Rural Water Supply in Kerala, India:

How to Emerge from a Low-Level Equilibrium Trap

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Abstract

The current situation in water supply in rural Kerala can be described as a "low-level equilibrium trap". Systems provide a low level of service with few yard taps. Because there are few connectors and because tariffs are low, little revenue is generated. The water authority can afford to maintain the system up to a level at which the reliability of service is low, forcing consumers to supplement piped water from traditional sources. This study analyzes contingent valuation data collected in three areas of Kerala. The analysis shows that, by making a few critical policy changes -- encouraging connections by public financing of connection charges, raising tariffs, and improving reliability -- the systems can ratchet up to a "high-level equilibrium" in which there are a large number of connectors, revenues are greatly increased, supply can be made much more reliable, access to yard taps is made substantially more equitable, and there are large improvements in welfare.

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) [Briscoe and de Ferranti, 1988].

This study examines willingness to pay for hookups to piped 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

[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

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 reliability 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. 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

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month, was US$ 0.36.

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 bidding games that were conducted in several areas where piped water is currently available and in other areas where water systems are being built but are not yet operational, in order to assess 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 five 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, some policy implications of the findings are considered. 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, each area includes 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.

Table 1 about here

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 pumps repairs that are required on average more than once a month [Singh and Ramasubban, 1989]. Pump failure is the most important problem and is attributed primarily to fluctuations in voltage. The pump in Ezhuvathuruthy, for example, failed on 15 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 about four or five hours a day.

Public taps are located at specified distances along the main pipe; every 200 meters is a common spacing. 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 is implicit in 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.

Table 2 about here

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 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.

Water Source Characteristics. Table 3 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. 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 3 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.

Table 3 about here

Connection charges for the entire sample were computed based on the distance from the house to the actual or planned water main. On average, households that were connected faced the highest connection charge (or were farthest from 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

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

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.

Bidding Games. Table 4 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 4 about here

Table 5 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 nonconnectors 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

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

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 3. 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.

Table 5 about here

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.

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.[4] 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

As shown in Table 4, 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 major analytical hurdle is 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

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[4] 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 3 and a more detailed discussion later in the paper.

regression model is inappropriate, and the probit (based on the normal distribution) or logit (based on the logistic distribution) regression model is used [Maddala, 1983]. 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 as the maximum willingness to pay for a yard tap, which can then be analyzed using the ordered probit statistical model. Those results provide no additional information and are available from the authors.

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 6. 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.

Table 6 about here

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.[5]

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 7 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

[5] The standard errors for the probits based on the full 13,800 observations tend to be about a third of those we report, resulting in t-statistics about 3 times too large. Because our approach is inefficient, the reported t-statistics are somewhat understated, which we do not consider a problem because the significance levels in general are high. The means of the coefficients from the 100 probits, as expected, are almost exactly the same as those reported for the large sample.

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 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.

Table 7 about here

Results for the Full Sample

Table 8 contains the estimation results for the full sample, using the information from all three bidding games. 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[6]; and the mean of each variable

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

in the sample used for the estimation.

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 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. 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. At first glance, this finding appears to run 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.[7]

Table 8 about here

In fact, however, the apparent large difference in elasticities is illusory because the scale and time horizon for the tariff and connection charges are different. The tariff is a charge for a current service; the connection charge is for a durable good. The two can be made equivalent by discounting the latter. Table 9 illustrates this idea. Column 1 contains the mean value of the tariff and connection charge from the bidding games. Column 2 shows the value of a ten-percent increase in the tariff or in the connection charge. Column 3 shows the implied

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[7] 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.

reduction in the probability of hooking up, given these changes and the elasticities in Table 8.[8] Columns 2 and 3 show the result that if the connection charge is not treated by the analyst as a durable good, a 1.8 rupee change in the tariff apparently 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 30 years at a 20 ~~percent~~ real rate of interest to show the implied increase in annual cost.[9] On an annualized basis, 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 and a 21.9 rupee increase in the connection charge (column 6). These increases correspond to a 2 ~~percent~~ 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.

Table 9 about here

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) in trading off between the quoted connection

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[8] 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.

[9] As is demonstrated later in this section, this is the implicit interest rate at which the responses for connection costs and tariffs are equivalent.

fee and the monthly tariff. Thus, at some interest and amortization schedule, the connection charge and tariff can be made equivalent to the household. In this particular case for the reasonable amortization period of 30 years, the implicit interest rate faced by consumers is 20 percent. 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.

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 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 plausible 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. Responses 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. It is pertinent to note that this observation on the importance of financing connection costs has long been understood by water authorities and acted upon in areas where it is standard practice to finance connection costs.

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.

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 sociological 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.[10] The results are organized in Table 10. The two largest increments in probability 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.

Table 10 about here

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.[11] 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

[10] 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.

[11] 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.

excluded abundant water site.[12] 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.

Summary

Respondents are quite sensitive to the monthly tariff for water and to the price of a connection. The responses suggest that 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, small increments in the tariff could remove completely the credit market impediment to getting a connection.

Improved service does not appear to affect significantly 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

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[12] 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.

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.

Policy Simulations

In this section we use the probit results in Table 8 to estimate demand for water connections and system revenue across the range of tariffs quoted in the bidding games. We use the same technique to show potential gains in welfare if the supply of private water connections is expanded. 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. Using the coefficients in Table 8, 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.[13] For each price the total number of hook ups is counted, which is our measure of total demand. Connection cost is set to 100,[14] and whether service is improved is set to zero in this simulation. The other independent variables are the actual values for each household.

Figure 1 shows the result. The monthly tariff appears on the horizontal axis, the number of connections 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[15] would connect, including 100 percent of the A1 households, 83 percent of the A2 households, and 61 percent of the B households.

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[13] 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.

[14] 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.

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

Figure 1 about here

Figure 1 illustrates some basic truisms of economics. First, prices are often set at 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. In the sample villages, for example, 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. An alternative and possibly more appropriate criterion than arbitrarily low tariffs might be to "set the tariff so that revenues are 90 percent of the maximum," which is considered next.

cross subsidy

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 1 is 14 rupees, corresponding to 445 connections and monthly revenue of 6,230 rupees. At a tariff of 10 rupees, monthly revenue (5,650 rupees) is 91 percent of the maximum, but the number of connectors is 120 greater among the sample than would be the case if revenues were maximized.

Welfare Effects of Higher Tariffs and More Connections

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 2, 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 1. However, the number of connections has been scaled up to the whole population using the data reported in Table 1. 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 connect.

Figure 2 ambout here

Consumer surplus, a measure of economic welfare, is shown as the crossed area above the 5 rupee price in Figure 2. 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.

How could private connections be expanded 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 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 3 as the "New Price" line. Suppose further that the supply of connections is expanded to 2,500, which clears the market at that price. 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 revenue, according to our estimates.

Figure 3 about here

How could the water system expand connections at a 10-rupee tariff? The water authority could borrow 1,746,390 rupees for 30 years at a real interest rate of 5 percent with monthly payments of 9,375 rupees (this capital cost would consume 5 rupees of each 10-rupee tariff). This loan would allow it to pay for connections for the 2,250 new customers at an average of 776 rupees per connection, about 1.5 times the estimated average cost for the A2 and B households in the sample. An equal amount would be availabble monthly for recurrent costs or to finance other capital costs (compared to 1,250 today in total). 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 3 as the shaded area. We estimate roughly that consumer surplus in Figure 2 is 5,500 rupees, compared to 25,000 in Figure 3, 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 by 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 and paying for recurrent costs on a per household basis, so our example would not change in that respect. 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 opportunities to serve them better.

Yearly Water Costs and Income Distribution

Table 11 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.

Table 11 about here

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 percent connecting falls 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 apparently 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.

Conclusion

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 high among households that are already connected, especially among those in scarce-water areas.

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.

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 for our full-sample estimates. In estimates not reported in this paper, 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.

The findings of significantly higher willingness to pay by current owners of yard taps 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 in making long-term plans of that nature is the capital cost differential between a minimal quality system and a high quality system, and how recurrent costs vary over the life of the system. It may be possible that much higher quality systems can be purchased within the constraints of consumers' existing willingness to pay.

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. The connection-cost impediment should be a relatively easy one for the water authority to eliminate. Satisfying the excess demand that exists for yard taps would greatly increase the water authority's revenues and ability to finance connection costs, not to mention service improvements.

This study therefore traces out a "new" path which water-supply planners in Kerala (and many other parts of the developing could) could follow. The current water-supply situation in rural Kerala can be described as a "low-level equilibrium trap". Systems provide a low level of service with few yard taps. Because tariffs are low and there are few connectors to pay the tariffs, little revenue is generated. The water authority can afford to maintain the system only up to a level at which the reliability of service is low, forcing consumers to supplement piped water from traditional sources and reducing further the willingness of people to pay for such a system.

Our analysis shows that, by making a few critical policy changes -- encouraging connections by financing connection charges through higher tariffs and improving reliability -- the systems can ratchet up to a "high-level equilibrium" in which there are a large number of connectors, revenues are greatly increased, supply is more reliable, access to yard taps is substantially more equitable, and there are large improvement in welfare. The critical ingredient in effecting such a change is a change in perception about the purpose of a public water-supply system. Rather than trying to provide a heavily subsidized, minimal-service-to-all system, planners need to understand and respond to patrons' demands.

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List of Figures

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		B Sites: No Improved Water Source
		Connectors	Nonconnectors	
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. Water Source Characteristics (Means and Frequencies) by Site

Water Source Characteristics	Unit	A Sites: Connectors	A Sites: Nonconnectors	B Sites
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 4. 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 5. **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

Note: NAP = Not applicable

Table 6. 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

1. Maximum willingness to pay in the tariff game: 5 rupees (current tariff)
Maximum willingness to pay in the improved game: 20 rupees

Table 7. 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 8. Probit Estimates of Choosing a Yardtap in the Bidding Games; Information from All Games Combined, Including Tariff, Connection Cost, and Improved System Bidding Games

Variable	Full Model Coefficient	Std Error	t-statistic		Elasticity	Mean
Dependent Variable: Hook up?						0.302
Constant	-0.301	0.472	0.637			1.000
Tariff	-0.060	0.006	10.184	*	-1.465	17.633
Connection charge	-0.001	0.000	4.020	*	-0.289	218.747
Improved Service	-0.058	0.204	0.286			0.114
Distance to current source	0.00002	0.0004	0.039		0.001	31.597
Queue at current source	0.003	0.003	0.895		0.032	8.412
Per capita income	0.00002	0.00001	1.823	*	0.083	2613.400
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
Saline water area	-0.232	0.135	1.710	*		0.359
A2 household	-0.307	0.332	0.924			0.315
B-village household	-0.492	0.338	1.456			0.666

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 9. **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/year	Rupees/year	Rupees	Percent	Percent
Tariff	17.6/mo.	1.76/mo.	-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

Table 10. **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 11. 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

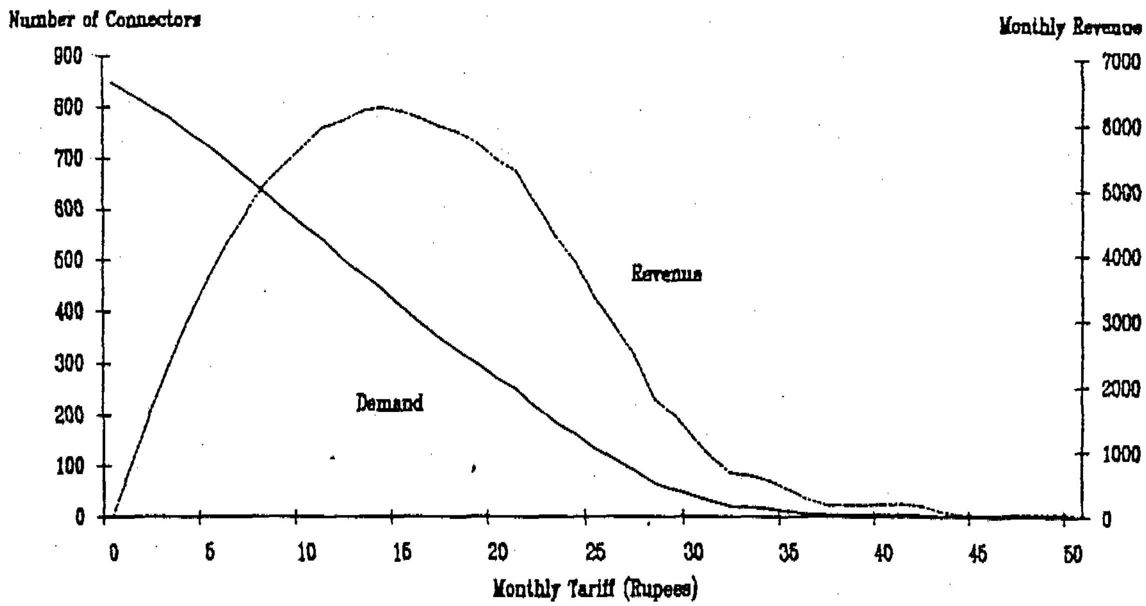

Figure 1. Simulated Demand and Revenue at Each Price Quoted in the Bidding Games, with Connection Cost=100 and No Improvement in the Water Systems, for the sample of 1,129. Derived from Table 8.

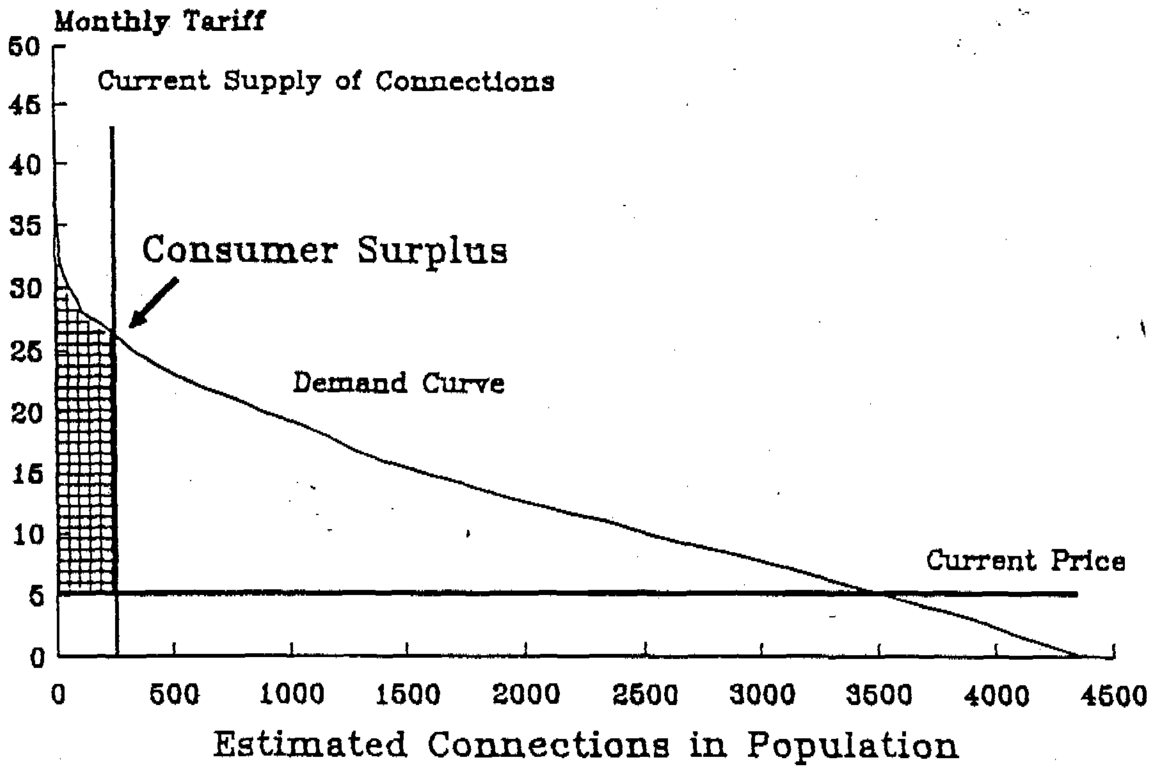

Figure 2. Current Availability of Yard Taps and Its Economic Consequences, Given the Estimated Demand Curve in Figure 1.

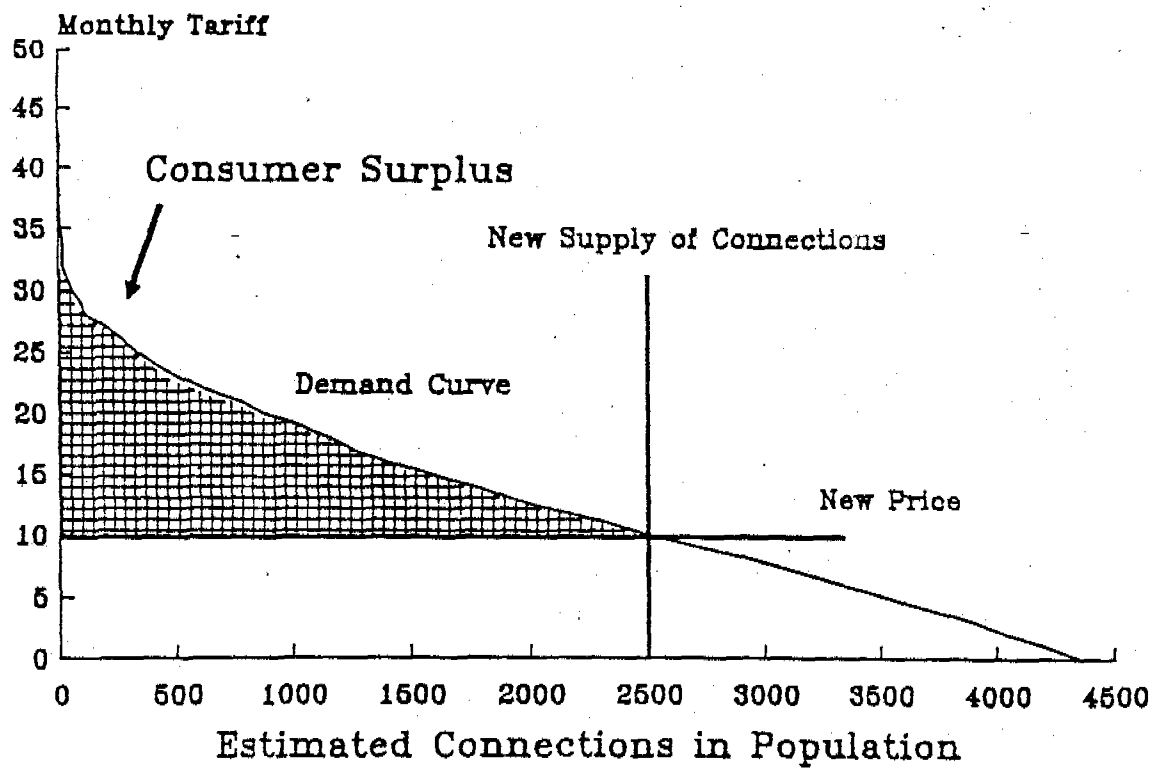

Figure 3. Simulated Change in Welfare with a Higher Price and Unconstrained Connections