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SUSTAINABILITY OF WATER AND SANITATION SYSTEMS

Demand analysis of RWS in Central India

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IN POOR COUNTRIES like India, the Governments often take upon themselves the responsibility of providing safe drinking water to the people inhabiting the rural areas. A supply driven program can become unsustainable in the long run. Using a conditional logit model, this research looks at the demand side. It identifies the determinants of choice and finds that free water is not necessarily the best policy because the capability to pay and willingness to pay already exists.

Safe water has long been recognised as a basic need (e.g., ILO, 1976). While delineating policies for achievement of universal coverage by the year 2000, the New Delhi Declaration called for "some for all, rather than more for some". Coming, as it did, at a time when neoclassical counter-revolution was in ascendance, it is somewhat surprising that an egalitarian declaration, achieved a broad consensus at the Global Consultations.

Inevitably, when policy initiatives emerged out of this declaration, the neoclassical economists of the World Bank and some donor countries found the "welfare state" connotations of the Delhi Declaration disconcerting and criticised these initiatives as the 'first standard paradigm" (World Bank Water Demand Research Team, 1993).

World Bank's criticism of 'free drinking water, however, has had little influence on the rural water supply program in India, in which the foreign aid component is negligible. The biggest water supply program in the world continues to be a supply-driven program (NDWM, 1993). The recognition of demand for drinking water as an economic good has been marginal in policy making especially at the State level.

We propose to analyse the demand for safe drinking water in rural areas of central India — the 'demand' in this case meaning the ability to pay and the willingness to pay - and to see if it has any policy implications.

The model

Choosing a source of water is an economic decision that involves choice among discrete alternatives. Accordingly, for this research, a discrete choice probabilistic model will be appropriate. Since the utility is not directly observable, an indirect utility function will be used.

Conditional indirect utility function of household h:

$$U_{ih} = U_{ih}(X_{ih}, Z_{ih}) \qquad (1)$$

where

i indicates the water source;

h denotes the household;

X is a vector source characteristics; and

Z is a vector of household characteristics .

According to random utility theory, such unobservable or unmeasurable influences are assumed to be captured in a random term, which for operational purposes is usually assumed to be added to the systematic term:

$$U_{ih} = V_{ih} + e_{ih} \qquad (2)$$

where V is the systematic term and e is the random term.

Let the variable y_{jh} indicate household h's choice decision on source j such that:

$$y_{jh} = \begin{cases} 1 \text{ if } V_{jh} + e_{jh} > V_{ih} + e_{ih} \\ \text{for } i, j = 1,...J \text{ and } i \neq j \\ 0 \text{ otherwise} \end{cases} \qquad (3)$$

The expected value of y_{jh} is thus:

$$E(y_{jh}) = P(y_{jh} = 1) \qquad (4)$$

$$= P(U_{jh} > U_{ih}) \qquad (5)$$

$$= P(V_{jh} + e_{jh} > V_{ih} + e_{ih}) \qquad (6)$$

The independent variables in vector X_{jh} vary across sources. The standard statistical method of dealing with them is a logit model. The independent variables in vector Z_{jh} do not vary across sources. The standard approach for them is the polychotomous model.

Our data structure will include both types of independent variables. However, since source characteristics do not influence household characteristics and vice versa, the household's utility function may be assumed to be additive:

$$V_{ih} = BX_{ih} + \alpha_i Z_h \qquad (7)$$

The following conditional logit model can be used to deal with the data structure which includes both groups of independent variables:

$$P_h(j) = \frac{e^{BX_{jh} + \alpha_j Z_h}}{\sum_{i=1}^{J} e^{BX_{ih} + \alpha_i Z_h}} \qquad (8)$$

The estimation procedure for this conditional logit model is essentially the same moor a standard logit model because the household-specific vector Z_h can be transformed into a choice-specific vector. Therefore, the maximum likelihood method will give a consistent estimate of the parameter vector B. The state of the art on this subject is available in Rao, Maddala and Vinod (1993).

Water is classified either as safe or unsafe. UN organisations, viz. UNICEF and WHO, follow this classification and leave it to the individual countries to decide chemical, biological or other characteristics that classify water as safe. In this study, water has been classified as 'safe' or 'unsafe' as per norms of Government of India, i.e., water from hand pumps and piped water supply schemes was considered safe whereas water from dug wells was classified as unsafe. Thus we have three types of water - unsafe water (subscript u), Safe water from public sources (subscript s) and safe water from private yardtap (subscript t). In the habitations without piped water supply, the choice is between the first two types whereas in habitations with piped water supply, the choice is between the last two types.

In case of habitations without piped water supply, the probabilities of a household choosing safe water $P_h(s)$ and choosing unsafe water $P_h(u)$ are given by the following equations:

$$P_h(s) = \frac{e^{BX_{sh}+\alpha_s Z_h}}{e^{BX_{uh}+\alpha_u Z_h} + e^{BX_{sh}+\alpha_s Z_h}} \quad (9)$$

$$P_h(u) = \frac{e^{BX_{uh}+\alpha_u Z_h}}{e^{BX_{uh}+\alpha_u Z_h} + e^{BX_{sh}+\alpha_s Z_h}} \quad (10)$$

$$P_h(s) + P_h(u) = 1 \quad (11)$$

In case of habitations with piped water supply, the probabilities of a household choosing a yardtap Ph(t) and choosing a public standpipe Ph(s) are given by the following equations:

$$P_h(t) = \frac{e^{BX_{th}+\alpha_t Z_h}}{e^{BX_{sh}+\alpha_s Z_h} + e^{BX_{th}+\alpha_t Z_h}} \quad (12)$$

$$P_h(s) = \frac{e^{BX_{sh}+\alpha_s Z_h}}{e^{BX_{sh}+\alpha_s Z_h} + e^{BX_{th}+\alpha_t Z_h}} \quad (13)$$

$$P_h(t) + P_h(s) = 1 \quad (14)$$

The two sets of equations being used allow a ready interpretation of the selection probabilities in terms of the relative representative utilities of alternatives and are relatively amenable to computation.

As the contingent valuation method suffers from various biases, viz. (1) Hypothetical bias due to the hypothetical nature of the question; (2) Strategic bias because the respondent may perceive an opportunity to manipulate the outcome; (3) Compliance bias because the respondent attempts to anticipate responses the interviewer wants; and (4) Starting point bias with bids being influenced by interviewer's suggestions; the revealed preference method has been used in this research. The dependent variable is the choice variable.

Interpretation of regression results

Maximum likelihood estimation of the conditional logit model can be shown under very general conditions to provide estimators that are asymptotically efficient and normally distributed. Examples suggest that the approximation is reasonably good, even in small samples. When independent variables are highly correlated, their matrix becomes singular and the results explode. The problem of selection of independent variables in logit models is more acute than in linear regression. The selection has to be on the basis of economic theory and intuition rather than a computer dictated algorithm where forward or backward selection depends on Wald statistic or change in likelihood ratio. A large number of regressions with different variables were tried to reach the final results.

Through successive regressions of conditional logit model in case of habitations without piped water supply, we conclude (Table 1) that the determinants of the choice of safe water are as follows:

- Distance of the source from home is highly significant with a negative sign. Lesser the difference between the distance from home to the safe source and that from home to the unsafe source, higher the probability of choosing safe water.
- The proportion of women in the household is a significant factor in choosing a safe source.A household with a higher proportion of women among its members has a higher capability of hauling water from larger distance.
- The proportion of ado men in the household and their educational level are not significant.
- Household size is not a significant factor. Though bigger households need more water, they also have more person-hours available for hauling water and it appears that the two effects cancel out.

In case of habitations with piped water supply we conclude (Table 2) that the determinants of choosing private household connection (yardtap) are as follows:

- Price of water has a negative effect on the choice variable. Higher the price, lower is the probability of households opting for private connection.
- Income has a positive effect on choice of yardtap. In other words, economically better off households prefer private connection whereas poorer households make do with public standposts.
- Household size has a positive effect on the choice variable. Controlling for other household characteristics, bigger households prefer to pay for a yardtap rather than obtaining free water from a public standpipe. This could be due to the fact that in absence of metering, the tariff for yardtap is the same and the bigger households can get more water for their money.
- Households with higher proportion of men prefer a yardtap, whereas households with higher proportion of women prefer to spend time at the public standposts.

This could be so due to the fact that hauling water is mainly women's work.

- Neither the educational level of women nor of men is significant. This could be due to the fact that Fe choice is between two sources of safe water and therefore it is the economic status rather than educational level that determines the choice.

If the value of time is defined as marginal rate of substitution between the time spent in collecting the water and the money paid for the water it can be calculated from two of the estimated parameters as mentioned in equation below:

$$\text{Value of time} = \frac{B_\tau}{B_\pi} \quad (15)$$

where B_τ is coefficient for time and B_π is coefficient for price.

We use maximum likelihood parameter estimates from the regression of the yardtap decision model (Table 2) for this purpose.

Value of time in terms of money = Rupees 9.93 per day (1 U.S.$ = Rupees 31.37 and 1 £ = Rupees 50 in 1994).

By dividing the sample into two parts on the basis of median income and following similar procedure, we find that the value of time for the households above the median income is Rupees 12.71 per day, whereas that for the households up to the median income is Rupees 7.28 per day.

The minimum wage rate for unskilled labour in the study area as fixed by the Labour Commissioner is Rupees 28 per day. Because of problems of implementation, it could be assumed that the going market rate would be as little less than that. Our study finds that on the average people value time savings resulting from improved access at Rs 10 per day which is a little less than half the market wage rate for unskilled labour in the local economy. Willingness to pay is significant.

Conclusion

This study reveals that perception of health benefits by the people is significant and they are prepared to spend significantly higher amount of time in collection of safe water as {suf d try Unsafe water. The general assumption that people are either unwilling or unable to pay for water is incorrect.

Due to lack of clear thinking relating to demand and user charges, a perverse tariff system exists in most third world cities. In almost all poor countries, there is an element of subsidy in urban water supply, that goes mainly, albeit unintentionally, to the rich (Briscoe, 1992). This scenario could also occur in rural water supply when the program expands unless sufficient attention is paid to demand analysis.

There is a need to reconsider the policy of "some for all, rather than more for some" called for by the New Delhi declaration and adopted by the UN General Assembly as "strategy for the 1990's". Rather than trying to provide a free or heavily subsidised minimum service to all system, the policy makers need to consider an improved service to all and higher level of service to those who are willing to pay more.

References

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Table 1. Maximum likelihood parameter estimates of safe water decision model
(Dependent variable is choice of source Safe = 1, Unsafe = 0)

Independent variable	*Final regression*	
Time extra in hours per day	–0.60*	(0.12)
Proportion of women in household	7.07*	(1.61)
Proportion of men in household	–0.77	(1.50)
Female educational level	0.36*	(0.08)
Household educational level	–	
Income per capita in Rupees per day	–	
Intercept	0.18	(0.95)

Table 2. Maximum likelihood parameter estimates of yardtap decision model
(Dependent variable is choice of source Yardtap = 1, Public standpipe = 0)

Independent variable	*Final regression*	
Price in Rupees per day	–8.53	(1.29)
Time extra in hours per day	–9.69*	(1.20)
Household size	–	
Women as proportion of household size	–2.81*	(1.73)
Men as proportion of household size	7.34*	(2.23)
Female educational level	–	
Household education level	–	
Income per capita in Rupees per day	0.53*	(0.08)
Intercept	–9.22	(1.79)

Note: Standard errors in parentheses. Number of observations for each regression is 245.

* Wald statistic significant at 1% level.

** Significant at 5% level.

*** Significant at 10% level.