Water supply coverage and cost-recovery in Kathmandu: Understanding the role of time preferences and credit constraints

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Abstract

His Majesty's Government of Nepal is planning to lease the operation of water supply services in Kathmandu Valley to the private sector. The objective of privatized water supply is more complete coverage, higher quality service, and cost-recovery. Privatization is controversial precisely because of that cost-recovery objective: higher and regular charges for an essential good such as water may be highly regressive. In particular, the concern is that connection charges (the up-front charge for connecting a household to the water supply system) may fall disproportionately on poor consumers unconnected to the piped water network or the poor will be excluded altogether because the private operator will anticipate affordability constraints and not extend the network to poor areas. The design of water consumption tariffs and targeted connection subsidies offer a set of policy levers to redress this situation. For example, connection charges could be reduced or financed at concessionary rates with cross-subsidization from water consumption tariffs. The effect of alternative charge structures depends on water consumers' time preferences and credit constraints, which are often context- and/or group-specific. This paper reports on the findings of a field experiment that was conducted in Kathmandu in 2001. Using household survey data from an attribute-based choice experiment, we estimate discount rates and examine the impact of credit constraints and financing options on the probability of connecting to the water network, conditional on socio-economic status. Our results show that (a) there is strong support for a plan that would result in improved water services and higher water tariffs, (b) financing connection charges over a 2 year period would significantly improve equity, and (c) discount rates are heterogeneous – the poor and the credit-constrained households having significantly higher rates. We discuss extensions to the current model that could allow us to (a) compare and contrast hyperbolic and exponential discounting, (b) independently identify risk aversion through non-linear utility specifications, and (c) more comprehensively address heterogeneity through random parameter and latent-class modeling. We also discuss how estimated discount rates could be used in policy simulations. Simulations of revenue neutral options to expand coverage show that subsidizing and/or financing connections (compensated by higher monthly water bills) would improve the distributional incidence of privatized water supply.

Introduction: Water supply in Kathmandu Valley

His Majesty's Government of Nepal is planning to lease the operation of water supply services in Kathmandu Valley to the private sector. The objective of privatized water supply is more complete coverage, higher quality service, and cost-recovery. Privatization is controversial precisely because of that cost-recovery objective: higher and regular charges for an essential good such as water may be highly regressive. In particular, the concern is that connection charges (the up-front charge for connecting a household to the water supply system) may fall disproportionately on poor consumers unconnected to the piped water network or the poor will be excluded altogether because the private operator will anticipate affordability constraints and not extend the network to poor areas. The design of water consumption tariffs and targeted connection subsidies offer a set of policy levers to redress this situation. For example, connection charges could be reduced or financed at concessionary rates with cross-subsidization from water consumption tariffs. The effect of alternative charge structures depends on water consumers' time preferences and credit constraints, which are often context- and/or group-specific (e.g., poor have very high discount rates). This paper reports on the findings of a field experiment conducted in Kathmandu in 2001. Using household survey data from an attribute-based choice experiment, we estimate discount rates and examine the impact of credit constraints and financing options on the probability of connecting to the water network, conditional on socio-economic status.

Kathmandu Valley is supplied through seven piped systems fed by 17 springs from surrounding hills and 15 deep tube wells. The National Water Supply Corporation (NWSC) produces about 120 million liters per day during wet season and 80 million liters per day during dry season. It serves about 70 percent of the valley population through approximately 100,000 private connections and 1,300 public taps. The consumers are primarily households (95 percent), with institutions (2 percent), commercial enterprises (2 percent), and industrial firms (1 percent) comprising the remainder. Although about 70 percent of the connections have meters, a significantly smaller percentage is fully functional. Almost all the private water connections (97 percent) are supplied through half-inch pipes.

Unfortunately, the public water supply in Kathmandu is neither sufficient, reliable, nor safe. Most of the city receives water for less than 4 hours per day even in the wet season. A consumer satisfaction survey (SILT-DRC, 1999) reveals that about 50 percent of the NWSC customers felt that the quality of service was "poor," whereas another 15 percent believed that their connection produced practically "no water." Water shortage is blamed on leaking pipes, stealing from the system, and declining well yields. Of the 35 deep tube wells in the NWSC system, only 15 are functional and another four need significant maintenance before they can be operated. These shortages are exacerbated by rapid population growth (4 percent per annum), delays in development and implementation of alternative supplies, below-cost tariffs, and poor collection of monthly water bills.

The quantity concerns are compounded by quality issues. Poor quality and insufficient water impose serious environmental health risks on the population in the valley. Water is mostly contaminated by high concentration of nitrogen-ammonia and fecal coliform: approximately 70 to 80 percent of the tap water samples tested between 1988 and 1992 showed high concentration of fecal coliform during wet season. Halwai (2000), Tiwari (2000), SILT-DRC (1999), and Whittington et al. (2004) present additional details on the poor state of the water supply situation in the Valley.

In summary, it is not hard to see why households in the Kathmandu Valley would want improved water services. The existing system delivers insufficient, unreliable and unsafe water. Perhaps, the only appealing aspect of the existing service from the households' perspective is that at least they do not have to pay much only about $2 per month on average (Pattanayak and Yang, 2002). But even this is somewhat misleading. To combat the drinking water shortage, households engage in a variety of coping behaviors, including collecting water from scarce public sources;

purchasing it from vendors and neighbors; investing in tube wells, storage tanks, and filtration systems; and boiling water before drinking or cooking. These activities impose coping costs on an average household of about 1 percent of current incomes and almost twice as much as the current monthly bills paid to the water utility (Pattanayak et al., 2004). What are not known is how much households would be willing to pay for improved services, how such information can be used to design subsidies to provide piped water to the poor, and what if anything discount rates and credit constraints imply for piped water provision.

Our results show that (a) there is strong support for a plan that would result in improved water services and higher water tariffs, (b) financing connection charges over a 1-2 year period would significantly improve equity, and (c) discount rates are heterogeneous – the 'poor' and credit constrained households having significantly higher rates.

This paper is organized as follows. In the second section of the paper we present a simple model of household water choice under credit constraints and show how it can be used to infer discount rates. The third section describes the fieldwork and sampling strategy. In the fourth section we present the findings of the research, and in the fifth section we offer some concluding remarks.

Model specification: Household choice of water supply

Random utility modeling of household discrete choices provides a framework for calculating discount rates as the ratio of estimated marginal utilities. Hausman's (1979) seminal air conditioner study provides the inspiration for using household choices over consumer durables with differing capital and operating costs to estimate discount rates. Unfortunately, data on actual household choices typically lack statistical variation and/or include alternatives and attributes that are not orthogonal (Hanemann, 1984). Thus, we designed and field experiment in which the piped water service options differed in key attributes to generate data that allow econometric identification of discount rates and evaluation of the impact of financing on use of urban services. Such experiments also referred to as attribute-based choice experiments or 'conjoint models' in the marketing literature.

Consider households who are not currently connected to the urban water supply system, but who might be willing to pay for a connection. We consider two possible types of connections: shared with other households (SH) and private (PR). For both types of connections, households have to pay a connection charge (C) and monthly water bills (M). When presented with the choice among SH, PR, and the status quo (staying unconnected), a household would choose the option that provides the highest utility. We model indirect utility as a linear function of income (y) and the type and cost of possible connections:

$$\nu = \beta(y - C) + \gamma M + \delta_S SH + \delta_P PR \qquad [1]$$

where y = income

C = connection charge in Nepalese Rupees.

M = monthly bill in Nepalese Rupees.

SH = 1 if shared connection

PR = 1 if private connection

Household choices can be modeled as a standard conditional logit:

$$\text{Prob} = \alpha + \beta C + \gamma M + \delta_S SH + \delta_P PR \qquad [2]$$

where y drops out because it is constant across choices, and the parameter $-\beta$ represents the marginal utility of income. If we assume that households consider their expected lifetime income when making this choice, then the marginal disutility of the net present value of M should be equal to the marginal disutility of C.

$$\frac{\partial U}{\partial C} = \frac{\partial U}{\partial NPV[M_\infty]} = \frac{\partial U}{\partial [M/r]} \qquad [3]$$

where r = monthly discount rate.

This implies that

$$\beta = \gamma r \quad \text{and} \quad r = \frac{\beta}{\gamma} \qquad [4]$$

and assumes (a) constant rate exponential discounting, (b) no binding credit constraints on households' ability to pay C, and (c) households' intention to continue paying the monthly water bill once they have connected to the system.

To address concerns that credit constraints may prevent households from connecting, water supply authorities may offer the option of financing the connection charge. For example, in our case, two possibilities are financing the connection charge in 24 installments of (C/20) or in 48 installments of (C/40). The empirical specification becomes

$$\text{Prob} = \alpha + \beta C + \beta_{24} C^{*} D_{24} + \beta_{48} C^{*} D_{48} + \gamma M + \delta_S SH + \delta_P PR \qquad [5]$$

where D_{24} and D_{48} are dummy variables indicating financing over 24 or 48 months.

Given the same assumptions as above, the following relationships should hold:

$$\partial U/\partial C = \partial U/\partial NPV\{C_{24}\} = \partial U/\partial NPV\{C_{48}\} = \partial U/\partial NPV\{M_{\infty}\} \qquad [6]$$

where $NPV\{C_{24}\} = [C/20][(1-(1+r)^{-24})/r]$ and

$$NPV\{C_{48}\} = [C/40][(1-(1+r)^{-48})/r]$$

Note that a 1.513% monthly discount rate should make households indifferent between financing over 24 months ($NPV\{C_{24}\}$) and paying up-front (C). A 0.77% monthly (or 10% annual) rate should make household indifferent between the 48 month financing option and paying up-front. From Eq. 5, we know that

$$\frac{\partial U}{\partial C_{NF}} = \beta$$
$$\frac{\partial U}{\partial C_{24}} = \beta + \beta_{24}$$
$$\frac{\partial U}{\partial C_{48}} = \beta + \beta_{48} \quad [7]$$
$$\frac{\partial U}{\partial M} = \gamma$$

Thus

$$\beta = [\beta + \beta_{24}][20r]/[(1-(1+r)^{-24})] = [\beta + \beta_{48}][40r]/[(1-(1+r)^{-48})] = \gamma r \quad [8]$$

If one or more of the assumptions do not hold, then there may be no one discount rate that solves all of these equalities. We assume that households plan to continue paying their monthly water bill once they have connected (i.e., (c) is a maintained assumption). We consider whether credit constraints influence results by splitting the sample into households who said they could easily obtain a one month loan vs. households who said that they were not sure or that they would have difficulty obtaining a loan. We evaluate the assumption of constant rate exponential discounting by calculating discount rates from equation 4 and from the various equalities embedded in equation 8.

Data collection

We designed and implemented a field experiment to generate data on household choices of piped water alternatives, under different financing scenarios. The survey was administered to 380 households currently unconnected to the water supply network in five municipalities in Kathmandu Valley (see Pattanayak et al., 2001; Whittington et al., 2002; Pattanayak et al., 2004 for more details on the survey). Households were selected using a multi-stage cluster sampling method on the basis of probability proportional to size (Babbie, 1990). The in-person interviews were conducted in Nepali by trained demographers from Tribhuvan University. The survey included an experiment that asked households to choose among two types of connections (and an opt-out option) with monthly consumption charges, one-time connection charge, and financing alternatives as attributes of each connection type. We defined 21 choice sets that had a design efficiency of 92%, and each household was presented with three choice sets. In addition to these questions, we collected extensive data on current options for water supply and levels of use; water storage, treatment and handling; availability of credit and typical interest rates; and socio-demographics, following the protocol described in Grosh and Glewwe (2000). The households in our sample own their homes, are currently not connected to the water system, and believe that they could be connected.

We conducted 17 purposive, open-ended discussions, 2 focus groups, and several pretests to design the survey instrument. Survey respondents were asked about their existing water uses; perceptions of water quality in terms of color, taste, health risk, and reliability; expenditures on piped water; types of coping behaviors; and monetary and labor costs related to the coping activities. Details of the sampling and data collection are presented in Pattanayak et al. (2001).

Model estimation

We estimated a conditional logit model for the 380 households in the five municipalities of Kathmandu Valley (McFadden, 1976). Specifically, the model generates estimates of the marginal disutilities of consumption and connection charges. This rate is significantly higher for the 'poor' sub-population, identified through principal component and cluster analysis of socio-demographics, and among households who state that they cannot obtain credit for an amount roughly equivalent to the connection charges. Only the 48-month option to finance the connection costs (not the 24-month option) increases the estimated probability of connection to the network. Variation in the finance period allows us to consider whether discount rates are constant: we reject this restriction. Credit constraints introduce household specific discontinuities or shadow prices for capital that exceeds the market price.

Table 1. Conditional logit model of household connection choices in field experiment conducted in the Kathmandu Valley of Nepal.

		Coeff.	P-value
M	Monthly consumption charge	-0.00177	0.0000
SH	Shared water connection alternative	0.69654	0.0000
PR	Private water connection alternative	1.47032	0.0000
C	Upfront connection cost	-0.00012	0.0001
CD24	C * Option to pay in 24 installments	0.00002	0.3644
CD48	C * Option to pay in 48 installments	0.00005	0.0199

We also estimated models for sub-samples of poor (207) vs. other households, and credit-constrained (191) vs. other households. (Note that income and other criteria identify the same set of households as poor.) Across the full sample and these partial samples, we find that in general, β and γ are negative and significant, while δ_S and δ_P are positive and significant. β_{24} is not significantly different from zero in any model. β_{48} is positive and significant for all households, poor households, and credit constrained households. It is only significant at the 20% level for households who are not poor and households who are not credit constrained. Collectively, these results suggest that financing for two years (paying off in 24 installments) does not make a significant difference to households' choices about connecting to the water supply system. Four year financing (paying off in 48 installments) is only an important factor for the poor and credit-constrained.

Because β_{24} is not statistically significant, we calculate discount rates with only the following three equations (from equations 4 and 8):

C to M: $\beta = \gamma r$

C to C48: $\beta = [\beta + \beta_{48}][40r]/[(1-(1+r)^{-48})]$

M to C48: $\gamma r = [\beta + \beta_{48}][40r]/[(1-(1+r)^{-48})]$

Table 2. Estimated annual discount rates for four sub-samples from the Kathmandu Valley of Nepal.

	C to M	**C to C48**	**C48 to M**
All	120%	48%	18%
Poor	140%	49%	8%
Not poor	108%	46%	24%
Credit constrained	117%	68%	51%
Not credit constrained	111%	38%	11%

Poor households and credit-constrained households generally have higher discount rates, except that poor households have lower rates for future comparisons (M to C48). Although these differences appear to be statistically significant, we will confirm this finding by conducting Wald tests and bootstrapping to obtain confidence intervals (Greene, 1997). The levels and patterns of these estimated discount rates are consistent with the empirical literature on well within the range of estimates reported in the literature. For example, Hausman (1979) found that rates vary between 5 and 90% (inversely with income) and Poulos and Whittington (2000) found rates between 10 and 20%.

Discussion

There are several possible factors influencing these different discount rates. Consider the following three comparisons:

- **C to M**: This discount rate could reflect credit constraints, enforcement issues, and possibility of disconnecting in the future. All of these could lead households to discount future monthly payments. Note that the estimated discount rate is only slightly lower if we assume that households will pay M for 48 months rather than forever.

- **C to C48**: This discount rate probably reflects a credit constraint, as supported by the large difference between credit-constrained and non-credit-constrained households. The 38% annual discount rate is probably the best estimate of short-term discount rates. This is 2.7% monthly, as compared to the 0.77% monthly rate that should make household indifferent between the 48 month financing option and the up-front charge. The consistently significant parameter on CD_{48} shows that households clearly are not indifferent.
- **C48 to M**: This discount rate may indicate that households apply a very low discount rate between future time periods: that is, there may be declining discount rates or some discontinuity between time zero (now) and the future, in terms of discounting. This is especially true for the poor. Note that the possibility of disconnecting also applies here, which would suggest that this rate is really a maximum.

These results pave the ground for the following kinds of extensions related to model specification and policy simulation. First, these results allow us to compare and contrast hyperbolic and exponential discounting. Second, if we are willing to re-specify utility in non-linear terms, we could identify and measure risk aversion. Third, we can more comprehensively address heterogeneity through random parameter and latent-class modeling. Fourth, recognizing that improved cost recovery is central to plans to expand and improve water supply in Nepal, the estimated parameters can be used in policy simulations. While time preferences are inherent to households, the credit constraint offers a potential policy lever. We can simulate revenue neutral options to expand coverage and consider if subsidizing and/or financing connections (compensated by higher monthly water bills) would improve the distributional incidence of privatized water supply (Pattanayak and Yang, 2002; Foster et al., 2003).

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