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Consumer Preferences for Water Supply?

An Application of Choice Models to Urban India

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Abstract

This paper examines consumer preferences for the attributes of alternative sources of water supply in Chennai, based on a household survey where respondents were given the description of a set of options. Their decision to choose one of the options is examined using discrete choice models. Whether consumer preferences are hierarchical or lexicographic is also briefly examined. Access to a yard tap is considered to be a more important attribute than water quantity, quality and the provider (the private sector or public sector). In general, the estimated willingness to pay is substantially higher than the present monthly water expenditures. However, some consumers, specially those living in the peri-urban areas, do not seem to be willing to pay for water supply improvements. Among the plausible reasons are a lack of trust in the public utility or a manifestation of the equity politics in India (the peri-urban households claiming their entitlement to subsidized water), or the presence of preference reversal.

Keywords: water supply, consumer preferences, discrete choice, lexicographic preferences

JEL classification: C25, D12, L95, Q25, R22

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1 Introduction

Should water supply planners in cities worry about consumer preferences? Is it necessary to consult with the consumers? Aren't policy priorities blindingly obvious? Just bring more water to such cities and everyone will benefit[1] and they would be willing to pay. Won't they?

This paper aims to examine some issues in relation to household preferences for different attributes of water supply. Investments to improve water supply can take a number of routes. For example, spending may be targeted to increase the quantity of water; or while the quantity is maintained at the same level, investments may be made to improve the quality of water; or the consumer may be required to use rainwater harvesting and other conservation techniques; and so on. Hence, from the water planner's point of view, there may be some merit in knowing consumer preferences for the various attributes and whether consumers are willing to consider changes in one attribute by compensating increases or decreases in other attributes. Consumers can be consulted in a number of ways and one such approach is to use a survey.[2]

Against this background, this paper reports an exploration into the use of choice models with an empirical study based on a survey of 148 respondents in Chennai (formerly known as Madras). It attempts to draw some inferences about consumer preferences for various attributes of water supply, ordering, if any, of these preferences, and aspects of consumer willingness to pay. Section 2 gives a brief review of the relevant literature; section 3 gives a summary of the theoretical framework. The details of the options used in the Chennai survey and the values of various attributes are discussed in section 4; the responses are analysed in section 5 using multinomial logit models. The issue of hierarchical preferences and some estimates of willingness to pay and a discussion on this are also included in this section. In section 6, conclusions and some issues for further research are presented.

2 Consumer preferences for water supply: A brief review of literature

In recent years, a number of studies have explored the demand for water supply using household surveys and the contingent valuation method (CVM) (for example, the World Bank Water Demand Research Team 1993; Singh *et al.* 1993; Altaf *et al.* 1993; and Griffin *et al.* 1995). Also, Blore (1996) and Whittington (1998) may be referred to for a discussion on issues in relation to administering CVM surveys in the developing

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1 The following paragraph from the World Bank (1995: 24) staff appraisal report of Second Chennai Water Supply Project sums up this belief: 'The project will benefit all consumers directly and indirectly … The poor will benefit particularly since they suffer most from the adverse impacts of health and inconvenience due to inadequate water supply at present … Thus, although benefits of the project will be widely distributed in Chennai, there will be particular benefits to the poor … .'

2 Other options include: analysing the number of complaints that are reported by consumers; consulting with selected representatives of different user groups through stake holder meetings; issuing 'citizen's charters'; creating an ombudsman to whom complaints can be made and so on. On the citizen's charter approach in Britain see Greenaway (1995); Meehan (1998). For a discussion on ombudsman approach see Steiber (2000). Paul (1992 and 1994) attempted to use surveys to seek consumer ratings for various services. For a critique of this, see Jenkins and Goetz (1999). Yet another alternative is to use citizens' jury. See for example, Aldred and Jacobs (2000).

countries. While the use of CVM was increasing in the developing world, in the Northern countries, CVM has come under criticism (for example, Hausman 1993; Kahneman and Knetsch 1992, McFadden 1994; O'Connor and Spash 1999). In this context, some authors in these countries have used an alternative approach referred to as choice modelling or choice methods. In such studies, the respondent is presented with a number of options and is requested to choose one of these options. The respondent compares the options in terms of her/his utility and chooses the option that maximizes the utility. According to the random utility maximization approach, this utility function contains two parts, the observable or deterministic part and the random part (Ben-Akiva and Lerman 1985; McFadden 2000). The observable part of the utility function is assumed to be a function of the values of the attributes of the option. By making appropriate assumptions about the random component, the decision can be modelled as a discrete choice situation with multinomial logit or probit models (explained in section 3).

Adamowicz (1995: 151) and Louviere (1996) feel that as compared to CVM where the focus is on willingness to pay, the choice methods allow the researcher to pose to the respondent a number of constructs to understand the influence of variations in the levels of attributes on their choice. Others have attempted to compare the choice methods with CVM and argued that the former are favourable on procedural and methodological grounds (for example, Morrison *et al.* 1996, Stevens *et al.* 2000). According to Hanley *et al.* (1998: 416), choice modelling makes it ' … easier to estimate the value of the individual attributes that make up an environmental good … This is important since many management decisions are concerned with changing attribute levels'. Further, they feel that choice methods enable the researcher to arrive at the marginal values of attributes which ' … may be difficult to identify using revealed preference data because of co-linearity or lack of variation'. Some inferences can also be drawn about hierarchical or lexicographic preferences.[3]

At the time when the field work for this research was being designed (in 1996), very few studies were reported in the literature on the use of choice methods for water supply issues in the developing countries.[4] A widely cited study of applying choice modelling to developing countries is that of Mu *et al.* (1990) on village water demand. They examined households' source choice decision, based on a sample of 69 households in Ukunda, Kenya. In this study, households could choose from three sources, namely, a

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[3] In consumer demand theory, the decision process is 'compensatory' in that a shortfall with respect to one attribute can be compensated by higher values of other attributes (for example, rationed water supply but of treated water, versus unlimited water supply, but untreated water and hence, requiring some purification). An alternative is to approach the decision rule as being 'non-compensatory'. Two widely known models of this kind are lexicographic rules and elimination by aspects rules (Engel *et al.* 1995: 222-5; Ben-Akiva and Lerman 1985: 35-7). Preferences are called lexicographic when consumers ' … give absolute priority to one commodity over all others and therefore, imply a strict ordering, as in a lexicon' (Spash 2000: 198).

[4] Even today, the situation has not changed substantially. A key word search on Social Science Citation Index (SSCI) with the key words 'discrete choice AND water' produced 14 hits. Only one of these (Kamuanga *et al.* 2001) related to developing countries, but using a contingent valuation survey and not choice modelling. Another search with the key words 'random utility AND water' produced 16 hits. Not one of them was on developing countries. There is a possibility that choice model studies are conducted but not published in sources covered by the SSCI or catalogues with different key words. However, the general conclusion that there is little in the literature on applying choice methods in the developing countries, remains valid.

vendor, a well or a kiosk. The attributes used were: price, time spent at the source, respondent's perception of taste of water from the three sources (bad or good). The authors mentioned that due to their small sample, they were unable to model simultaneity between quantity demanded and source choice and hence, they '… assumed that a household chooses a water source independently of the quantity of water they intend to use' (1990: 526). The independent variables include the attributes mentioned above and three respondent characteristics, namely, income, the number of women in the household and the years of education (using alternative specific constants). From the results they conclude that 'the time it takes for a household to collect water from a particular source and the number of women in a household significantly affect a household's decision on which source of water to use, while income appears to be relatively unimportant' (1990: 528).

In another study of water source choice in Faisalabad, Pakistan, Madanat and Humplick (1993) used ' ... a system of inter-related models to represent the different decisions made by a household in response to pipe water deficiency'. Thus, households have different decisions to make: a connection decision; a storage decision; and a source choice decision for usage 1, for usage 2 and so on (i.e., whether to use the water source for a given function, such as, cooking, bathing, washing etc.). In their study, the ' … lower-level decisions are conditional on the predicted choices of higher-level models … [;] … feedback in the form of composite variables from the lower-level models is included in higher-level models'. They used a sequential maximum likelihood approach. Though they recognize that such an approach yields parameters that are consistent but not efficient, they ignore the alternative of a full information maximum likelihood (such as a nested multinomial logit model) on the grounds that ' ... such an exercise would be extremely time consuming'. In my view, linking a source of water with a specific purpose is restrictive. It assumes that the respondents do not have the flexibility to use water from a given source for a number of purposes, specially because of the economies of scale relating to the capital costs.[5] Further, though they have used a hierarchy of decisions, they did not explore whether the underlying preferences are hierarchical or lexicographic.

In a recent study of assessing environmental values associated with water supply options in the Australian Capital Territory, the Centre for International Economics (CIE 1997) used the choice modelling approach to analyse the trade-off between different features (attributes) of various water supply options.[6] Using the discrete choice models, they examined the relative valuations (marginal rates of substitution) between different attributes. According to this study, the impact on the flows in rivers was considered by the households to be the most important attribute (p.119). Other attributes (in that order of relative importance) were the household cost of water, the quantity of water (or the level of restrictions), the protection of species, and the impact on the appearance of the urban area. The impact on the quality of water came out as the least significant attribute.

5 For example, from an environmental conservation point of view, it would be ideal if people could recycle sullage (bathwater) and use it for flushing purposes. The marginal cost of such recycled water is not zero but in many cases higher than the marginal cost of fresh water, mainly because of the capital costs of installing a separate plumbing system to make such recycling possible.

6 Also see Blamey *et al.* (1999a).

Choice modelling has been applied mainly in the context of recreational values of using water[7] (for example, for fishing purposes). Since my interest is on domestic water supply, those studies are not considered here. Against this background, the research reported in the present paper was designed to consider the following issues:

i) Exploring whether choice methods could be used to gain information about preferences of urban households;

ii) In that, using a universal choice set of upto six options; in addition to attributes conventionally used in water supply studies (such as quantity and quality), include attributes to reflect access, the nature of provider (public or private sector) and environmental values (whether an option requires action by respondents to conserve water and recycle some of it);

iii) Exploring whether the number of options available to a consumer has any influence on the decision process; and

iv) Exploring whether there is any indication of consumers considering these options in a hierarchical or lexicographic manner.

3 The theoretical framework

3.1 Modelling consumer choice

The starting point is that of *a consumer choosing the best things that she can afford* (Varian 1996: 33; emphasis added). The consumer is assumed to have well behaved preferences (i.e., preferences are complete, reflexive and transitive) and utility function (see Johansson 1987). Such a consumer is able to compare rank alternative commodity bundles. In relation to a particular commodity, the various options available are contained in the universal choice set *C*. A consumer *i* may consider all (or only a sub-set of) these options and either choose one of those options or choose none of them. Following the random utility theory, the individual *i*'s utility function has the form:

$$U_{ij} = U(Z_{ij}, S_i) \tag{1}$$

where Z_{ij} is the vector of the attributes[8] of option *j* available to this individual *i* and S_i is the vector of his/her socioeconomic characteristics. However, this utility function cannot be observed by the researcher. In turn, it is assumed to contain a deterministic

7 Two studies on domestic water supply may be mentioned. In Vossler *et al.* (1998), households who pay for water on a flat rate were presented with an offer to have water meters installed for free but with hypothetical monthly charges. They used conditional logit models to analyse the responses. Hewitt and Hanemann (1995) re-visit an earlier study and this time analyse the data with a discrete/continuous choice model and compare the results with the earlier results of water demand estimated by regression models. They find that the price-elasticity in the choice model was much higher.

8 Blamey *et al.* (1999b) and Blamey *et al.* (2000) discuss the scope for labelling i.e., giving each alternative a specific name or including such information as a generic attribute.

part (V) that can be observed by the researcher and a random component, which is unobservable. Thus,

$$U_{ij} = V(Z_{ij}, S_i) + \varepsilon_{ij} \tag{2}$$

In the context of choice modelling, the water planner could use the above framework to present details of the various alternatives to a sample of respondents and collect information on which of these options is chosen. Following Ben-Akiva and Lerman (1985: 31-2), the respondent's decision process involves five steps, namely: (i) definition of the choice problem; (ii) generation of alternatives; (iii) evaluation of attributes of the alternative; (iv) choice; (v) implementation. The probability that individual i will choose option j among n options (from a choice set C) is:

$$\Pr ob(j \mid C) = \Pr ob\{V_{ij} + \varepsilon_{ij} > V_{in} + \varepsilon_{in}, all(n \neq j) \in C\} \tag{3}$$

By making appropriate assumptions about the error terms, the above can be rewritten so that the probability of choosing an alternative is a function of Z_{ij} and S_i. Other than income, all socioeconomic characteristics of this individual are unchanged when the individual is considering various options. Following Hanemann (1984), in comparing the two utilities, the individual should be indifferent between two options if:

$$V_{ij}(Z_{ij}, m_i - C_{ij}) = V_{in}(Z_{in}, m_i - C_{in}) \tag{4}$$

where income (m) is assumed to be the sole individual characteristic; Z_{ij} represents a vector of attributes relating to the good in question; C is the cost involved in acquiring the option (j or n). Because the individual's preferences and utilities are well behaved, the rational respondent is able to arrange and rank commodity bundles and choose that bundle which gives him/her maximum utility. By making assumptions about the random component, the probability of the consumer choosing an option can be expressed as a function of attributes of the option (including the cost). If the error terms are assumed to be (i) independently distributed; (ii) identically distributed; and (iii) following McFadden (1984), each of the error terms is assumed to be Gumbel (or type-1 extreme value) distributed,[9] then a logit model can be used:

$$\log(P_{ij} / (1 - P_{ij})) = \beta' Z_{ij} \tag{5}$$

The left hand side is the log of the odds that a particular choice is made. The RHS is a linear function of attributes. Maddala (1983: 34-7) elaborates how this method can be applied in the case of polychotomous choice (i.e., more than two options).

If the error terms are assumed to be multivariate normal distributed, then multinomial probit models can be used. However, evaluation of multinomial probit regressions

9 Domencich and McFadden (1975: 56-65) discuss various alternative specifications. Also see Maddala (1983: chapter 2 and also chapters 3 and 5); Ben-Akiva and Lerman (1985: chapters 3, 4, and 5). McFadden (1984: 1411) classifies models into three families: probit models (binomial and multinomial); logit models (binomial, multinomial and generalized extreme value-GEV); elimination models (hierarchical elimination by aspects-HEBA). Models under both GEV type logit models and HEBA models, are referred to as nested multinomial logit (NMNL) models.

involves evaluating several integrals. McFadden (1984: 1420) and Maddala (1983: 63) suggest that this computation burden is an impediment to using probit models.

3.2 Considering the issues of hierarchical or lexicographic preferences

In the above discussion, we assumed that the consumer has well behaved preferences (i.e., preferences are complete, reflexive and transitive). In comparing different commodity bundles, such a consumer is expected to use a compensatory mechanism to make the commodity bundles with different magnitudes of individual goods comparable. However, Lockwood (1997: 85) points out that ' … a person with noncompensatory preferences can produce a value ranking of the alternatives such that one can be said to be better than another, but is unwilling to make tradeoffs between the alternatives'. If consumers use a lexicographic rule, they may rank goods on the most important attribute and then on the second most important attribute and so on. Such consumers may consider different dimensions of the good differently (and hence attributes are non-continuous) and they may not be willing to trade-off one attribute for another (also see chapter 8 of Broome 1999).

There is scope to explore non-compensatory behaviour using elimination by aspects (EBA) and hierarchical[10] elimination by aspects (HEBA) models (Maddala 1983: 64-70). EBA models are similar to lexicographic models where ordering of relevant aspects (attributes) is specified *a priori*. Though EBA model is consistent with random utility maximization, Maddala points out that if there are *n* aspects, the number of subsets that one must consider is ($2^n – 2$) which can be very large as *n* increases. HEBA has been proposed where the alternatives are represented by a tree diagram. In HEBA, the respondent's decision to choose an option is seen as an indication of which attributes are considered to be more important than other attributes. In making the decision, the respondent selects a link from the tree and all other alternatives that do not include that link are eliminated (Maddala 1983: 66). Within the random utility maximization approach discussed earlier, nested multinomial logit models (NMNL) are used to represent HEBA process. McFadden (1978) used such a model to examine housing characteristics. McFadden (1984) and Ben-Akiva and Lerman (1985) compare an NMNL model with a multinomial logit (MNL) model (which is a special case of NMNL, where there is only one branch) to explore whether respondents consider some attributes to be more important than others.

The use of random utility maximization approach to explore hierarchical or lexicographic preferences could attract criticism. First, consumers are likely to have lexicographic preferences ' ... when a good is essential[11] or has a moral or other irreducible form of value' (Spash 2000: 201). Lockwood (1997 and 1998) argues that compensatory rule based methods (as in the MNL models) can only handle exchange values. To some extent, this criticism applies to NMNL models as well because within a given branch, attributes are considered to be tradable. He suggests an integrated value

[10] van den Bergh *et al.* (2000: 52) suggest a link with Maslow's theory of hierarchy of needs.

[11] Johansson (1987: 46) briefly discusses the question of essentiality of goods in relation to whether a consumer surplus measure can be infinitely large. He points out that ' … the assumption of non-essentiality is both necessary and sufficient in order for the compensated surplus measures to be finite'. Non-essentiality assumption means that goods are substitutable.

assessment method to incorporate value expressions of exchange with those of noncompensatory and weakly comparable modes of value expression. Second, while lexicographic preferences may be indicating a non-consequence motivation, bringing them into the utility maximization framework tantamounts to ignoring this and assuming that consumers are motivated purely by consequences alone.[12] A third criticism relates to how attributes are considered. In some cases, certain attributes may be relevant only if certain other attribute takes a relevant value. This case of causally-prior attributes has received some attention (see Blamey *et al.* 1998). However, another important aspect that has not received much attention is the absence of information about some attributes. In the case of what may be called 'experiential attributes', a consumer cannot know the values that a very relevant attribute (for example, the taste in the case of a food product) takes until after making a decision to consume. In such cases, the consumer may use the values of other surrogate attributes (brand name, freshness date, country of origin, condition of packaging, etc.) to make the (first time) purchase decision. The model of consumer[13] in marketing studies provides scope for exploring such issues by including 'post-purchase evaluation' and 'divestment' as stages in the purchase process (and therefore, equally worthy of marketing manager's attention). In the RUM based models discussed above, the consumer is assumed to have full information on all relevant attributes (and the random error represents any gaps) and the decision process does not include feedback possibility.[14] Thus, I recognize that even as choice modelling approaches can contribute to some improvement in understanding the consumer decision process, they suffer from many philosophical and procedural criticisms as well.

4 Options and attributes: details from the Chennai survey

The empirical work for this paper focuses on Chennai which has been facing water supply shortages for over three decades now.[15] Chennai is located in a region that is not comprised in any major river basin. Also, it lies outside the usual path of the south-west monsoon making summer a prolonged affair until the rains arrive in late-September or early October. The statistic of Chennai being the metropolitan city with the lowest per capita quantity of water supplied has been mentioned very often.[16] In recent months,

12 van den Bergh *et al.* (2000: 51) very briefly allude to the *teleological* versus *deontological* approaches.

13 See, for instance, Engel *et al.* (1995: 134 and also chapter 8) therein.

14 Manski (1999) discusses some issues relating to choice expectations in incomplete scenarios. Also see McFadden (1999) who argues that ' … both theoretical and empirical study of economic behaviour would benefit from closer attention to how perceptions are formed and how they influence decision-making'. The concept of procedural rationality proposed by Simon can be incorporated to overcome the assumption about information.

15 An analysis of water supply issues in Chennai is discussed in Anand (2001a).

16 For instance, the World Bank (1986: 3) stated, 'Madras city remains the lowest supplied metropolitan area in India with an average 78 lpcd … The corresponding figures for other cities are Bombay 253, Delhi 220, Calcutta 190 and Bangalore 125 lpcd'. A decade later, in CMDA (1995: 94-5) a similar statement is made. The figures used this time were Madras (70 lpcd) with Bangalore (90 lpcd), Bombay (150 lpcd), Calcutta (190 lpcd), Delhi (160 lpcd) and Pune (275 lpcd). A similar statement is also found in the World Bank (1995: 2).

water from distant sources was being transported to Chennai by special trains and on road by tanker trucks to meet with shortage[17] even as a large project to supply water from the river Krishna from the neighbouring state of Andhra Pradesh is progressing.

Against this background, a survey of 148 respondents in Chennai was undertaken during June-October 1996. Details of the survey design are summarized in Appendix 1. At the outset, it needs to be pointed out that the sample size of 148 responses has its own limitations in exploring choice processes using multinomial logit models where bigger sample would be an advantage, specially in relation to the iterations converging towards a solution. To this extent, the results discussed here should be seen as exploratory.

4.1 Options and attributes

In the absence of prior information about parameters of attributes, exogenous sampling approach is used in this research.[18] Based on an assessment of the water supply situation in Chennai, seven options were developed using different combinations of some of the attributes of interest. For example, a policymaker or planner may be interested to know the following:

i) *Yard tap or shared tap*: whether water supply improvements should aim to give yard-tap connections to all households.

ii) *Quantity and quality*: whether investments should be directed to increase the quantity or to improve the quality while maintaining the present levels of quantity supplied;

iii) *Public sector or private sector*: whether consumers prefer water supply provision by a government agency or whether they are ambivalent as to who provides the service; and

iv) *Incur costs to conserve*: whether consumers have preferences for conservation and recycling aspects and whether consumers support a policy that requires them to engage in water harvesting and using recycled water for non-drinking purposes.[19]

Based on the various issues identified during the preparatory stage, seven options were developed for use in this study. A brief description of these options is given in Table 1.

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[17] See news items dated 5 August 2001 and 26 August 2001 in *The Hindu*, available at www.hinduonnet.com/ .

[18] There are two ways to implement a choice modelling approach: exogenous sampling and choice-based sampling. In ' … exogenous sampling the analyst selects decision makers and observes their choices, while in choice-based sampling the analyst selects the alternatives and observes decision makers choosing them' (Manski and McFadden 1981: 7). The latter requires some *a priori* information on parameters.

[19] Relevant in the light of recent thrust in Chennai, as the state government has made rain water harvesting a priority. Town planning regulations are being revised to make rain water harvesting compulsory in large buildings.

The attributes of interest are: monthly charge for the household (CHARGE); quantity[20] of water to be supplied (QUANT); whether such water is treated to meet with standards or not (WQUAL); whether it will be delivered via a yard tap (YARDTAP); and whether it will require the connection to be shared among designated households (SHARED); whether it will be delivered by private sector (PRIVATE); and whether an option requires the household to engage in rainwater harvesting and recycling of sullage (ENVIRON). The first two are ordinal variables while the others are binary variables. The values of the various attributes (other than CHARGE) of these seven options are shown in Table 2.

The option to choose 'none' was not included in the description. However, during the interview respondents were told that they have the option to choose none of the options.[21] The universal choice set, thus, has eight options in all. All the attributes in the 'none' option are coded as zeroes.

Table 1
Description of the seven options for water supply in Chennai survey

Name of the option	Description
IH1 and IH2	These options provide for yard-tap connections to supply treated water by the public sector provider. (IH-1 for residents in Chennai City and IH-2 for those in peripheral areas. It was necessary to make this distinction as the master plan for water supply in Chennai is based on providing 150 lpcd for citizens of Chennai city and 50 lpcd for citizens of adjoining urban areas.)
PP	This option provides a yard-tap connection from a network of water mains to be provided by a private sector firm who has been awarded a franchise from the public sector provider, supplying treated water.
OH1 and OH2	These two options are very similar to the IH options (i.e., same amount of treated water, to be supplied by public sector provider) with the only difference that ownership is to be shared among five designated households (i.e., a communal source but not an open access resource as in the case of a stand post).
ENV	This is an 'environment-friendly' conservation option that requires the respondent to indulge in rainwater harvesting and recycling of sullage for flushing purpose.
TS	In this option, consumers will get a supply of water by private tanker trucks (TS). This not treated water. The consumer is required to make arrangements to collect water from the tanker truck in the street and to store it.

[20] The quantity here is not the quantity demanded by the consumer but the quantity that they will get if they choose an option. For simplicity, I have used the notation quantity to refer to the 'quantity of water to be given by the option in litres per capita per day'. For example, think of a consumer choosing a breakfast cereal in the super market. The weight displayed on the cereal box enables the consumer to compare different options and calculate unit prices and so on. The quantity variable here has a similar function.

[21] Though water is essential, when a respondent chooses 'none', they are not saying that they do not need any water, but only that they would prefer the status quo to the options offered in the survey. In Anand (2001a), I have reported that respondents rely on more than one source of water. Those who do not have any source of water in the premises, collect water from static tanks or public stand posts and deep tube wells (called India Mark-2 pumps) and some times from generous neighbours who allow others to collect water from their well.

For the respondent, each option was available at a monthly user charge (CHARGE). However, the capital costs of obtaining a connection (for those who do not have this facility) were not included. For the ENV option, participants were told that the capital cost of installing a rainwater harvesting system would be amortized and converted into a monthly instalment (and treated as the monthly charge). The charges used in the interviews were randomly selected from a range covering Rs 1 to Rs 350 (i.e., up to nearly twelve times the then prevailing monthly tariff of Rs 30 for unmetered connections). The frequency distribution of monthly charges used in the survey is shown in Table 3.

Table 2
Values of various attributes for the seven options in the Chennai survey

Attributes	IH-1	IH-2	PP	OH-1	OH-2	ENV	TS
YARDTAP Convenience of yard-tap connection (1=yes; 0=no)	1	1	1	0	0	0	0
QUANT Quantity of water in litres per capita per day (lpcd)	150	50	150	150	50	30% saving [1]	150
WQUAL Quality of water: Treated water=1; otherwise=0	1	1	1	1	1	0	0
PRIVATE Private sector=1; otherwise=0	0	0	1	0	0	0	1
ENVIRON Whether a commitment to conservation needed (yes=1; no=0)	0	0	0	0	0	1	0
SHARED Connection to be shared with others (no=0; yes=1)	0	0	0	1	1	0	0

Note: [1] Based on current consumption levels, this is equivalent to 30% of 88 litres per capita per day or 26.4 litres per capita per day.

Table 3
Price ranges used for each option

Price range (Rs)	IH1	IH2	PP	OH1	OH2	TS	ENV
0-30	2	0	0	1	1	0	0
31-60	3	6	1	12	8	0	6
61-90	11	8	2	10	3	0	3
91-120	24	11	7	2	0	0	11
121-150	17	6	13	1	1	0	14
151-180	6	2	7	0	0	0	7
181-210	19	2	4	0	0	122	18
211-240	2	1	2	0	0	0	5
241-270	3	1	2	0	0	0	5
271-300	7	0	1	0	0	0	3
301-350	0	1	0	0	0	0	1
N	94	38	39	26	13	122	73
Mean	153	122	153	65	58	210	168
Standard Deviation	66	63	48	22	25	0	64

4.2 Choice sets used in the survey

While the universal set has eight options, the maximum number of options that a respondent could be offered is six (see Figure 1). This is because IH1 and OH1 could be offered only to citizens of Chennai city and IH2 and OH2 could be offered to citizens of the rest of the Chennai metropolitan area (CMA).

Figure 1
Options for respondents in Chennai city and those in the rest of CMA

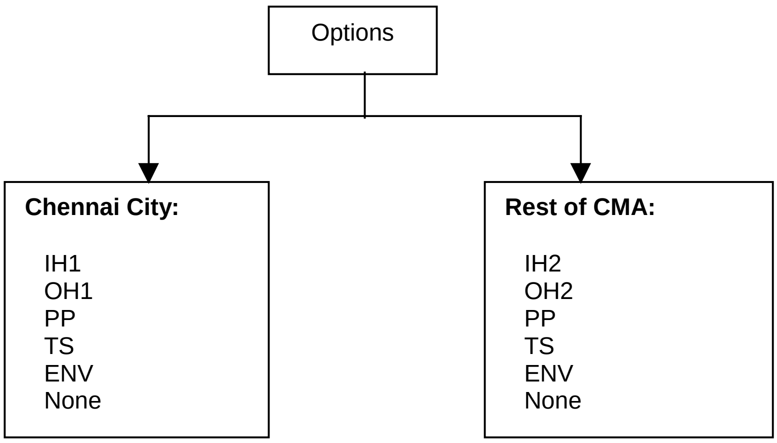

Table 4
Respondents per the choice sets used in the Chennai survey

No. of options [1]	No. of respondents receiving the choice set: Chennai city		Rest of CMA		Total sample
2	IH1 + TS	18	IH2 + TS	6	
	IH1 + OH1	5	IH2 + OH2	2	
	OH1 + TS	1	OH2 + TS	1	
	PP + TS	10			
	IH1 + PP	2	IH2 + PP	1	
	Subtotal	36		10	46 (31.1%)
3	IH1 + TS + ENV	45	IH2 + TS + ENV	19	
	IH1 + OH1 + TS	6			
	IH1 + PP + TS	5			
	IH1 + PP + OH1	6	IH2 + PP + OH2	10	
	PP + OH1 + TS	2			
	PP + TS + ENV	2			
	Subtotal	66		29	95 (64.2%)
4	IH1 + TS + ENV + OH1	6			
	IH1 + PP + TS + ENV	1			
	Subtotal	7		0	7 (4.7%)
	Total	109	Total	39	148

Note: [1] When the option to choose 'none' is included, effectively the number of options is 3, 4, and 5, respectively.

In each group, a sample of the various possible combinations was picked up and these were used in the survey.

5 Analysis of preferences of consumers in Chennai

5.1 Options chosen by the respondents

Out of the 148 respondents, 130 respondents chose one of the options given to them and the remaining 18 respondents opted for 'none'. The break-down of how many respondents chose which option is given in Table 5.

It is seen that 65 per cent of respondents in Chennai city and 59 per cent of respondents in the peri-urban areas opted for an option that gives a yard-tap connection to public (or state provided) water supply. From the above table, it may appear that there is no perceptible preference for yard tap provided by private sector. Table 6 gives the break up of information to see whether people did not choose an option even when it was available in their choice set.

From Table 6, it appears that preference for yard tap seems to be more influential than preference for a particular provider or a preference for sharing the connection and thereby lowering the monthly charges.

Table 5
Options chosen by respondents in Chennai city and the rest of CMA

	Respondents in		
	Chennai city (%)	Rest of CMA (%)	All respondents (%)
IH1	65.1	–	48.0
IH2	–	59.0	15.5
PP	14.7	10.3	13.5
OH1	3.7	–	2.7
OH2	–	7.7	2.0
ENV	6.4	0.0	4.7
TS	0.0	5.1	1.4
None	10.1	17.9	12.2
Total	100.0	100.0	100.0
(N)	(109)	(39)	(148)

Table 6
Propensity to choose an option when it is in the choice set

	Number of respondents		
	Who had this option available in their choice set (M)	Who chose this option (N)	N as a percentage of M
Option IH1: Yard tap, public sector	94	71	75.5
Option IH2: Yard tap, public sector	38	23	60.5
Option PP: Yard tap, private sector	39	20	51.3
Option OH2: Shared tap, public sector	13	3	23.1
Option OH1: Shared tap, public sector	26	4	15.4
Option ENV: Rainwater harvesting	73	7	9.6
Option TS: No tap, private sector	122	2	1.6
None of the options		18	
Total		148	

As mentioned earlier, about 12.2 per cent of the respondents, i.e., 18 respondents, did not choose any of the options offered. The main reasons for not choosing any option were: *not interested in any changes* (three respondents); *satisfied with the existing system* (three respondents); *do not believe it can be changed by individual action* (three respondents); *it is government's responsibility to provide water supply and it should not be based on whether I am willing to pay* (two respondents); *we are already paying taxes* (two respondents); *we have to consult with family members* (one respondent); *I need to discuss with community leaders* (one respondent); *I need to consult the landlord* (one respondent); other reasons (two respondents). The issue of whether respondents who chose 'none' were systematically from a particular socioeconomic background or gender[22] was examined. No specific pattern was noticed.

Prima facie it appears that as the number of options available to a respondent increases, the probability of choosing 'none' decreases. This seems to indicate that respondents are more likely to choose 'none' if the choice set available to them is narrow. This needs to be explored further.

5.2 Towards modelling the decisions of Chennai respondents

Earlier, a multinomial logit was shown (equation 5) as:

$$\log\,(P_{ij}\,/(1-P_{ij})) = \beta' Z_{ij}$$

The RHS is a function of attributes. For example, we can write:

$$\begin{aligned}\log\,(P_j\,/\,(1-P_j\,)) &= \beta 1{*}CHARGE_j + \beta 2{*}YARDTAP_j + \beta 3{*}\,PRIVATE_j\\ &\quad + \beta 4 * ENVIRON_j + \beta 5{*}WQUAL_j + \beta 6{*}QUANT_j + \beta 7{*}SHARED_j \qquad (6)\end{aligned}$$

Some results from MNL models[23] are reported in Table 7. For convenience, in this Table, I have identified models with a number which indicates the number of attributes included in the specification. Thus, a model with six attributes is called D-6; one with five attributes is called D-5 and so on.

In the Table, the following details are reported: (i) the parameter estimates; (ii) the values of the log-likelihood function when it is maximized $L(\beta^*)$ and with no coefficients L(0); (iii) the models being compared for the likelihood ratio (LR) test; (iv) the LR test statistic; and (v) the degrees of freedom for the Chi square test (K_U-K_R); and (vi) the critical value of Chi square. Following Ben-Akiva and Lerman (1985: 166), to compare a model that is specified with K_U number of attributes (the unrestricted model U) with another model that includes K_R attributes (the restricted model R), the test statistic is:

$$\xi = -2\{L(\beta_R^*) - L(\beta_U^*)\} \qquad (7)$$

[22] Chi square and independent samples t-tests did not indicate any systematic difference between the 18 respondents who chose none and the 130 respondents who chose one of the other options.

[23] As part of testing for model specification, I tried to check for the independence from irrelevant alternatives (IIA) property. These details are given in Appendix 2.

where β_R denotes the restricted model and β_U denotes the unrestricted model. This test statistic has a limiting Chi square distribution[24] with degrees of freedom equal to (K_U-K_R).

Table 7
Results of multinomial logit (MNL) models

	Model D-6	Model D-5	Model D-4
CHARGE	-0.0049	-0.0081*	-0.0066*
YARDTAP	1.9451**	2.2023**	1.1545**
PRIVATE	-0.8915*	-1.6232**	-1.1829**
ENVIRON	-2.4428**	-1.7323**	-1.0786*
WQUAL	-0.6633	-1.6643*	
QUANT	-0.0152*		
SHARED			
L(β*)	-83.29	-88.44	-93.10
L(0)	-307.75	-307.75	-307.75
Rho squared bar [1]	0.7099	0.6964	0.6845
LR: models being compared	–	D5,D6	D4,D5
LR statistic	–	10.3	9.32
Degrees of freedom	–	1	1
Critical Chi square	–	7.88**	7.88**

	Model D-3	Model D-2	Model D-1
CHARGE	-0.0077**	-0.011**	-0.0081**
YARDTAP	1.5621**	1.7978**	
PRIVATE	-0.9474**		
ENVIRON			
L(β*)	-96.08	-100.28	-141.27
L(0)	-307.75	-307.75	-307.75
Rho squared bar	0.6781	0.6677	0.5377
LR: models being compared	D3, D4	D2, D3	D1, D2
LR statistic	5.96	8.4	81.98
Degrees of freedom	1	1	1
Critical Chi square	3.84*	7.88**	7.88**

Note: ** significant at 1%; * significant at 5%.

Some researchers use a goodness of fit measure defined as: rho square = 1 - [L(β*) / L (0)] where the value of the log likelihood function when it is maximized, L(β*); and the value of the log likelihood function when all coefficients are set to zero, L(0). Ben-Akiva and Lerman (1985) point out that interpreting rho square (as in case of R square in ordinary least square regression) whenever some additional independent variables are added is problematic. They suggest the calculation of rho squared bar (akin to adjusted R square in OLS): rho squared bar = 1 - {[L(β*) - K] / L (0)}, where K is the number of parameters (regressors). For example, for model D-6, the value of L(β*) is -83.29; the value of L(0) is -307.75; the number of regressors (K) is 6. Hence, rho squared bar = 1 - (-83.29 – 6)/(-307.75) = 1 - 0.290138 = 0.709862.

24 For example, model D-6 has six attributes ($K_U = 6$); we want to impose a restriction that the parameter of QUANT attribute is zero. Hence, we want to estimate a restricted model (D-5, with K_R being 5). We have, L(β_R*) i.e., the value of log-likelihood function maximized from the restricted model (D-5) = -88.44; L(β_U*) from model D-6 is = -83.29. The LR test statistic is: -2*(-88.44 + 83.29) = (10.3). There is 1 degree of freedom for the Chi square test. The critical value from the Chi square table for 99% significance was found to be 7.88. Since the test statistic is larger than critical value, we can reject the null hypothesis that model D-5 is a better specification. Hence, we accept the alternative specification that model D-6 is a better specification than D-5 and so on.

With regard to the results in Table 7, the following points may be noted:

i) It was not possible to specify a model with all seven attributes. It was resulting in singular Hessian. Therefore, I start with six attributes. Anomalous results arose when the attribute SHARED was used. It appears that the way the choice set has been specified, the attributes SHARED and WQUAL were somehow inter-related. Since WQUAL and QUANT were more interesting from the policy point of view, I decided to concentrate on them and omit SHARED attribute from the analysis. In model D-6, we find that two of the parameters were highly significant (at 1 per cent level) and another two were significant (at 5 per cent level). Rho squared bar indicates that goodness of fit is quite high.

ii) Model D-5 is specified with five attributes (and dropping QUANT and SHARED attributes). Three attributes were highly significant (1 per cent) and the other two attributes were significant (5 per cent). As compared to model D-6, rho squared bar has slightly decreased. The LR-test indicates that the null hypothesis that model D-5 is a better specification than model D-6 can be rejected at 99 per cent level.

iii) On the similar lines, the remaining columns in Table 7 impose further restrictions on the number of attributes. However, both rho squared bar and LR tests indicate that as we go on decreasing the number of attributes, there is a reduction in goodness of fit and some loss is model specification.

On the whole, the above regression results seem to indicate that consumers consider a number of attributes. Since we do not have any information on attributes from other studies[25] in Chennai or elsewhere, it is difficult to say whether the models meet prior expectations. While CHARGE and YARDTAP attributes have the signs as expected, for the other attributes, the expectation is that the sign of attributes such as quality (WQUAL) and quantity (QUANT) should be positive. The negative sign of ENVIRON attribute is probably indicating two things: (i) consumers may be sceptical how far individual efforts to engage in water harvesting and recycling of sullage is a solution to water supply shortage; (ii) they may be sceptical how far such schemes are practicable in a crowded metropolitan area. The parameter of attribute water quality (WQUAL) was not significant in model D-6. During the survey, it was seen that many consumers already engage in boiling or filtering it. Many of them have already invested resources to buy water filters, etc. It may be one reason why WQUAL is not significant.

5.3 Hierarchical or lexicographic decisionmaking—MNL versus NMNL models

Do Chennai consumers consider attributes in a hierarchical manner or consider some attributes to be more important than others? If respondents consider attributes in this way, any amount of increase in one attribute may not make an option preferable if it

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[25] In the Kerala study by Singh *et al.* (1993), probit regressions included the following attributes: monthly tariff (-0.0605); connection charge (-0.0010); improved service (-0.0582). They also included some attributes of existing source such as distance to current source (0.0002); time taken in minutes in the queue at current source (0.0028). In their case, the attribute ‘improved service’ was expected to have positive sign.

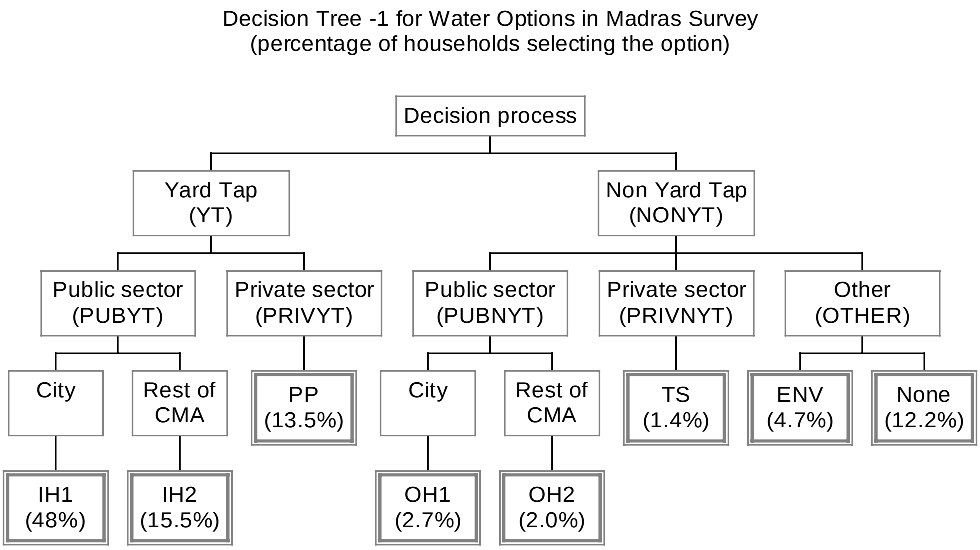
lacks in the attribute that they consider to be important. Following McFadden (1984) and Ben-Akiva and Lerman (1985), I have attempted to explore this issue with the use of a nested multinomial logit model (NMNL).

The nested-MNL model explores whether options are being considered in a hierarchical manner based on a ranking of attributes. If we find the presence of such hierarchical decisionmaking, then a nested MNL (NMNL) model will be a better specification than an ordinary MNL model, specially in relation to estimated probabilities.

The null hypothesis is that MNL model (model D-6) is the correct specification. The alternative hypothesis is that a NMNL model is a better specification. To test this, the options offered in Chennai survey can be seen in terms of various tree structures depending on how the attributes are considered. For example, if the consumer considers options having the attribute of YARDTAP first, before considering other aspects, we have a tree structure as shown is Figure 2.

Such a tree structure can be analysed with the help of a nested multinomial logit (NMNL) model. The model relating to the above tree is shown in Table 8 as N-1. In a nested model, in addition to attributes, inclusive values have to be estimated.[26] The number of inclusive values depends on the number of branches and twigs in the tree. The tree structure in Figure 2 implies that there are two inclusive values at level 1 (YT, NONYT); at the next level we have inclusive values relating to whether the service provider is public sector or private sector or other (in case of a YARDTAP option, the inclusive values are PUBYT and PRIVYT; for non-yard-tap options we have PUBNYT and PRIVNYT; we also have OTHER). Thus, a full model will have to estimate parameters of all attributes plus seven inclusive values.

Figure 2
Decision tree where 'YARDTAP' is considered first



26 See McFadden (1978: 80) for a discussion on inclusive values.

Table 8
Results from FIML estimator for NMNL models [1]

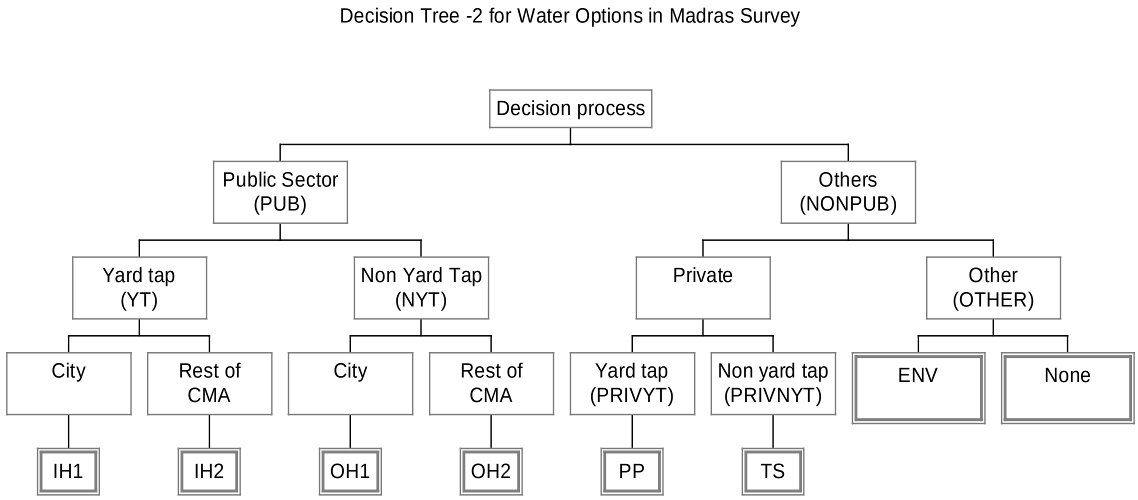
	FIML (nested) model			
Variable	Model N-1	Standard errors	Model N-2	Standard errors
CHARGE	0.00655	0.0121	-0.0077	0.019
YARDTAP	0.9154	3.208	1.8520	5.4839
QUANT	-0.031	0.054	-0.0121	0.035
PRIVATE	-1.001	4.254	-0.8382	2.687
WQUAL	-1.4161	4.484	-0.7509	3.617
ENVIRON	-2.4215	4.308	-2.4641	5.635
IV parameters: level 2				
PUBYT	0.422	0.778	0.8823	2.427
PRIVYT	0.325	0.570	0.819	3.014
PUBNYT	0.439	1.039	1.0226	2.778
PRIVNYT	1.052	2.429	1.294	3.8059
OTHER	1.659	4.385	1.013	2.834
IV parameters: level 1				
YT	0.9188	1.039	–	–
NONYT	1.1907	2.182	–	–
PUB	–		0.934	1.283
NONPUB	–		0.816	2.246
L(β*)	-71.7645		-77.2602	
L(0)	-306.0062		-311.2773	
Rho squared bar	0.7230		0.7100	
Chi squared	468.48		468.03	
Degrees of freedom	13		13	
Significance level	0.0000		0.0000	

Note: [1] Some authors have used a sequential approach (i.e., fitting a MNL model for one twig; then adding an inclusive value for the branch and estimating the model again and so on) instead of estimating the full information maximum likelihood (FIML) model (where parameters of attributes as well as those of inclusive values are estimated simultaneously). McFadden (1984: 1432) points out that in general sequential estimation may be inefficient. It may be noted that during the estimation it was found that Hessian was not positive definite. The Limdep programme used BHHH estimator.

If households consider the institution providing the service first and consider the attributes of the service such as YARDTAP at the next layer, we have an alternative tree is shown in Figure 3 (and as model N-2 in Table 8).

In this case, we have two inclusive values at level 1 (PUB and NONPUB relating to public sector and non-public sector, respectively); under each of them again we can have inclusive values corresponding to branches relating to YARDTAP or non-yard tap options (PUBYT, PUBNYT, PRIVYT and PRIVNYT) and OTHER. Thus, in this case also we have seven inclusive values.

Figure 3
An alternative decision tree where the institution providing the service comes first rather than YARDTAP or other attributes



The following observations may be made from the results in Table 8:

i) In both the NMNL models, we find that none of the parameters are significant,[27] though I am estimating 13 parameters here as opposed to 6 parameters in model D-6. There, we saw that YARDTAP and ENVIRON were highly significant (at 99 per cent); PRIVATE and QUANT were significant (at 95 per cent).

ii) The inclusive values may give some idea about model specification.[28] McFadden (1984: 1426) points out that the parameters of inclusive values should lie in the interval 0,1 and that when the estimates of these parameters are ' … outside the unit interval may indicate a mis-specified hierarchical structure'. In both the models reported in the above Table we can see that some of the inclusive values are outside the 0,1 interval.

iii) A Wald or LR test can also be used to compare the model specifications. McFadden (1984) suggests a Wald test statistic based on whether the inclusive values (λ_r) are close to 1 or not. The statistic suggested by him is:

$$W = (1-\lambda_r)^2 / SE^2_{\lambda_r} \qquad (8)$$

[27] t- ratios are not reported above but the highest t-ratio in model N1 was for inclusive value parameter YT and the value was just 0.884. All other parameters had t-ratios lower than this value. In model N-2 also, none of the parameters had t–ratios above 1.0.

[28] Following McFadden (1984: 1423-5), where r denotes the primary cluster and h denotes the secondary cluster, the inclusive value parameters k_{rh} (level 2) and λ_r (level 1) are 'measures of the independence of alternatives within sub clusters and clusters' respectively. McFadden points out that if k_{rh} = λ_r = 1, the NMNL model reduces to a simple MNL model. When 0< k_{rh} and λ_r < 1, the NMNL model is considered to be consistent with a hierarchical structure.

Where $SE_{\lambda r}$ are standard errors. This statistic is Chi square with *r* degrees of freedom under the null hypothesis. For model N-1, this statistic is:

$$W = (1- 0.9188)^2/ 1.0391^2 + (1- 1.1907)^2/ 2.182^2 = 0.0137$$

We can see that the critical value of Chi square for even 90 per cent level for 2 degrees of freedom is 4.61. Hence, we cannot reject the MNL specification in favour of a NMNL specification based on a Wald test.

Similarly, Wald statistic for model N-2 is:

$$W = (1- 0.934)^2/ 1.2832^2 + (1-0.814)^2/2.246^2 = 0.0095$$

Again, we cannot reject the MNL specification based on a Chi square test.

On the basis of these points,[29] it appears that the MNL model specification can be accepted rather than a NMNL model. Therefore, households in Chennai do seem to attach a lot of importance to some of the attributes such as YARDTAP but it appears that they do not make the decisions in a hierarchical manner or using lexicographic rules.

5.4 Welfare estimates and willingness to pay

Estimating implicit prices can help in making point estimates of willingness to pay (WTP) for a change in one of the attributes. Morrison *et al.* (1998: 10) point out that '… implicit prices are the marginal rates of substitution between the attribute of interest and the monetary attribute'. From the various betas estimated in the MNL model D-6, these implicit prices are estimated. These are shown in Table 9.

Table 9
Point estimates of implicit prices Rs (1996)

	Betas from Model D-6	Implicit prices
CHARGE	-0.0049	–
YARDTAP	1.9451	-396.94
PRIVATE	-0.8915	181.94
ENVIRON	-2.4428	498.53
WQUAL	-0.6633	135.37
QUANT	-0.0152	3.10

Note: In a compensatory framework (as in a utility function), the ratio of the parameters of two attributes indicates the rate at which the consumer will be willing to trade off one of these attributes for the other. See Ben-Akiva and Lerman (1985: 160). By taking a ratio of the parameter of an attribute with the parameter of monetary attribute, we arrive at implicit price. Thus the parameter for YARDTAP is 1.945. The implicit price for YARDTAP is 1.945/0.0049 = 396.94.

29 McFadden (1984) suggests another aspect of comparing MNL and NMNL models. This is to compare the point elasticities of changes in the attribute (for example, price) of one option on the remaining options estimated from MNL model and the NMNL model. In the MNL model, because of the IIA property, all other alternatives will have the same elasticity. In the NMNL model, only the options within a twig will have the same elasticity. If the difference in the elasticities from the two models is substantial, then MNL model, because of its IIA assumption, may be under (or over)estimating elasticities. I have attempted this comparison and did not find a substantial change in both sign and magnitude of these point elasticities.

The implicit prices are based on *ceteris paribus* assumption. From the signs of the parameters, we see that only yard tap attribute has positive sign and all other attributes have negative signs. Thus, while the implicit price of ENVIRON attribute is the largest in magnitude, its direction is different from that of YARDTAP attribute. Are these prices indicating that a yard-tap connection is welfare increasing whereas changes in all other attributes are welfare decreasing? To explore this, we need to examine compensating surplus measures. Following Hanemann (1984), Johansson (1987) and Adamowicz *et al.* (1994), compensating surplus can be estimated by comparing two situations where there is a change in the level of an environmental resource from R_0 to R_1. The individual should be indifferent between the initial state (represented by 0) and the new state (represented by 1):

$$V_0(Z_{iR_0}, m) = V_1(Z_{iR_1}, m - CS) \tag{9}$$

where income (m) is assumed to be the sole individual characteristic; Z_i represents a vector of attributes relating to the good in question. Subscripts R_0 and R_1 indicate the levels of these attributes before and after the change. Based on this, CS can be estimated (Morrison *et al.* 1998: 4; Rolfe *et al.* 2000: 295):

$$CS = -\frac{1}{\beta_M}\{\ln(\sum_i \exp^{V_0}) - \ln(\sum_i \exp^{V_1})\} \tag{10}$$

where β_M is the coefficient of the monetary attribute and is interpreted as the marginal utility of income (to transform the change in utility into monetary measure). For a single option, the above equation reduces to:

$$CS = (-1/\beta_M)(V_0 - V_1) \tag{11}$$

Each of the indirect utility functions can be estimated using:

$$\begin{aligned} V = {} & \beta 1 * CHARGE + \beta 2 * YARDTAP + \beta 3 * PRIVATE \\ & + \beta 4 * ENVIRON + \beta 5 * WQUAL + \beta 6 * QUANT \end{aligned}$$

Using this approach, compensating surplus was calculated for each respondent in the survey, depending on the option chosen by them. For this, the parameters estimated from model D-6 are used. The existing utility level (V_0) was calculated based on the following:

$$\begin{aligned} V_0 = {} & -0.0049 * TOTCOST + 1.9451 * (CONECT) - 0.6633 * (CONECT) \\ & - 0.0152 * WATENDOW \end{aligned}$$

where *TOTCOST* is the estimated total expenditure Rs per month on water (including direct costs, cost of time and expenditure on improving the quality; for a discussion on this see Anand 2001a.);

CONECT is a dummy variable taking value 1 if respondent has a yard-tap connection and 0 otherwise;

WATENDOW is the total quantity of water they presently have access to in litres per capita per day (lpcd) (also discussed in Anand 2001a).

Then, for respondents choosing IH1, utility V_1 is calculated as:

$$V_1 = -0.0049*IH1CHARGE - 0.6633*1 - 0.0152*150$$

where *IH1CHARGE* is the price at which IH1 option was offered to them. Then, using equation 10, compensating surplus is calculated for each respondent.

5.5 Is WTP related to the current expenditures on water?

Before interpreting the willingness-to-pay figures, it needs to be mentioned that these WTP figures are relative to the options used in the survey (Rolfe *et al.* 2000). In my survey, respondents had the option to choose 'none' (which is equivalent to the status quo). Hence, anyone who chose an option can be thought to have considered the utility from choosing that option in comparison with the existing utility level. Therefore, the figures can be treated as willingness to pay for moving from the present situation of water supply to a new situation described by the option concerned. However, the WTP figures must be interpreted as broad indicators of consumer preferences rather than exact welfare measures.

Prior expectation is that the current expenditure on water and willingness to pay for improvement in water supply should be positively related. Appendix 3 reports figures showing the estimated current monthly expenditure towards water and compensating surplus for respondents choosing each of the seven options. However, as can be seen from Table 10, in general there is a negative relationship between what people are spending on water supply now and the estimated willingness to pay.

Table 10
Do current expenditures on water explain willingness to pay for improved water supplies?

	Constant	Total expenditure on water per month	Direct costs	Cost of time spent collecting water	Expenditure to improve water quality	Adj. R-square (N)
Compensating surplus (CS) for IH1	178.254 (6.362)	-0.706 (-3.322)				0.097 (94)
CS IH1	204.331 (4.619)		-1.962 (-2.358)	-0.232 (-0.242)	-0.427 (-1.711)	0.126 (94)
CS IH2	22.092 (0.790)	-1.112 (-3.031)				0.181 (38)
CS IH2	77.292 (1.966)		-3.939 (-3.947)	-2.128 (-1.876)	-0.132 (-0.292)	0.337 (38)
CS for PP	132.158 (2.122)	0.052 (0.100)				-0.027 (39)
CS for PP	130.006 (1.713)		-0.453 (-0.318)	1.027 (0.817)	0.197 (0.276)	-0.050 (39)

This needs to be examined further. A negative relationship is possible if the respondents consider their current expenditures to be much above the norm and hence, they expect the state to subsidize water in future as a way of compensating them for the past excessive expenditures incurred by them. Other reasons are also plausible and I will return to this issue shortly.

5.6 Do respondent characteristics explain WTP?

An exploration is made to examine how the estimated WTP is related to various socioeconomic characteristics of the respondent.[30] The OLS regression results for those choosing IH1, IH2 and PP are shown in Table 11. In each case, a number of alternative specifications were examined based on adjusted R-square and F-tests to check if the restricted model (when a variable is dropped) is a better specification than the unrestricted model. Also, to test for multicollinearity, I used tolerance factor (measured as 1 minus R-square obtained for each independent variable using all the other independent variables as regressors). Where two or more independent variables are highly correlated, this R-square will approach 1 and thus the tolerance factor will approach zero. To check for heteroskedasticity, the White test was used. In this, the normalized residuals (i.e., the difference between the value of dependent variable and the value as predicted from the model) are saved as variables. Then, the residual is regressed with the independent variables. If the residuals have a good relationship with the independent variables, the assumption of homoskedasticity of error terms cannot be rejected. Here, we found that in all three cases, there was no relationship between the residuals and the independent variables.

With regard to WTP for IH1, the two most significant variables are whether the respondent has access to well and access to tubewell. Considering that these are quite capital-intensive, the negative relationship between having these sources and willingness to pay for improved tapped water supply is plausible.

With regard to willingness to pay for IH2 (i.e., households located in the peri-urban areas), many variables are significant. Willingness to pay is negatively associated with having a water connection, having a well or tubewell and positively with the level of satisfaction with existing water supply.

With regard to those who chose the PP option, the only variable with high significance was location; those in the peripheral areas having a negative preference for the PP option compared to those living in Chennai city.

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30 There are a number of other variables, which may be of interest. However, many of these were correlated to each other causing collinearity and hence, were not included. In Anand (2001a) regression results with expenditure on water as the dependent variable and socioeconomic characteristics as the independent variables are reported. Hence, including expenditure in the regressions in Table 11 here would cause collinearity.

Table 11
Do socioeconomic characteristics explain WTP?

	CS for IH1	CS for IH2	CS for PP
Constant	177.343 (2.810)	49.322 (0.806)	204.762 (1.445)
Attitude toward water supply (Likert scale 1 to 5)	-4.127 (-0.285)	38.505 (2.562)	31.965 (0.990)
Female (dummy)	-39.512 (-1.231)	9.627 (-0.311)	46.373 (0.579)
Household size	5.060 (0.714)	-21.142 (-4.043)	-7.069 (-0.715)
Respondent lives in a hutment (dummy)	18.008 (0.394)	44.964 (1.303)	-148.067 (-1.397)
Respondent is owner (dummy)	25.075 (0.782)	46.424 (1.184)	-70.581 (-0.928)
Respondent has water connection (dummy)	34.993 (0.972)	-119.870 (-3.011)	-8.946 (-0.090)
Respondent has a well within the premises (dummy)	-80.128 (-2.201)	-87.196 (-2.468)	108.178 (1.041)
Respondent has a tubewell within the premises (dummy)	-232.902 (-5.755)	-65.812 (-0.802)	-99.205 (-0.964)
Respondent lives in the rest of CMA (dummy)	–	–	-204.176 (-2.126)
R-square	0.331	0.692	0.343
N	94	38	39

Note: t-statistics in parentheses.
With regard to collinearity, tolerance factor was used.

5.8 Reasons for reluctance to pay

One of the results from the analysis discussed above is that some respondents, a majority of them in the peri-urban areas, do not have (positive) willingness to pay for water supply improvements. This may come as a surprise at a time when the considerable professional opinion[31] among those working in the water sector is that those living in urban areas would be willing to pay for services. Though the main message of the World Bank Water Demand Research Team (1993) study is also on these lines, it also envisages that some communities may be unwilling to pay for any type of improved water service. It recommends 'doing nothing' as the policy option in such cases (1993: 68). Even when water scarcity is purported to be an endemic problem

31 For instance, the World Bank's (1995: 23) appraisal report of Second Madras Water Project notes '… Actual payments will understate the ERR since consumers may be willing to pay more than they do pay'. Recommendation to the effect that water tariffs and pricing policy should be based on consumer willingness to pay has been made in World Bank (1992: 105); World Bank (1994: 117); government of India (1996); Brockman and Williams (1996: 25, 30 and 111); and World Bank (2000: 146-7). Others while largely agreeing with this view, are a bit more cautious (Arriens *et al*. 1996: 72 and also 243-5; McIntosh and Yniguez 1997: 33).

in Chennai, why are some households reluctant to pay? There are several plausible explanations:

i) *Lack of trust in the water utility*: The consumers may not have trust in the water utility (the local government, in case of peri-urban areas) that it will keep its side of the contract of increasing water supply in return for their increased payments. However, in case of regression results relating to CS for IH2, we found a positive relationship between the level of satisfaction with the water supply and WTP. This seems to emphasize the point that the performance of the water utility is important in influencing consumer willingness to pay—in line with the arguments in Singh *et al.* 1993.

ii) *Public water supply is excessively expensive*: Consumers face a horizontal supply curve (or a marginal cost curve) but according to their calculation, it should be much lower than the levels I have used in the survey. Thus, the equilibrium quantity demanded is more but the equilibrium price is lower than the figures I used in the survey. They may feel that the marginal costs of public water supply are much higher because of inefficiency, wastage and excessive capital intensity. They may be using a marginal cost curve based on their own personal experience of tapping ground water through shallow well or tubewell.

iii) *Urban consumers claiming their entitlement to subsidy*: Even though these consumers realize that the marginal cost curve is much higher than what they would like, they feel that they are entitled to water supply from the state. This may also be related to the 'group equity' politics of India that Bardhan (2001) focuses on. There are two possible explanations how this group equity issue enters into the picture in case of peri-urban households. First, about 92 per cent of all water withdrawn from India's water resources is used for agriculture (WRI 2000). In many states (including Tamil Nadu) such water is given to farmers free of cost or at fairly nominal charges. Some of the peri-urban areas have large irrigation tanks with water allocated to farmers. Thus, the peri-urban households are more likely to be aware of farmers getting water at little or no cost. Second, there is reason to believe that the water supply service levels are quite poor in the peri-urban areas compared to Chennai city where the metro water board supplies water (Anand 2001a). In that light, households in peri-urban areas seem to be expressing their protest when asked about their willingness to pay. The lack of willingness to pay from the peri-urban households here may be indicating their aspirations to press their claims of their entitlement towards free water (and hence, a demand for the state to subsidize it).

iv) *Preference reversal*: These results may be an indication of preference reversal (Tversky *et al.* 1990). Given the various risky choices, these peri-urban households indicate preference in ordering these choices, but when using prices may order them differently. There can be three possible reasons for preference reversal: violation of transitivity; procedure invariance and independence axiom (Thaler 1992: 84). In my survey, I have tried to control for procedure invariance by varying the number of options given, the sequence in which the options were presented and also the prices at which each option was given. While I tried to examine the issue of hierarchical elimination by attributes (and thus, examine if preferences are continuous), I did not check for violation of transitivity of preferences. As per the independence axiom, if the consumer prefers A to B, then in case of risky choice, so long as the probability of getting A and B is the same, A should still be preferred to B. Perhaps, consumers in the peri-urban areas may be using different probabilities for different options and hence, the independence axiom may be violated. Policy and regulations may have different kinds of impacts on different sources of water supply and that may be one of the reasons for this violation. For example, the probability of getting a yard-tap connection in the outskirts of the rest of metropolitan area of Chennai may be very remote in the immediate future. The probability of getting water from a tanker truck (TS) on the other hand may be fairly high, if one did join such a scheme. Thus, either a violation of transitivity or violation of the independence axiom could be a reason behind the apparently low willingness to pay in Chennai.

v) *Accounting for capital and sunk costs and side payments*: Since I did not make any mention in my survey about capital costs (and any side payments) for obtaining yard-tap connections, households may be adding a hidden cost to the figures that I did mention. Thus, they may have given responses after off-setting their willingness to pay to cover the capital cost. I divided the sample into those who already have a connection and for those who do not have a connection, I estimated a monthly equivalent of the capital cost of getting a connection as Rs 269 per month (Rs 8,000; a discount rate of 8 per cent and period of 3 years). Even when this was added to the willingness to pay figures, the results did not change significantly. Therefore, this explanation cannot be relied upon.

This discussion indicates the need for further exploration of willingness to pay. I should emphasize that I am not suggesting that water supply should be subsidized or that efforts should be given up to improve the financial base of water utilities by trying to increase the tariffs to reflect the marginal cost of water rather than historic average costs. The main import is to understand consumer preferences better and gear the water utility to respond to these preferences with appropriate products.

6 Conclusions

This paper is an exploratory study, having all the limitations of a small sample. In spite of these limitations, there are some important issues arising from the discussion here. This study was conceived in a background where very few studies have been reported in the literature on the use of choice models to discuss urban water supply policy issues in the developing countries. In such countries, households often depend on more than one source of water. Also, a majority of the households pay a flat monthly charge and some households do not have private connections and hence, do not pay any charges. In a previous paper, I have examined issues relating to access and also the expenditures incurred by households on water supply (Anand 2001a). Against this background, the research reported in this paper made an attempt to examine how households in the city respond to different attributes of water supply, whether their decisions indicate lexicographic preferences and whether the estimated willingness to pay is related to socioeconomic characteristics. From the empirical work, the following points may be recapitulated:

i) We found that the yard-tap connection was the most 'valuable' attribute for households compared to other attributes, namely, quantity of water, its quality, whether the water connection is provided by public sector or by private sector and whether respondents are required to engage in rainwater harvesting

ii) However, it appears that respondents do not make their decision in a hierarchical manner, i.e., their decision process does not indicate lexicographic ordering of the attributes considered in this study.

iii) Contrary to prior expectations, we did not find a positive and upward sloping relationship between the current expenditure on water and estimated willingness to pay.

iv) However, we do find that a majority of households living within Chennai city consider water supply improvements to be valuable and are willing to pay. As can be expected, those who have invested in their own wells and tubewells are less likely to pay than those who do not have those sources.

v) The story of households living in the peri-urban areas seems to be different. Their willingness to pay is negatively associated with having a connection or having a well or a tubewell and is positively associated with the level of satisfaction with the existing water supply. While the reason for a negative relationship between WTP and having wells or tubewells is clear, the relationship between having a connection and being unwilling to pay needs to be teased out. Some conjectures to explain this lack of willingness to pay were mentioned in the previous section: not trusting the local government; trusting it but feeling that, due to inefficiency, the costs of public water supply are higher than what they should be; or claiming an entitlement towards subsidy (on the lines of Bardhan's argument about group equity); or a manifestation of preference reversal phenomenon.

There are a number of issues that could be pursued in further research. While I explored the issue of lexicographic preferences, this can be examined more directly (by asking the consumers) rather than drawing inferences from their expression of choices. Secondly, my use of NMNL models was limited to exploring hierarchical ranking within the attributes used. There is scope to pursue this further in terms of expanding other attributes of water supply (such as the number of hours of supply, reliability of supply, etc.). Another aspect is to examine whether there is evidence of hierarchical ordering of various commodities and services, of which water supply is just one item. Such an exploration may throw light on whether different groups of respondents face different kinds of trade-offs, for example relating to the time it takes to collect water versus leisure or water quality versus short- and long-term health consequences, and so on.

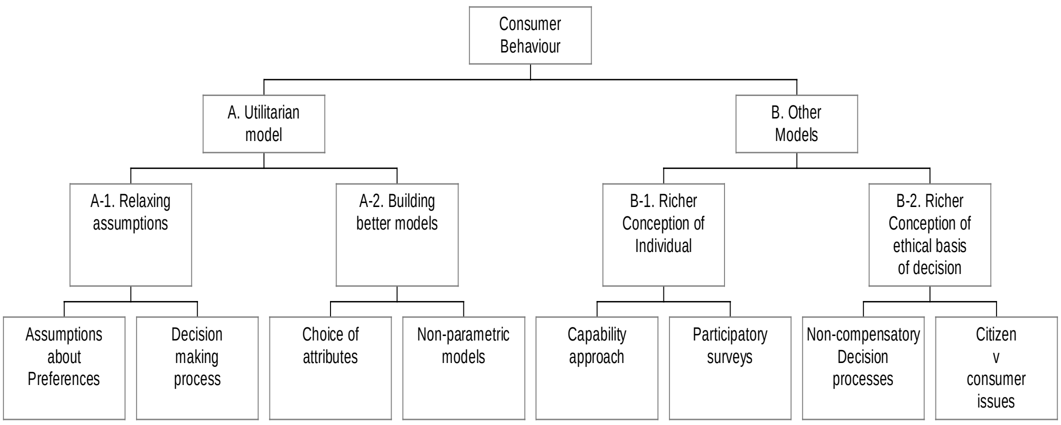
With regard to choice experiments, in the absence of prior information on attributes, I did not have the option of using choice-based sampling. From the parameters generated in this study, there is scope to pursue that option. Also, there is scope to examine the effect of varying the number of options. Here we found some evidence that as the number of options increases, the probability of respondents not choosing any option drops significantly. This could be explored further with careful control and experiment groups. In explaining the choice process, I have used only the attributes of the options.

Inclusion of socioeconomic characteristics may improve the insights that such models can give of the decision process. This is being explored in a forthcoming paper.

With regard to welfare estimates and willingness to pay, we found some results as per general expectations but some rather puzzling results of peri-urban households not having willingness to pay. I have identified some of the plausible reasons. These issues need to be examined further.

I am aware that the approach used here has many limitations. I have briefly touched on some of them in the previous sections of the paper. In addition to those, an important aspect to remember is that in choice methods we start with the decision made by the respondent and work backwards to understand the preferences. Thus, the information we so generate relates to those who made the choice. These methods may not fully explain the preferences of those who did not choose any option. While choice methods give us some insight into consumer decisions, other equally nuanced approaches may be equally promising. Some issues for future research[32] can be identified in the form of a tree as shown in Figure 4. Items in the last row in this Figure are not exhaustive but shown as examples.

Figure 4
A research agenda: Alternative strands to pursue



The discussion in this paper largely focused on the strand A-2 and the lexicographic aspects of it concern the strand B-2, in the above Figure. Even while using the utilitarian perspective, one could focus on relaxing the various assumptions about preferences (for example, Dubourg *et al.* 1997) and the nature of the utility functions. While much attention is paid to the process of how the consumer makes decisions (as seen from Engel *et al.* 1995 and Ben-Akiva and Boccara 1995), others recommend that the micro-economic models of consumer behaviour also need to focus on this aspect (McFadden 1999). An alternative approach may be to consider these issues from the capabilities approach. Sen (1984: 315-6) points out, ‘a characteristic—as used in consumer theory—is a feature of a good, whereas a capability is a feature of a person in relation to goods’.

[32] The agenda proposed here has some common aspects with those proposed by van den Bergh *et al.* (2000) and O’Connor (2000).

An exploration of applying the entitlements approach to examine issues of access in water supply (Anand 2001a) indicates the potential for following this strand. The lexicographic models discussed in this paper were within the utilitarian strand, but there is scope to extend such models to examine the various issues of ethical basis of decisionmaking and non-compensatory decision processes.

Appendix 1—Household survey in Chennai and interviews[33]

The data for this study comes from a household survey undertaken by me as part of my doctoral research during June to September 1996. Details of the survey design and diagnostics are provided in Anand (1996 and 2001b). The questionnaire covered a number of issues including household attitudes toward environment and public services; water consumption and expenditures; willingness to pay issues. The questionnaire design was based on two focus group discussions in Chennai in June 1996.

The sample households were drawn using a multi-stage cluster sampling method. My aim was to sample 200 households. The target sample was distributed to the 3 different parts of the metropolitan area (Chennai city, 9 towns and rest of metropolitan area) using population-proportionate sampling (PPS) method. Then, in each part, spatial clusters were identified. For example, in case of Chennai city, the city is divided into 10 zones by the Corporation of Chennai and I used these 10 zones as clusters. In the next stage, in each zone, clusters were created using Census wards or divisions. In the next step, in each selected ward, clusters were created using street networks. The blocks so created are sometimes known as super-blocks. Then in that block, all the housing units were numbered and using random sampling, the sample households were identified. In all, I interviewed 148 households representing different parts of Chennai. These households represented different socioeconomic groups, about 43 per cent of respondents were women. All age groups were represented. Some summary statistics from the survey are reported below.

Male; Female %	56.8; 43.2
Average age of respondent, years	43.1
Average years of schooling	10.2
Average household size	5.08
Owners, %	66.2
Those living in hutments (slums) %	18.9
Average number of rooms in house	3.17
Having water connection, %	48.6
Having a toilet, %	87.8
Having electricity, %	97.0
Having, TV %	93.2

In addition, I had in-depth interviews with officials of the Metro Water Board, the Corporation of Chennai, researchers at the Central Groundwater Board, Chennai, Institute of Water Studies, Chennai; three whole sale water tanker operators; a private company engaged in mineral water production; several water tanker drivers of both public sector and private sector. I had also used participant observation method to understand water transactions and benefited from discussions with retail water vendors.

33 Reproduced from Anand (2001a).

Appendix 2—Specification of MNL models: The IIA Property

With regard to MNL models, the axiom of independence from irrelevant alternatives[34] (or the IIA property) ' … states that the odds of *i* being chosen over *j* is independent of the availability or attributes of alternatives other than *i* and *j*' (McFadden 1984: 1413). Because of this ' … the ratio of the probabilities of choosing any two alternatives is independent of the attributes of any other alternative in the choice set' (Hausman and McFadden 1984: 1219). Further, McFadden (1984: 1414) notes that ' … when the IIA property is valid, it provides a … useful restriction on model structure … Thus, for example, one can use the model estimated on existing alternatives to forecast the probability of a new alternative so long as no parameters unique to the new alternative are added'.

Hausman and McFadden (1984) provide an extension of the Hausman specification test for MNL models using the IIA property. Their test '…is based on eliminating one or more alternatives from the choice set to see if underlying choice behaviour from the restricted choice set obeys the independence from irrelevant alternatives property.' (1984: 1220). They suggest that the unknown parameters from both the unrestricted and restricted choice sets are estimated. If the parameter estimates are approximately the same, they suggest that the MNL model is not rejected. While IIA property is useful as a test of specification, McFadden (1984: 1418) cautions that ' … this test is an omnibus test which may fail because of mis-specifications other than IIA. Empirical experience and limited numerical experiments suggest that the test is not very powerful unless deviations from MNL structure are substantial'.

I attempted to test for the IIA property in the various specifications of MNL model discussed here. For this, a model is specified with all the alternatives (unrestricted model); then one of the alternatives is dropped and the model is re-specified (restricted model). Hausman-McFadden test statistic could not be calculated as the covariance difference matrix was not positive definite. Hausman and McFadden (1984: 1226) note this possibility in case of small samples. They suggest comparing the probabilities and ratios of probability of selecting two options when a third option is omitted from the choice set. Table A below presents the predicted probabilities from the models discussed above. Actual probability is based on which option was chosen by sample respondents. The other columns are probabilities predicted by the MNL model.

From Table A, looking at rows numbered 10, 11 and 12, the IIA property is evident when comparing predicted probabilities from model D-6 with the case when OH1 was omitted. For example, all the three ratios (of probabilities) shown above match to 4th decimal place. However, the ratios of probabilities for model D-6 and a restricted model when IH1 is omitted (shown in the last column) were quite different. The impact of dropping IH1 does, however, seem to be far more significant. Note that dropping IH1 makes the sample size smaller.[35] More importantly, it affects the information available

[34] McFadden (2000: 4) points out that due to Debreau, the IIA axiom was cast as 'red-bus, blue-bus problem'. Also see Domencich and McFadden (1975: 77). Ben-Akiva and Lerman (1985: 52-3) cite Tversky's point that IIA is a special case of order independence, which requires that the sequence in which options are encountered should not have any impact on the decision.

[35] This is because the choice variable Y_{ij} should get the value of 1 at least once for every valid observation (that option j has been chosen by individual i). However, when the all lines of data

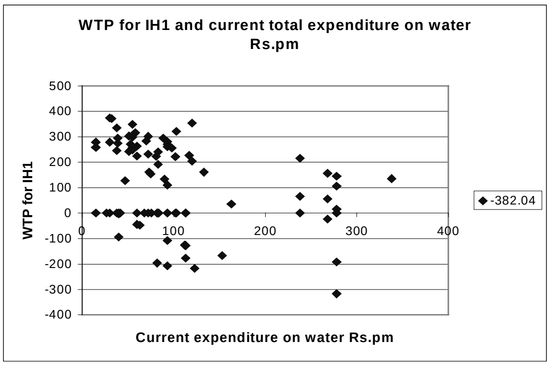
from the remaining respondents. As we saw earlier, YARDTAP is a significant attribute in all models. By dropping IH1, we are losing quite a lot of information about this attribute and how consumers perceive it. The above result may also mean that the specification of model D-6 is not very good. As already mentioned, I could not include all seven attributes. Hence, I have settled for the next best option, which was to specify a model with six attributes (D-6). This choice seems to have come with some loss in model specification (which is what the failure of IIA property in table above also seems to indicate).

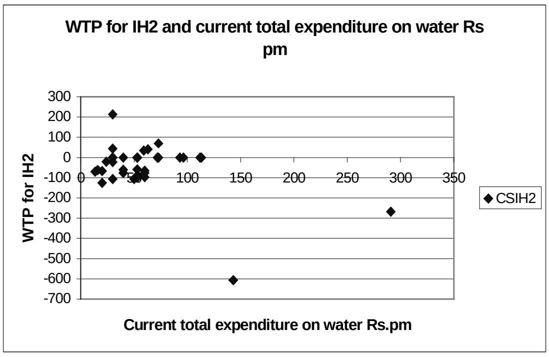
Appendix Table A
Predicted probabilities from model D-6 (unrestricted case) and when one of the alternatives is dropped

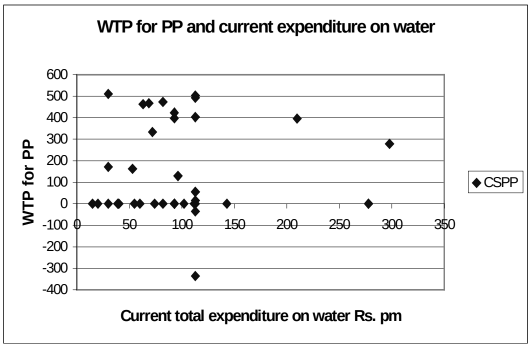
		Probability of selecting an option			
		Actual	Predicted from model D-6	When OH1 omitted	When IH1 omitted
1	IH1	0.4797	0.4595	0.4722	0.0000
2	IH2	0.1486	0.2095	0.2153	0.3377
3	PP	0.1351	0.0946	0.0972	0.2078
4	OH1	0.0270	0.0270	0.0000	0.0390
5	OH2	0.0203	0.0203	0.0208	0.0519
6	TS	0.0203	0.0608	0.0625	0.0779
7	ENV	0.0473	0.0473	0.0486	0.0909
8	None	0.1216	0.0811	0.0833	0.1948
9	Total	1.0000	1.0000	1.0000	1.0000
Some ratios of probabilities					
10	IH2/PP		2.2143	2.2143	1.6250
11	TS/ENV		1.2857	1.2857	0.8571
12	TS/PP		0.6429	0.6429	0.3750

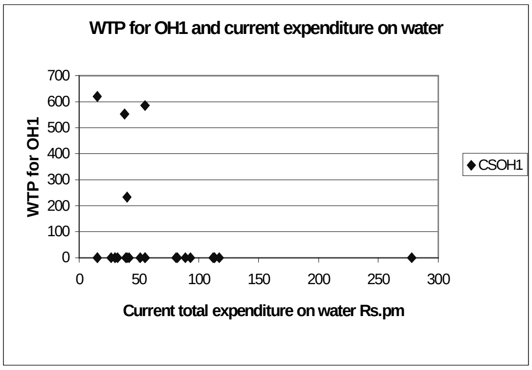
relating to IH1 are omitted, many observations (where the respondent indeed chose IH1) will become invalid observations and drop out of computation.

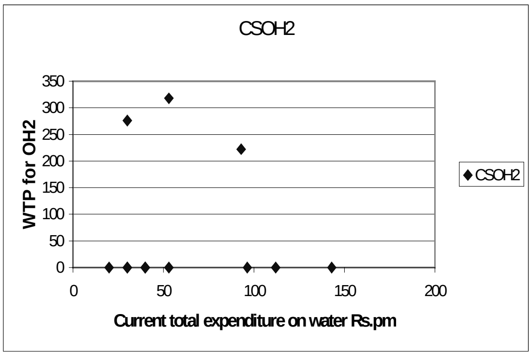
Appendix 3—WTP and current expenditure on water per month: Are they related?

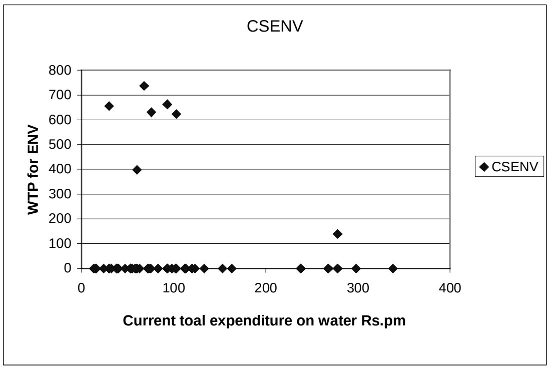


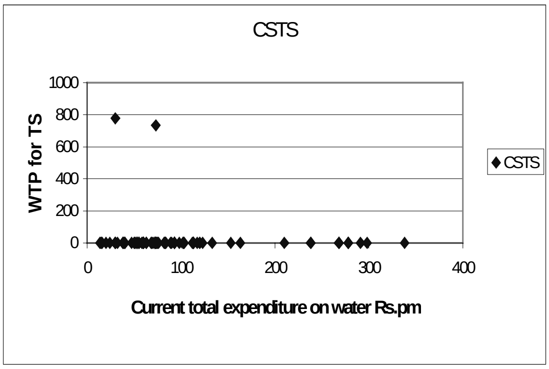












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