	0.509	0.296	1.718 *		0.110				
Primary school complete	0.629	0.277	2.275 *		0.197				
Middle school complete	0.961	0.280	3.430 *		0.181				
Secondary school complete	1.132	0.275	4.125 *		0.264				
More than secondary	1.290	0.292	4.423 *		0.178				
Scarce water area	0.347	0.139	2.501 *		0.253	0.055	0.118	0.468	
Saline water area	-0.232	0.135	1.710 *		0.359	-0.399	0.114	3.507 *	
A2 household	-0.307	0.332	0.924		0.315	-0.690	0.319	2.167 *	
B-village household	-0.492	0.338	1.456		0.666	-1.043	0.319	3.267 *	

Estimates are weighted by the population of the sampling unit. The means are the same for both models. The probit as a whole is significant at better than the .00001 level for a likelihood ratio test (chi-square). An "*" next to the asymptotic t-statistic indicates that the coefficient is significant at the .10 level or better for a two tailed test.

13,800 observations were used to estimate the coefficients, 12 for each household. The reported standard errors are the means of the standard errors estimated for 100 separate probits run on the actual sample of 1150 households, in which one observation was randomly drawn for each household, sampling with replacement from the population of 13,800 observations.

Table 13. Equivalence of the Tariff and Connection Charges

	1	2	3	4	5	6	7	8
	Mean Price from the Bidding Games	Ten Percent Increase in the Mean Price	Resulting Percentage Change in the Probability of Choosing a Yard Tap	Change in Annual Expenditure Due to the Increase in the Mean Price	Forced Equivalence in the Annual Change in Expenditure, Tariff and Connection Charge	Change in the Mean Price Consistent with Equal Annual Expenditure	Resulting Percentage Change in the Mean Price	Percentage Reduction in the Probability of Hooking Up
Unit	Rupees	Rupees	Percent	Rupees	Rupees	Rupees	Percent	Percent
Tariff	17 6	1.76	-14 7	21 2	4 2	0 4	2 0	-2 9
Connection Charge	218 7	21 87	-2 9	4 2	4 2	21 9	10.0	-2 9
In this example, the increase of 21 9 rupees in the connection charge is amortized over 6 years at a real interest rate of 5 percent								

Table 14. Incremental Effects of Schooling on the Probability of Choosing a Yard Tap

Schooling Level	Percentage Increase in Probability over the Previous Level	Percent at each Level of Schooling	
		A2	B
Primary	5.9	18	21
Middle	13.1	9	21
Secondary	4.7	33	22
At least some college	3.5	28	12

Table 15. Probit Model of Choosing a Yardtap in the Bidding Games for the A Nonconnectors and B Households Only; Information from Connection Cost and Tariff Bidding Games

Variable	Coefficient	Std Error	t-statistic		Elasticity	Mean
Dependent variable: Hook up?						0 308
Constant	-0 499	0.381	1 308			1 000
Tariff	-0 068	0 007	10 262	*	-1 521	16 241
Connection cost	-0.001	0.000	4.191	*	-0.362	237 613
Distance to current source	0 0001	0 0005	0.208		0.005	34.366
Queue at current source	0.004	0.004	1.205		0 046	7.573
Per capita income	0 00002	0.00001	1.457		0.078	2659 032
Electricity	0.307	0.130	2.357	*		0 452
Number of rooms	0.110	0.037	2.975	*	0.468	3.076
Males in government service	0.227	0.132	1.722	*		0.250
Hindu	-0.190	0.142	1.342			0.434
Sex of HH head	0.059	0.134	0 436			0.240
Sex of respondent	-0 262	0.117	2.244	*		0.585
Some primary school	0.476	0.331	1.438			0.117
Primary school complete	0.544	0.309	1.762	*		0.200
Middle school complete	0.920	0.314	2.932	*		0.195
Secondary school complete	1.080	0.307	3.515	*		0 253
More than secondary	1.204	0.326	3 686	*		0.160
Scarce water area	0.222	0.159	1 396			0.245
Saline water area	-0.257	0.154	1.665	*		0.358
B-village household	-0.183	0.143	1.278			0 760

Estimates are weighted by the population of the sampling unit. The probit as a whole is significant at better than the .00001 level for a likelihood ratio test (chi-square). An "*" next to the asymptotic t-statistic indicates that the coefficient is significant at the .10 level or better for a two-tailed test.

7,200 observations were used to estimate the coefficients, 8 for each household. The reported standard errors are the means of the standard errors estimated for 100 separate probits run on the actual sample of 900 households, in which one observation was randomly drawn for each household, sampling with replacement from the population of 7,200 observations.

Table 16. Probit Model of Choosing a Yardtap in the Bidding Games for the A Households Only: Information from Tariff and Improved Service Bidding Games

Variable	Coefficient	Std Error	t-statistic		Elasticity	Mean
Dependent variable. Hook up?						0 229
Constant	-0.458	0.559	0.821			1 000
Tariff	-0.040	0.006	6.638	*	-1 684	27 500
Improved Service	0.132	0.150	0 876			0 500
Distance to current source	0.001	0.003	0 227		0.011	11 065
Queue at current source	0 001	0 004	0 229		0 021	15 330
Per capita income	0.00004	0.00003	1.508		0.133	2194 633
Electricity	0.139	0.226	0.616			0.487
Number of rooms	0.054	0.039	1.390		0.324	3 885
Males in government service	-0.256	0.172	1.493			0 328
Hindu	-0.062	0.209	0.295			0 675
Sex of HH head	0.015	0 183	0.085			0 237
Sex of respondent	-0.342	0.166	2.052	*		0.681
Primary school complete	0.551	0.390	1.413			0.180
Middle school complete	0.420	0.459	0.915			0 084
Secondary school complete	0.883	0.368	2.401	*		0.339
More than secondary	1.239	0.384	3.223	*		0 291
Scarce water area	0.823	0.201	4.101	*		0 313
Saline water area	-0.153	0.270	0.565			0 354
A2 household	-0.610	0 271	2.255	*		0.919

Estimates are weighted by the population of the sampling unit. The probit as a whole is significant at better than the .00001 level for a likelihood ratio test (chi-square). An "*" next to the asymptotic t-statistic indicates that the coefficient is significant at the 10 level or better for a two-tailed test.

4,400 observations were used to estimate the coefficients, 8 for each household. The reported standard errors are the means of the standard errors estimated for 100 separate probits run on the actual sample of 550 households, in which one observation was randomly drawn for each household, sampling with replacement from the population of 4,400 observations.

Table 17. Probit Model of Choosing a Yardtap in the Bidding Games for the A-site Connecting Households Only; Information from Tariff and Improved Service Games

Variable	Coefficient	Std Error	t-statistic	Elasticity	Mean
Dependent variable: Hook up?					0 444
Constant	-0 569	0 788	0.723		1 000
Tariff	-0 044	0 009	5 068 *	-1 143	27 500
Improved Service	0.708	0 230	3.076 *		0 500
Distance to current source	0.001	0.002	0.712	0 024	21 376
Queue at current source	0 0002	0 013	0 018	0 0005	2.146
Per capita income	0 00005	0.00004	1.390	0 166	3533 271
Electricity	-0.248	0.578	0.430		0.960
Number of rooms	-0.009	0 040	0.217	-0 043	5 199
Males in government service	-0.202	0.232	0.871		0 584
Hindu	-0 364	0.273	1.332		0.655
Sex of HH head	-0.027	0.277	0.097		0 283
Sex of respondent	-0.028	0.247	0.115		0 496
Middle school complete	-0.183	0.519	0.354		0.106
Secondary school complete	0.439	0.432	1.015		0 394
More than secondary	0.795	0.463	1.717 *		0.420
Scarce water area	2.566	0 385	6.665 *		0.310
Saline water area	0.907	0.308	2.942 *		0 420

Estimates are weighted by the population of the sampling unit. The probit as a whole is significant at better than the .00001 level for a likelihood ratio test (chi-square). An "*" next to the asymptotic t-statistic indicates that the coefficient is significant at the 10 level or better for a two-tailed test.

2,000 observations were used to estimate the coefficients, 8 for each household. The reported standard errors are the means of the standard errors estimated for 100 separate probits run on the actual sample of 250 households, in which one observation was randomly drawn for each household, sampling with replacement from the population of 2,000 observations.

Table 18. Distribution of Responses in B-site Bidding Games

	Abundant	Scarce	Saline	Overall
Current source	61 2	72.9	79 3	71 1
Public tap	0.0	1.6	2.3	1 3
Yard tap	38 8	25.5	18.4	27 6

Note: The full sample of B-site households is 600 In the two bidding games administered to those households -- the connection cost and simple tariff games -- a total of 8 responses were recorded per household. The frequencies are for 4,540 nonmissing responses out of a possible 4,800.

Table 19. Ordered Probit Estimates of Maximum Willingness to Pay in Each Type of Bidding Game

Variable	Tariff Coefficient	Tariff t-statistic	Tariff Mean	Improved Coefficient	Improved t-statistic	Improved Mean	Connection Cost Coefficient	Connection Cost t-statistic	Connection Cost Mean
Dependent Variable: Maximum Willingness to Pay			14 68			18.27			361.34
Constant	-11 90	-1 73 *	1.00	-4 47	-0 39	1 00	-233 33	-1 66 *	1.00
Distance to traditional source	0 004	0 62	33 65	0 02	0 15	9 16	0 02	0 09	34 34
Queue at traditional source	0 07	1.39	7 41	-0 02	-0 28	15 08	2 89	2 00 *	7 57
Per capita income	0 0003	1 58	2674.40	0 0008	1 97 *	2193 60	0 02	2 54 *	2659 60
Electricity	6.49	3 63 *	0 46	2 65	0.70	0 49	176 70	3 16 *	0 45
Number of rooms	1.72	3.67 *	3.12	0 53	0 77	3.89	60 75	3 67 *	3 08
Females in government service	-1 93	-0 63	0 05	-1 16	-0 23	0 07	-43 57	-0 40	0 05
Males in government service	4.17	2.42 *	0 26	-8 44	-2.74 *	0.33	150.10	2 51 *	0 25
Hindu	-3.61	-1 89 *	0.44	-1 86	-0 53	0 68	-135 86	-2 23 *	0 43
Sex of household head	2 23	1 23	0 24	-1 96	-0 62	0 24	6 55	0.12	0 24
Sex of respondent	-5.66	-3 61 *	0 58	-9 22	-3.20 *	0 68	-115 16	-2.34 *	0 59
Some primary school	5 67	1 17	0 11	20 17	1 86 *	0 06	278 72	2 46 *	0 12
Primary school complete	11.28	2.54 *	0 20	28 07	2 88 *	0.18	263.20	2 47 *	0 20
Middle school complete	15 27	3 40 *	0 19	22 76	2.16 *	0 08	539.74	4 85 *	0 19
Secondary school complete	19.51	4.42 *	0 26	34 61	3 59 *	0 34	609 21	5 56 *	0 25
More than secondary school	23.67	5.08 *	0 17	44 64	4 46 *	0 29	628 53	5 21 *	0 16
Scarce water area	4 45	2.10 *	0 25	18 66	5 20 *	0 31	115 58	1 68 *	0 24
Saline water area	-5 25	-2.46 *	0 36	-6.46	-1 45	0 35	-170 83	-2.60 *	0 36
A2 household	-5 39	-1 15	0 23	-22.44	-4 59 *	0 92			
B-village household	-8.16	-1 77 *	0 74				-96 16	-1 58	0 76
Sigma	19 00	23.10 *		23 75	16 48 *		567 77	19 61 *	
Sample size for estimation	1082			521			847		
Full sample size	1150			550			900		

	Tariff Category	Tariff Number	Tariff Percent	Improved Category	Improved Number	Improved Percent	Connection Cost Category	Connection Cost Number	Connection Cost Percent
Distribution of dependent variable	0-9	639	59	0-9	198	38	0-99	281	33
	10-19	235	22	10-19	106	20	100 199	127	15
	20-29	84	8	20-29	88	17	200 499	110	13
	30-49	31	3	30.49	38	7	500 699	62	7
	50 +	93	9	50 +	91	17	700 +	267	32

Note Estimates are weighted by the population of the sampling unit Those are maximum likelihood estimates of the "grouped regression model" or the "ordered probit with known thresholds." The regressions as a whole are significant at better than the .00001 level for a likelihood ratio test. An "*" next to the asymptotic t-statistic indicates that the coefficient is significant at the .10 level or better for a two tailed test

Table 20. Logit Coefficients Explaining Actual Use of Public Tap, Yard Tap, and Well in the A Sites

Variable	Model Including Source Characteristics				Model Excluding Source Characteristics				Means
	Log Odds of Choosing Yard Tap Relative to Choosing Public Tap		Log Odds of Choosing Well Relative to Choosing Public Tap		Log Odds of Choosing Yard Tap Relative to Choosing Public Tap		Log Odds of Choosing Well Relative to Choosing Public Tap		
	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic	
Constant	-4.143	-1.80 *	3.190	1.58	-4.392	-3.32 *	1.798	2 52 *	1 00
Estimated connection cost	0 001	0.57	0 001	0 60	0 001	1.49	0 0006	1 00	606 54
Distance to traditional source	0.009	0.42	-0.017	-0 56					11 29
Queue at traditional source	-0 167	-7.20 *	-0 159	-6 47 *					15 90
Per capita income	0 0003	1 12	0.0002	0 69	0 0002	4.37 *	0 0001	2 14 *	2254 20
Number of rooms	0.141	0.61	-0.032	-0.13	0.333	3.42 *	0.189	2 59 *	3 91
Males in government service	0 924	1.15	0 107	-0 15	0 886	2 30 *	0.071	0 25	0 34
Hindu	-1.120	-0 89	-1.430	-1.16	-0.717	-1 54	-1.055	-2 94 *	0 68
Sex of household head	-0 212	-0.26	-0.787	-0.93	-0 052	-0.13	-0 473	-1 53	0 25
Primary school complete	2.856	2 58 *	0 552	0 53	1 890	1 85 *	0.356	0 60	0 17
Middle school complete	3.366	2 29 *	0 242	0 16	2.743	2.54 *	0.291	0 46	0 09
Secondary school complete	3.747	3.59 *	0 855	0 83	2 434	2 58 *	0.421	0.79	0 34
More than secondary school	4.452	3.31 *	1.709	1 37	3 070	3.10 *	1 255	2 24 *	0 30
Scarce water area	-1.767	-1.17	-2 549	-1 77 *	-1.794	-2.78 *	-2 669	-6 47 *	0 34
Saline water area	-0.013	-0.01	-1.354	-0 73	-2.305	3 61 *	-3 725	-7 36 *	0 36
Likelihood ratio chi-squared statistic (degrees of freedom)	514 31 (28)				232 40 (24)				
Observations	534				534				

Note: The estimates take into account the choice-based sample, and the t-statistics are based on the corrected covariance matrix An "*" next to the asymptotic t-statistic indicates that the coefficient is significant at the 10 level or better for a two-tailed test. The models as a whole are significant at better than the .00001 level for a likelihood ratio test (chi-square) A total of 550 observations were used, the difference between 550 and "observations" shown at the bottom of the table is caused by missing values for one or more variables used in the model (one was lost because the dependent variable could not be assigned to one of these three categories; most of the others were yard tap owners who did not know the distance to their alternative traditional source). The same sample is used for both models.

Table 21. Marginal Effects on the Probability of Actually Choosing Public Tap, Yard Tap, and Well as the Primary Water Source in the A Sites

	Model Including Source Characteristics						Model Excluding Source Characteristics						
	Public Tap		Yard Tap		Well		Public Tap		Yard Tap		Well		
Variable	Marginal Effect	t-statistic	Marginal Effect	t-statistic	Marginal Effect	t-statistic	Marginal Effect	t-statistic	Marginal Effect	t-statistic	Marginal Effect	t-statistic	Means
Proportion choosing source	0.385		0 095		0 52		0 385		0.095		0 52		
Constant	-0 487	-1 03	-0 514	-3 89 *	1.001	2 01 *	-0 199	-1 22	-0 466	-4 28 *	0 666	2 07 *	1 00
Estimated connection cost	-0 0003	-0.60	0 00006	0 53	0 0002	0 46	0 0002	-1.11	.00006	1 56	0.0001	0 62	606 54
Distance to traditional source	0 003	0 46	-0 002	1.28	-0 005	-1.09							11 29
Queue at traditional source	0 038	7 64 *	-0 006	-2.74 *	-0 031	-5.27 *							15 90
Per capita income	-0 00006	-0 78	0 00002	1 62 *	0 00004	0 60	-0 00003	-2 93 *	0.00001	2.20 *	0 00002	1 47	2254
Number of rooms	0.001	0 02	0.014	1.37	-0 015	-0.31	-0.050	-2.98 *	0 0193	2 70 *	0 031	1 36	3 91
Males in government service	-0 055	-0 32	0 074	1 80 *	-0 019	-0 11	-0 047	-0 72	0 073	2 49 *	-0 026	-0 29	0 34
Hindu	0 327	1.13	-0 026	-0.44	-0 302	-1 17	0 238	2 95 *	-0.010	-0 26	-0 228	-2 06 *	0 68
Sex of household head	0 165	0 84	0 021	0.53	-0.186	-1.12	0 097	1.40	0.019	0 60	-0 116	-1 23	0 25
Primary school complete	-0.215	-0 93	0 218	2.73 *	-0 003	-0.01	-0.140	-1.05	0 145	1.72 *	-0 005	-0.02	0 17
Middle school complete	-0.172	-0.50	0.277	3.26 *	-0.106	-0 34	-0.159	-1.11	0.222	2.51 *	-0.063	-0 24	0 09
Secondary school complete	-0 308	-1 33	0 280	3 99 *	0 028	0 12	-0 173	-1 43	0 189	2 43 *	-0 015	-0 07	0 34
More than secondary school	-0 505	-1.76 *	0 298	3 66 *	0 207	0 70	-0 364	-2 81 *	0 202	2.53 *	0 162	0 68	0 38
Scarce water area	0 575	1 69 *	-0 026	-0.38	-0 549	-1 76 *	0 600	6.11 *	-0 022	-0 48	-0.577	-3 85 *	0 34
Saline water area	0 272	0 62	0 066	0 85	-0 337	0 89	0 830	7 02 *	-0 014	-0 33	-0 816	-5 68 *	0 36
Observations													534

Note: The "marginal effects" and "t-statistics" are calculated at the mean values of the dependent and independent variables in the previous table They are accurate only at the means of both the dependent and independent variables.

Table 22. Estimates of the Quantity of Water from the Yard Tap and Quantity of Water from All Sources, A Site Households, Liters per Day

	Daily Quantity of Tap Water					Daily Quantity of Water from All Sources					
	Ordinary Least Squares Estimates		Self Selection Model Maximum Likelihood Estimates			Switching Regression Model - Maximum Likelihood Estimates					
						With Yard Tap			Without Yard Tap		
Variable	Coefficient	t-statistic	Coefficient	t-statistic	Mean	Coefficient	t-statistic	Mean	Coefficient	t-statistic	Mean
Dependent: Liters per day					115 99			468			232
Constant	54 177	1.080	53 688	0 498	1 00	190 499	5.776 *	1 00	-1136	-3.704 *	1.00
Per capita income	-0 001	-0.693	-0.001	-0 486	3671 60	-0 004	-1 634	3626 30	0.022	1.623	2113 9
Electricity	-3 861	-0.147	-3 610	-0 084	0 96	-16 999	-0 901	0 96			
Distance to current source						-0.348	-0 779	20.95	2 227	1 818 *	10 25
Queue at current source						-0.460	-2.055 *	2.18	-13 486	-3 636 *	17 32
Number of rooms	-0.792	-0.461	-0 785	-0.302	5.17	11.429	4 415 *	5 17	43 133	2 203 *	3.76
Males in government service	10.764	1.033	10.780	0 917	0 57	-2 551	-0 205	0 57	162 812	1 836 *	0 32
Hindu	5.678	0.447	5.689	0.391	0 66	-3 128	-0 228	0 66	11 988	0 110	0 69
Sex of HH head	-15 896	-1.470	-15.893	-1 316	0 28	-29 294	-2.059 *	0 28	34 184	0 369	0 25
Primary school complete	11.232	0.269	11.288	0 136	0 07	-22.749	-0.691	0 07	299 913	1.378	0 18
Middle school complete	2.891	0 070	2 941	0.035	0 11	9 104	0 282	0 11	461.411	2 010 *	0 09
Secondary school complete	18 910	0 487	18.969	0.239	0.38	5 441	0 179	0 39	478 881	2 414 *	0 34
College complete	33.788	0.858	33 833	0.424	0 43	16 238	0 518	0 42	465 110	2 263 *	0 28
Scarce water area	24 448	1.697 *	24 443	1 638	0 32	-147 755	-7 999 *	0 34	-58 083	- 518	0 34
Saline water area	-3 446	-0.272	-3 340	-0.165	0 41	-119 738	-6.234 *	0 42	199 217	1 642 *	0 35
Number of people in HH	5 923	3 305 *	5 921	3 317 *	6 55	17 542	9 818 *	6 50	2 739	0 188	6 87
Covariance. choice and quantity			0 190	0 008		111.56	37 638 *		458 567	8 38 *	
F-Statistic		2.151 *									
Observations used		235		533				238			298
Observations with yard tap		235		235				238			0

An "*" next to the asymptotic t-statistic indicates that the coefficient is significant at the 10 level or better for a two-tailed test Distance and Queue are excluded from the tap quantity regression because they should not (and actually do not) affect demand for tap water. Electricity is excluded from the last switching regression equation because it is perfectly collinear with the Saline water area variable - no households that are not hooked up in that area have electricity The OLS regression as a whole is significant at about the 2 percent level, and the maximum liklohood estimates are significant at the 1 percent level for a likelihood ratio test. Although the sample sizes for the two regimes are reported separately for the switching regression, all observations are pooled for the joint estimation of the parameters of the two equations. The underlying coefficient estimates for the probits are not reported. For the self selction model, the probit estimates are for the probability of owning a yard tap, for the switching regression, they are for the probability of being in each regime

Table 23. Actual and Estimated Per Capita Quantity of Water from Yard Taps and All Sources, Average for A Site Households by Traditional Water Characteristics

	Daily Liters per Capita			Abundant Standardized to 100		
	Abundant	Scarce	Saline	Abundant	Scarce	Saline
Yard tap owners						
Yard tap: actual	18	31	16	100	172	3
Yard tap: predicted	19	32	16	100	168	3
All sources: actual	106	87	66	100	92	6
All sources: predicted	82	80	36	100	98	4
Sample size	63	76	96			
Households without yard taps						
Yard tap: actual	0	0	0			
Yard tap: predicted	19	25	16	100	132	3
All sources: actual	52	29	30	100	56	5
All sources: predicted	122	80	97	100	66	9
Sample size	99	100	99			

These averages were calculated using actual reported quantities, predicted tap quanity based on the selection-corrected estimates in Table 22, and predicted consumption from all sources using the switching regression coefficients in Table 22. All variables wer divided by reported household size to get per capita estimates.

Table 24. Mean Percent of Income Spent on Water Annually by Income Quintile and Water Source Characteristics for Three Simulated Tariffs

quintiles for per capita income	traditional water characteristics	tariff = 5			tariff = 10			tariff = 15		
		connectors	percent connecting	percent of income to water	connectors	percent connecting	percent of income to water	connectors	percent connecting	percent of income to water
poorest	abundant	39	67	3.3	26	45	7.4	7	12	6.1
	scarce	46	58	3.5	36	45	7	25	31	11.6
	saline	24	26	2.4	9	10	6.5	6	7	12.5
second	abundant	29	63	1.2	21	46	2.2	14	30	3.2
	scarce	47	61	1.3	29	38	2.7	20	26	3.9
	saline	35	33	0.9	27	25	1.8	11	10	2.7
third	abundant	37	64	0.7	27	47	1.3	19	33	1.9
	scarce	58	68	0.9	50	59	1.9	40	47	2.6
	saline	37	46	0.7	27	33	1.2	21	26	1.6
fourth	abundant	65	83	0.3	53	68	0.7	38	49	0.9
	scarce	59	77	0.5	54	70	1	48	62	1.6
	saline	48	72	0.3	33	49	0.6	28	42	0.9
richest	abundant	111	89	0.2	95	76	0.3	69	55	0.5
	scarce	44	85	0.3	40	77	0.6	34	65	0.8
	saline	42	89	0.2	38	81	0.3	31	66	0.5
full sample	abundant	281	77	0.8	222	61	1.5	147	40	1.3
	scarce	254	68	1.3	209	56	2.4	167	45	3.5
	saline	186	47	0.7	134	34	1.3	97	25	1.8