Accepted Conference Paper
Submitted to the 36th Australian Conference of Economists
Hobart, September 2007

Title

Household willingness to pay to avoid drought water restrictions :A case study of Perth, Western Australia

Authors

S. Tapsuwan[1], D. C. Brennan[2], G. D. Ingram[1] and M. Burton[2]

[1]*Policy and Economic Research Unit, CSIRO Land and Water, Australia.*

[2]*School of Agricultural and Resource Economics, University of Western Australia*

Abstract

The development of new water sources to meet growing urban demand rarely takes explicit account of consumer preferences for the attributes of reliability, which affects the supply buffer required and the timing of augmentation; nor the non-market attributes of different source development options. This study examined consumer preferences for source development options and for avoiding outdoor water restrictions using choice experiments (CE). The study found statistical evidence that if households were willing to move away from the status quo (a scenario in which they would have to endure severe water restrictions) they would be willing to pay 22 percent more on their water usage bill to be able to use their sprinklers up to 3 days a week. Additionally, on average, households would pay a higher water bill of approximately 50% more to finance a new source of supply instead of enduring severe water restrictions.

Keywords

water pricing, logit, desalination, aquifer, water restriction, choice experiments

1 Introduction

One of the fundamental questions faced in the urban water sector is the optimal level of supply, given rising demand driven by population growth, increasing cost of supply augmentation, and variability in the yield of water sources due to the vagaries of the weather and more recently due to climate change uncertainties. A higher level of supply relative to forecast demand can provide some security against droughts, but there is a trade-off between the cost of excess capacity and the expected cost of failing to meet demand in dry years. Economic efficiency would require that these longer term and shorter term decisions be made with some regard for consumer preferences, whereas most decisions are made by planners according to engineering rules of thumb that are more often influenced by political judgement than consumer welfare.

Whilst there has been some progress towards the alignment of source development planning with consumer preferences via the widespread adoption of volumetric charging to signal long-run marginal cost in many countries [*OECD*, 1999], the reliability issue has not been resolved using pricing methods, either in the long run or the short run. Long run marginal cost calculations used for setting prices are usually based on a predetermined level of service reliability [e.g. *Turvey*, 1976; *OFWAT*, 2001]. In the short run when water supplies must be allocated across time according to uncertainties of reservoir yields, non-price rationing methods are generally used to manage shortfalls in supply. In Australia, where extreme climate variability poses uncertainties in water supply and outdoor use makes up a significant proportion of demand, rationing methods focus on the prohibition of outdoor uses. The implementation of water restrictions is usually carried out according to transparent rules regarding the degree of water storage drawdown that invokes restrictions of different levels of severity. The mildest restrictions prohibit watering during periods of the day when evaporation is highest, moderate restrictions involve rationing the number of days that sprinklers are allowed to be used for watering gardens, and the most severe restrictions ban all outdoor uses of water. At the present time, a prolonged period of low dam yields has resulted in most urban Australian consumers experiencing some level of water restriction for the past two to three years. Whilst water restrictions have some political appeal as a way of managing water shortages because customers share the burden more equally [*ERA*, 2005], economists have highlighted the efficiency costs of quantitative restrictions (e.g. *Dwyer*, 2006; *Edwards*, 2006; *Byrne et al*. 2006; *Crase et al*., 2006). Now that desalination technology is becoming an economic (although high cost) alternative and can provide a guaranteed supply once the investment is made, there is greater imperative to consider the question of supply augmentation jointly with consumer preferences for reliability.

A second issue relating to consumer preferences and source development planning is that there may be non-market attributes associated with different source development options. The development of new dams is particularly contentious given increased environmental awareness and the national emphasis on allocating water for the protection of water dependent ecosystems. Seawater desalination raises another set of environmental questions, particularly its high energy dependency. Water recycling is an alternative that may appeal to some because of the implications for reducing the quantity of wastewater pollution, whereas others find the idea of drinking recycled water distasteful.

This article focuses on consumer preferences regarding the provision of water supply, as they relate to the nature and severity of outdoor water restrictions and preferences towards particular source development options. We apply a choice experiment to determine whether consumers in Perth, Western Australia, are willing to pay to improve service attributes such as the duration and severity of sprinkler restrictions and whether there is a market premium on any of the source development options that are currently being considered for augmentation of supply.

There have been some economic studies undertaken in recent years to explore the trade offs between customer preferences, system reliability, and source development options. *Howe and Smith* [1993] applied contingent valuation to examine public's views regarding water supply reliability in the city of Aurora, Longmont and Boulder, Colorado. They found that for the city of Boulder, the water utility could reduce reliability of water supply since households were willing to accept (WTA) higher risks of annual shortage events. Several recent studies in Australia have used choice modelling (CM) to examine consumers' Willingness to Pay (WTP) to avoid sprinkler bans. *Hensher et al*. [2006] found that customers in Canberra, Australia, lack the WTP to avoid most types of drought-induced restrictions and were willing to tolerate high-level restrictions for limited periods each year, compared to paying higher water bills. *Gordon et al*. [8] investigated the WTP for future supply sources in Canberra. They found that households were willing to pay an increase of AU$47 on their bills to have recycled water for outdoor use. However, households were found to be WTP AU$55 to avoid drinking the recycled water. Apart from the two studies in Canberra, most published work has examined reliability in terms of WTP to avoid temporary (i.e. in terms of hours) disruption in supply that, from a policy perspective are more about the reliability of the distribution network, rather than about the underlying reliability of the water source (e.g. *Hensher*, *et al*., 2005; *Hatton McDonald et al*., 2005).

1.1 Case study Perth metropolitan households

The water utility supplying the city of Perth has an approach to system planning that can be described as extremely conservative. Source development planning is based on (virtually) a zero tolerance to complete sprinkler bans. This is done by planning for a 1 in 200 year risk of sprinkler bans. A review of other Australian water utilities finds that currently there is consensus that the frequency of restrictions that involve a total sprinkler ban should be limited to 1 in 25 years [*ACTEW*, 2004]. The objective of maintaining a capacity buffer to limit the risk of a total sprinkler ban to a one in 200 year event warrants review [*ERA*, 2005] as this virtually ‘no chance’ of sprinkler bans accelerates the need for development of new supply sources.

Amongst a number of potential new sources of supply, the study selected the following three that have received the most attention and investigation by the water utility:

1. Extracting groundwater from the south west Yarragadee aquifer, which is located in a nearby region, and which also involves investing in approximately 200 km of pipeline. This option involves some risk associated with lowering of water tables which may impact upon water dependent ecosystems which are a habitat for rare species. It may also impact on river flows and reduce the quality of riverine environments used for recreation purposes. Another concern is the opportunity cost of water in terms of foregone economic growth in the local region, which has been shown to be substantial [*Brennan*, 2006].

2. Constructing a second seawater desalination plant. The environmental impact can include greenhouse gas emission and uncertainty as to the impact of releasing hyper-saline brine back into the ocean.

3. Reverse Osmosis Managed Aquifer Recharge (ROMAR) involves injecting treated recycled wastewater from wastewater treatment plants directly into the underground aquifers under controlled conditions. The water can be withdrawn at a later date for indirect potable reuse, or used as a barrier to prevent saltwater or other contaminants from entering the aquifer.

At the time of implementing the study all three options were potentially available, however, at the time of writing (May 2007) the water utility's preferred Yarragadee scheme was deferred in favour of a desalination plant, apparently on the basis of perceived political backlash regarding the environmental risks associated with the south west Yarragadee.

1.2 The survey instrument

This study applies choice experiments (CE) as the survey instrument because it allows flexible alternatives and generates considerable cost savings through the ability to value a number of options simultaneously [*Gordon et al.*, 2001]. Choice experiments are a survey-based technique to model preferences for goods. The goods are normally described in terms of their attributes and the attributes have varying levels. In the survey, respondents are asked to choose their most preferred alternative from a set of alternatives having different attribute levels. By including the price as one of the attributes of the good, WTP for the attribute can be indirectly recovered from the people's choices [*Hanley et al.*, 2001]. The identification of attributes and levels in this study was done through a series of focus groups and a pilot survey. The final list of attributes is presented in Table 1. It includes measures of 'regular' outdoor restrictions, probability and severity of a complete sprinkler ban, sources of alternative water supplies and cost.

A statistical software package was used to generate the orthogonal experimental design that was needed to construct the CE survey. An orthogonal design is a combination of alternatives which would allow the attribute levels to vary independent of one another i.e. there is no correlation between the attributes [*Bennett*, 1999]. Given restrictions on the maximum sample size due to budget limitations, a one-ninth fraction of the $4 * 3^4$ full factorial design was used to reduce the number of choice sets down to $(4*3^4/9) = 36$ while maintaining orthogonality. The 36 choice sets were then segmented into four blocks of nine choice sets each. Each choice set listed three options, one of which was the status quo. The status quo remained the same across all choice sets while attribute levels in options II and III varied according to the experimental design.

An internet survey was chosen as the mode of obtaining responses due to its cost-effectiveness. Responses from each survey are automatically saved in a data-base file, which reduces non-sampling bias from inputting data incorrectly. It is known that internet access or coverage is the main hindrance of internet-based surveys. Hence, a panel of respondents was sought through an independent survey company and proportional stratified sampling was used to select respondents from each suburb of Perth to ensure coverage of the population.

1.3 The questionnaire

In the choice sets, respondents were presented with a range of supply augmentation options to choose. Figure 1 shows a typical choice set presented in web format. Option I was identical in each choice experiment, and represented the consequences of doing nothing about future supplies, and hence was described as the 'status quo' scenario. They were asked to consider the scenario over a 10 year time horizon (from now until 2016). In the 'do nothing' scenario, they would be faced with a level five (one watering day per week) sprinkler restriction which will never be lifted during the 10 year time period. Additionally, they would also face a one-in-three year chance of a total sprinkler ban which, once invoked, would persist until there is sufficient rainfall to refill dams and replenish aquifers. In this 'do nothing' case, their water usage bills would remain unchanged. Three future supply sources along with a brief description were presented to respondents for selection; they include extracting groundwater from the South West

Yarragadee aquifer, construction of the second desalination plant and injecting treated wastewater into the underground aquifer for future use. These options were not labelled because labels can prompt respondents to select their preferred alternative on the basis of the label alone and the impact of varying levels of attributes can become trivialised [*Bennett and Adamowicz*, 2001].

[Insert Figure 1 here]

Respondents were reminded before every choice set to keep in mind their budget constraints and were asked to provide an estimate of their annual water usage bill. A hyperlink was provided in the choice sets for respondents to click and read the details of each attribute if they feel the need for clarification. The final section of the questionnaire consisted of a series of socio-economic questions including whether the respondents own their residence, have an automatic reticulation (sprinkler) system and the number of people in the household. There were also questions on level of education, age and whether they were pensioners, as pensioners receive a rebate on their water bills.

1.4 The model

For a three option choice set, implicitly the respondent is assumed to be comparing the utility obtained from each of the three options. The utility from choosing a particular option is determined by the levels of the five attributes in the choice sets and the individual preferences as modified by the socio-economic variables. The assumed functional form of the utility functions (Vj) are shown in equations (1a) and (1b).

The status quo utility is specified as

$$V_1 = SQ + \sum \beta_k (A_{1k}) + \sum \beta_s (SQ * S_s) + \beta(BILL_1) + \sum \beta_{js} (A_{1j} * S_s) \quad (1a)$$

and options II and III utilities are specified as

$$V_2 = \sum \beta_k (A_{2k}) + \beta(BILL_2) + \sum \beta_{js} (A_{2j} * S_s)$$
$$V_3 = \sum \beta_k (A_{3k}) + \beta(BILL_3) + \sum \beta_{js} (A_{3j} * S_s) \quad (1b)$$

where

- *SQ* status quo dummy variable (SQ=1 for the status quo option and SQ=0 for options II and III.
- A_{nk} level of attribute k in option n
- S_s socio-economic variable s
- $BILL_n$ water usage bill amount (% change/year) in option n

When the data consist of choice-specific attributes instead of individual-specific characteristics, the appropriate model is the conditional logit model which is specified as

$$P(Y_i) = \frac{\exp^{\lambda V_i}}{\sum_{j=1}^{J} \exp^{\lambda V_i}} \qquad (2)$$

where V_i is the indirect utility function which represents the utility of the different options specified in (1) and λ is a scale parameter. Hence the model provides an estimate of the effect of a change in any of these attributes on the probability of one of these options being chosen [*Morrison et al*., 1998].

Estimation of the conditional logit model is simplest by Newton's method or the method of scoring. The log-likelihood is

$$\log L = \sum_{i=1}^{n} \sum_{j=1}^{J} d_{ij} \log \text{Prob}(Y_i = j) \qquad (3)$$

where $d_{ij} = 1$ if $Y_i = j$ and 0 otherwise. The conditional logit assumes independence from irrelevant alternatives (IIA) in that the disturbances are independent and homoskedastic. If a subset of the choice set is truly irrelevant, omitting it from the model altogether will not change parameter estimates [*Hausman and McFadden*, 1984].

A number of socio-economic variables were introduced into the model as interactions with the SQ. Incorporating socio-economic interaction terms improves the model by bringing in the heterogeneity, or difference between individual respondents. It also helps answer questions of varying preferences amongst different socio-economic groups.

2 Results

A total of 414 usable questionnaires were obtained. Response rate is difficult to estimate for a panel-based survey, because it is not simply the proportion of those who responded to the initial invitation. Sample filters (such as excluding households without private gardens and/or lawns) and the fact that the survey may be closed when target numbers are achieved, irrespective of the willingness of potential respondents to complete the survey make the concept of response rate problematic. Summary statistics for socio-economic variables that were hypothesized to possibly have an impact on choices are reported in Tables 2a and 2b. Not all of the socio-economic variables reported were significant in the final model. The conditional logit results presented in this paper were analysed using a specialised statistical software package. Table 3 presents the parameter estimates for the significant variables from the model. The β coefficients estimated under the conditional logit model can be used to estimate the part-worth, or the rate at which respondents are willing to trade-off one attribute for another. The part-worth indicates the change in water bill that the respondent would be willing to pay or willing to accept to achieve a change in an attribute that maximizes their utility. Part-worth is estimated by dividing the derivative of the utility function with respect to the attribute by (the -ve of) the coefficient of the price attribute.

[Insert Tables 2a, 2b and 3 here]

2.1 Preference for water restriction

Not all variables relating to water restrictions were significant. Of perhaps most interest is the lack of significance of any variable that relates to the probability or severity of a complete sprinkler ban (i.e. DURA1, DURA5, BAN110 and BAN1200). There are two possible interpretations of this result. One possible explanation is that that the welfare of consumers is genuinely not impacted by the prospect of a complete sprinkler ban. The other explanation is that households view the development of new sources overrides these outcomes. It is difficult to evaluate which of these is a more appropriate explanation, but it is likely to be the latter. This is because households do show a preference for increasing sprinkler days from 1 day a week (the status quo) to 3 days a week (DAY3). This is evidence that they do show some sensitivity to access to sprinkler use and therefore must have some concern over sprinkler bans.

A potentially perverse result, however, is the equivalence of the status quo and the option to use sprinklers for 5 days per week (DAY5). As 5 days use includes the possibility of using for 3 days, one might expect that DAY5 should be as least as valued as DAY3. A possible interpretation is that respondents' place a value on 'responsible water use'. Perth consumers have only been permitted to use sprinklers for 2 days per week since 2001, and during the past 6 years there have been repeated advertising campaigns promoting the social value of 'water wise' gardening practices. Thus whilst they should be at least as satisfied with 5 days as with 3 days, respondents might be attaching a social unacceptance to the additional 2 days per week. For example they may be concerned that 'other' irresponsible users will overexploit the resource if allowed to use for 5 days (even if they would not) and are prepared to trade away the increased value of their own (responsible) use of water to prevent this happening. However, without further evidence this is conjecture.

For the option of moving from 1 day to 3 days sprinkler use they are willing to pay 22% extra on their annual water usage bills (or around AU$57 based on average water usage bill of respondents surveyed = AU$260) to increase sprinkler days from one to three per week.

2.2 Preference for a new source of supply

The three alternative sources of supply are treated as separate variables. There is evidence of some variation in values due to the heterogeneity in the socio-economic factors, as measured by interaction terms between source and factors. Specifically, higher education levels tend to reduce the overall WTP value of desalination and Yarragadee options; being male tends to increase the preference for ROMAR, and having automatic reticulation tends to reduce the value for all sources, with a higher impact on ROMAR. (See Table 3).

Given the 3 socio-economic attributes used in the model, it is possible to identify eight possible representative respondents. Evaluating the WTP for each of these eight identifies the impact population heterogeneity has on WTP for different supply sources. Reported in Table 4 are the part-worths or WTP estimates (defined as % changes in bill) for different supply sources based on varying combinations of socio-economic characteristics which were significant in the model. These values ignore the status quo effect discussed in the next section and are therefore not a true measure of WTP for each source, but they do reflect the general preferences of different groups of the population towards each source, assuming status quo effects are held constant. It was found that men with lower than university education level and have no automatic reticulation were willing to pay nearly double (99% increase) their current bill to have ROMAR as the new supply source. On the contrary, women of the similar education level with automatic reticulation preferred the second desalination plant and were willing to pay 89% more on their usage bills to have this source. The group with the highest WTP for the South West Yarragadee were WTP up to 73% of their water bill and were the same group of men that preferred ROMAR.

The preference for ROMAR amongst men is consistent with *Leviston et al.*, [2006] where they found in their study on predicting community behaviour on indirect potable reuse of wastewater through managed aquifer recharge that males were more likely to support recycled water scheme than women. However, *Leviston et al.* [2006] did not find any other significant differences based on education income, age and family unit.

[Insert Table 4 here]

Note the results in Table 4 imply that there is no strong indication of people with automatic reticulation preferring a particular supply source. This can be interpreted as households with automatic reticulation are more concerned about having future water supply security than where the water actually comes from. It may be because these households have already invested in reticulation infrastructure and fear their investments would go to waste if they were no longer allowed to use their sprinklers due to shortage of supply.

2.3 Preference to move away from the status quo

It was stated in the choice experiment questionnaire that respondents will be faced with severe water restrictions if they decide to do nothing (do not augment supply) in the next 10 years. Generally in choice experiments, respondents have a tendency to be reluctant to move away from the status quo (status quo inertia). It is also the case that this preference for the status quo (irrespective of the attributes of the alternatives) can be influenced by the socio-economic characteristics of the respondent. These impacts can be evaluated by including a status quo dummy into the model, equal to one if the option is the status quo, and interacting (for example SQ*AGE) the dummy with respondent attributes. The results from Table 3 indicate a large number of significant respondent attributes: increased income, age, education, auto reticulation and presence of children are all associated with a lower preference for the status quo, while higher number of people per household tends to increase the preference for the status quo. Several summary estimates of the status quo effect can be calculated. If one takes a representative individual with the average socio-economic characteristics of the sample the status quo effect is not significantly different from zero. However, if one evaluates the effect for each individual in the sample one can see considerable heterogeneity, and in particular a large proportion has a significant negative effect. The interpretation of this effect is that these respondents positively prefer a change from the status quo, irrespective of the attributes of the alternatives on offer. This is contrary to the normal stasis argument. Interpretation of this in a strict form is problematic: the implications are that respondents would prefer to move away from the status quo, even if the alternative options have higher costs and no significant improvement in service levels or source. It is possible that the current high profile of the water crisis in Perth has led to an overstatement of the willingness to change, and a possible implicit assumption that any change from the status quo will be an improvement, even if this was not the case in all of the actual choices presented to them in the experiment.

The presence of a status quo effect (of either sign) leads to further issues in evaluating the amount that individuals will pay for alternative programs. Conventional part-worths (as reported in Table 4) reflect the value placed in a marginal change in an attribute. However, by definition, change in an attribute implies movement away from the status quo. Evaluating a change in the state of the world requires both the status quo and attribute specific effect to be included (Bennett and Adamowicz, 2001). Table 5 report estimates of the part-worths associated with all three sources, having taken into account the socio-economic attributes affecting both status quo and the alternative sources. Figures 2a – 2c are the corresponding histograms of the part-worths reported in Table 5. The distributions of WTP suggest mean values of around 50% increase in water usage bills; although there are some individuals which were willing to pay more than double (more than 100% increase) their current water usage bills to have the supply source they preferred. Note also in Figure 3b that maximum WTP for ROMAR was over 150% increase in water bills, the highest WTP of all three sources.

[Insert Table 5 and Figures 2a – 2c here]

3 Discussion

This study found that it was difficult to identify preferences to pay for reduced risk of water restrictions in either short or long term. The only water use attribute that was found to be significant was the increase from one sprinkler day per week (the proposed status quo) to three sprinkler days a week. Given the current level of two days a week, this may reflect a strong desire not to suffer further restrictions, as compared with the current position. However, the result that there was no similar value attached to 5 day per week restrictions (which could provide the respondent with the opportunity for 3 day watering which they valued), was counter-intuitive. It is possible that respondents may have found the attributes presented in a choice set format too difficult to understand, particularly because it involved the assessment of risk of an event which may have been difficult for them to grasp cognitively. Alternatively, respondents may have used the availability of new sources as a causally prior attribute. The source development options may have, in effect, introduced a labelling bias into the questionnaire. If it is the case that source development was seen as the overriding factor and the associated levels of reliability were ignored by respondents, some modifications to the survey instrument would be required in the future in order to assess the value of reliability.

In terms of preference for new source of supply, the CE approach found more significant results although it also indicated a high degree of variation in individuals WTP for different sources. We found evidence that households were willing to pay to have ROMAR as a new source of supply if they had to choose between ROMAR and severe water restrictions, which contrasts with findings from *Gordon et al*. [2001] that households have a negative WTP for drinking recycled water. The difference in the findings can be due to time frame as this study had been conducted in a time of heightened awareness of water scarcity and better public understanding of ROMAR. The difference could also be because ROMAR does not require households to drink recycled water directly. However, there are wide distributions of WTP, reflecting the heterogeneity of the individuals in the sample, although the vast majority were positive towards each source. We also found consistent results with *Leviston et al.* [2006] in that men are more likely to support ROMAR.

Information provided to respondents regarding different supply sources were all published information found on the water utilities' website and academic studies. Information on the uncertainties of health impact and environmental impact of different supply sources were kept at a minimal as to not bias the respondents' decision. Therefore the authors could not conclude that decisions regarding different supply sources were based on the respondents' perfect knowledge of the advantages, short-comings, environmental impacts and investment costs of each source.

4 Conclusions

This study attempts to estimate households' WTP for the attributes of water supply associated with source development planning, including reliability of supply and the nature of the new source. The study found that households consider water bill, supply source and the ability to water three days a week as important factors that affect household WTP. There were significant differences between different groups of the population regarding WTP for alternative sources, which may reflect different perceptions regarding the non-market effects of these source options, or different valuations on these non-market effects. The significance of premiums for alternative source development options indicates that water utilities and those involved in setting water planning strategies should not neglect consumer preferences towards these options.

There is consensus that the frequency of restrictions that involve a total sprinkler ban should be limited to one in 25 years [*ACTEW*, 2004]. This study could not conclusively justify the currently high supply buffer set by the water utility in Perth as results from the survey did not show any statistically significance results of WTP for different levels of sprinkler ban probabilities. There is a possibility that the BAN variables were not significant because respondents assumed that accessing new sources would alleviate the need for restrictions, even though the choice options did not reflect this. However, it would be incorrect to conclude at this point that the attribute was unimportant to the respondents as the attribute may not be statistically significant because there was not a perceived detectable difference in the attribute levels presented in the survey design. Possibly, a greater range of the attribute level may help induce a significant result.

There is significant difference in WTP for different water sources when one accounts for different socio-economic groups. The distributions of WTP suggest mean values of around 50% increases in water bills although there are some individuals with much higher estimated values, in excess of a 100% increase.

Acknowledgements

The authors would like to thank CSIRO Mathematical and Information Sciences, Dr Olga Barron, Zoe Leviston, Dr Peter Hairsine and Dr Peter Boxall for their valuable comments. This study is part of a CSIRO Water for Healty Country Project.

References

ACTEW Corporation Ltd. (2004), Future Water Options for the ACT Region in the 21st Century: An Assessment of the Need to Increase the ACT's Water Storage. Canberra.

Bennett, J. (1999), Some Fundamentals of Environmental Choice Modelling. Choice Modelling Research Reports. Canberra: University of New South Wales; No. 11.

Bennett, J. and V. Adamowicz (2001), Some fundamentals of environmental choice modelling. In *The choice modelling approach to environmental valuation*, Cheltenham: Edward Elgar.

Brennan, D., (2006), Economic Evaluation of Alternative Water Allocation Options in the South West Region (Busselton-Capel, Bunbury and Blackwood Groundwater Areas). *Water for a Healthy Country Report*. Perth.

Crase, L. and B. Dollery (2006), Water Rights: A Comparison of the Impacts of Urban and Irrigation Reforms in Australia. *The Australian Journal of Agricultural and Resource Economic*, 50(3), 451-462.

Dwyer, T. (2006), Urban Water Policy: In Need of Economics. *Agenda*, 13(1), 3-16.

Edwards, G. (2006). Whose Values Count? Demand Management for Melbourne's Water. *The Economic Record*, 82 (special issue), S54-S63.

ERA (Economic Regulation Authority) 2005, Draft Report on the Inquiry on Urban Water and Wastewater Pricing. Western Australia.

Gordon, J., R. Chapman, and R. Blamey (2001), Assessing the Options for the Canberra Water Supply: An Application of Choice Modelling. In *The Choice Modelling Approach to Environmental Valuation*. Cheltenham: Edward Elgar.

Hanley, N., S. Mourato, and R. Wright (2001), Choice Modelling Approaches: A Superior Alternative for Environmental Valuation?. *Journal of Economic Surveys*, 15(3), 435-462.

Hatton MacDonald, D., M. Barnes, J. Bennett, M. Morrison, and M.D. Young (2005), Using a Choice Modelling Approach for Customer Service Standards in Urban Water. *Journal of the American Water Resources Association*, 41(3), 719-728.

Hausman, M. J. and D. McFadden (1984), Specification Tests for the Multinomial Logit Model. *Econometrica*, 52(5), 1219-1240.

Hensher, D., N. Shore, and K. Train (2005), Households' Willingness to Pay for Water Service Attributes. *Environmental and Resource Economics*, 32(4), 509-531.

Hensher, D., N. Shore, and K. Train (2006), Water Supply Security and Willingness to Pay to Avoid Drought Restrictions. *The Economic Record*, 82(256), 56-66.

Howe, C., M. Smith, L. Bennett, C. Brendecke, J. Flack, R. Hamm, R. Mann, L.Rozaklis and K. Wunderlich (1993), The Value of Water Supply Reliability in Urban Water Systems. *Journal of Environmental Economics and Management*, 26(1), 19-30.

Leviston, Z., B.E. Nancarrow, D.I. Tucker, and N.B. Porter (2006), Predicting Community Behaviour: Indirect Potable Reuse of Wastewater through Managed Aquifer Recharge. CSIRO Land and Water Science Report 29/06. Perth: Australian Research Centre for Water in Society.

Morrison, M. D., J.W. Bennett, & R.K. Blamey (1998), Valuing Improved Wetland Quality Using Choice Modelling. Choice Modelling Research Reports. Canberra: University of New South Wales; No. 6.

OECD (Organisation for Economic Co-operation and Development) (1999), Household Water Pricing in OECD Countries. Working Party on Economic and Environmental Policy Integration, ENC/EPOC/GEEI(98)12/FINAL, Environment Directorate, OECD, Paris.

OFWAT (2001), role of LRMC in the provision and regulation of water services, available at URL <http://www.ofwat.gov.uk/aptrix/ofwat/publish.nsf/AttachmentsbyTitle/lrmc_report_a.pdf/$File/lrmc_report_a.pdf> Accessed June 20th 2007.

Train, K., (1986), Qualitative Choice Analysis, Theory, *Econometrics and an Application to Automobile Demand*, MIT Press, London.

Turvey, R. (1976), Analyzing the marginal cost of water supply, *Land Economics*, 52(2), 165-168.

Tables

Table 1: Attributes levels in the choice sets and coding

Attribute	Levels	Variables and coding
Sprinkler days allowed per week	1 day per week	DAY3=0, DAY5=0
	3 days per week	DAY3=1, DAY5=0
	5 days per week	DAY3=0, DAY5=1
Duration of sprinkler restrictions (over period 2006-2016)	1 year in the next 10 years	DURA1=1, DURA5=0
	5 consecutive years in the next 10 years	DURA1=0,DURA5=1
	All 10 years for the next 10 years	DURA1=0,DURA5=0
Chance of a sprinkler ban	A 1 in 3 year chance	BAN110=0, BAN1200=0
	A 1 in 10 year	BAN110=1, BAN1200=0
	Never have a sprinkler ban	BAN110=0, BAN1200=1
Source of new supply	Second Desalination	DESAL=1, ROMAR=0, YARRA=0
	South West Yarragadee	DESAL=0, ROMAR=0, YARRA=1
	ROMAR	DESAL=0, ROMAR=1, YARRA=0
	No new source supply	DESAL=0, ROMAR=0, YARRA=0
Bill	No change	Bill = 1, 2, 3
	100% increase (double)	
	200% increase (triple)	

Table 2a: Socio economic variables (dummy variables) and the percentage of responses

Variable	Description	(%) total responses
OWN	OWN=1 if respondent owns a home (paid off mortgage)	27
BORE	BORE=1 if household has a bore	17
PENSION	PENSION=1 if respondent is a pensioner	19
EDU	EDU=1 if respondent has university education or more	38
AUTO	AUTO=1 if household has automatic reticulation	57
GEND	GEND=1 if male	37
KID14	KID14=1 if household has children under the age of 15	22

Table 2b: Descriptive statistics of socio-economic variables (continuous variables)

Variable	Description	Average	Std. Dev.
INC	Gross annual household income	72,446	43,287
PPL	Number of people in the household	2.8	1.3
AGE	Age of respondent	45.	12.5
WBILL	Annual water usage bill for the household (AU$)	260	217.4

Table 3: Parameter estimates of the conditional logit model

Variables	Coef.	Std. Err.	P>|z|	[95% Conf. Interval]	
DAY3	0.2478††	0.0921	0.0070	0.0673	0.4282
DAY5	0.0996	0.0940	0.2890	-0.0846	0.2839
DURA1	-0.1032	0.0971	0.2880	-0.2935	0.0871
DURA5	-0.0950	0.0957	0.3210	-0.2825	0.0926
BAN110	-0.0156	0.0649	0.8100	-0.1427	0.1115
BAN13	0.0072	0.0958	0.9400	-0.1806	0.1950
BILL	-1.1331††	0.0547	0.0000	-1.2404	-1.0258
DESAL	1.0094††	0.2365	0.0000	0.5458	1.4729
ROMAR	0.8578††	0.2339	0.0000	0.3993	1.3163
YARRA	0.9265††	0.2298	0.0000	0.4762	1.3768
SQ	1.0522††	0.3784	0.0050	0.3106	1.7938
SQ*INC	-2.1E-06†	9.2E-07	0.0220	-3.9E-06	-3.1E-07
SQ*AGE	-0.0160††	0.0032	0.0000	-0.0223	-0.0096
SQ*PPL	0.2154††	0.0341	0.0000	0.1485	0.2822
SQ*EDU	-0.5207††	0.1885	0.0060	-0.8901	-0.1512
SQ*AUTO	-1.0177††	0.2044	0.0000	-1.4184	-0.6170
SQ*KID14	-0.5722††	0.1061	0.0000	-0.7802	-0.3642
DESAL*EDU	-0.6423††	0.2145	0.0030	-1.0627	-0.2219
ROMAR*EDU	-0.0760	0.2092	0.7160	-0.4861	0.3341
YARRA*EDU	-0.5291†	0.2124	0.0130	-0.9454	-0.1127
DESAL*GEND	-0.1304	0.1220	0.2850	-0.3696	0.1088
ROMAR*GEND	0.2674†	0.1194	0.0250	0.0333	0.5015
YARRA*GEND	-0.0983	0.1226	0.4230	-0.3385	0.1420
DESAL*AUTO	-0.4670†	0.2289	0.0410	-0.9156	-0.0184
ROMAR*AUTO	-0.6673††	0.2247	0.0030	-1.1078	-0.2268
YARRA*AUTO	-0.4690†	0.2267	0.0390	-0.9134	-0.0247
Log likelihood	-2965.4224				
LR $chi^2(26)$	1405.69				
Prob > chi^2	0.0000				
Pseudo R^2	0.1916				
No of obs	10017				

†† indicates statistical significance at the 99% confidence level
† indicates statistical significance at the 95% confidence level

Table 4: Part-worth of different supply sources based on varying socio-economic groups

Gender	Education	Have automatic reticulation	WTP		
			DESAL	ROMAR	YARRA
Men	≥University	Yes			
Men	≥University	No		93%	
Men	< University	Yes	36%	40%	
Men	< University	No	78%	99%	73%
Women	≥University	Yes			
Women	≥University	No		69%	
Women	< University	Yes	48%		40%
Women	< University	No	89%	76%	82%

Table 5: Part-worth of alternative sources

Source	Part-worth (reported as % increase water usage bill)	
	Mean	Median
Desalination	51%	52%
ROMAR	59%	57%
Yarragadee	48%	48%

Figures

	Option I (Status Quo)	Option II	Option III
Water restriction days	Can use sprinklers 1 day per week	Can use sprinklers 3 days per week	Can use sprinklers 5 days per week
Water restriction duration	All 10 years for the next 10 years	All 10 years for the next 10 years	5 consecutive years in the next 10 years
Sprinkler ban	A 1 in 3 year chance of a total sprinkler ban	A 1 in 10 year chance of a total sprinkler ban	Never have a total sprinkler ban
Source supply	No new source supply	South West Yarragadee aquifer	Second desalination plant
Water bill	No change	100% increase	200% increase
Please select the button for the option you most prefer			
	Select here for Option I (Status Quo)	Select here for Option II	Select here for Option III
Select only one	☐	☐	☐

Figure 1 Example of a choice set as seen by respondents on the internet

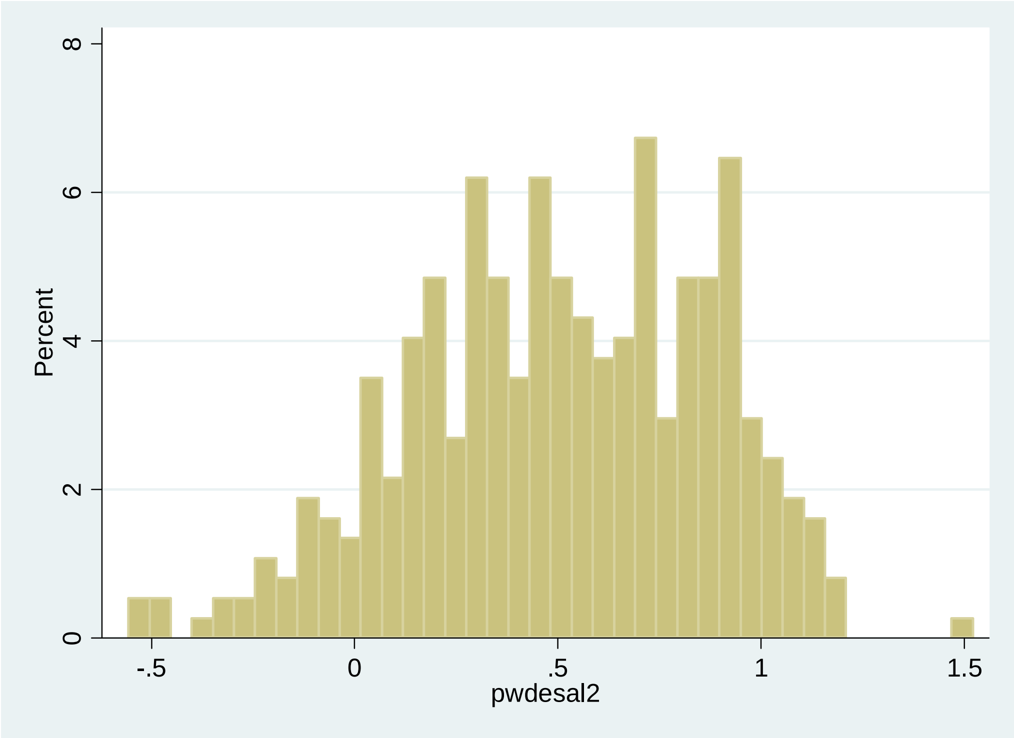

Figure 2a **Distribution of individual part-worths for source: Desalination plant**

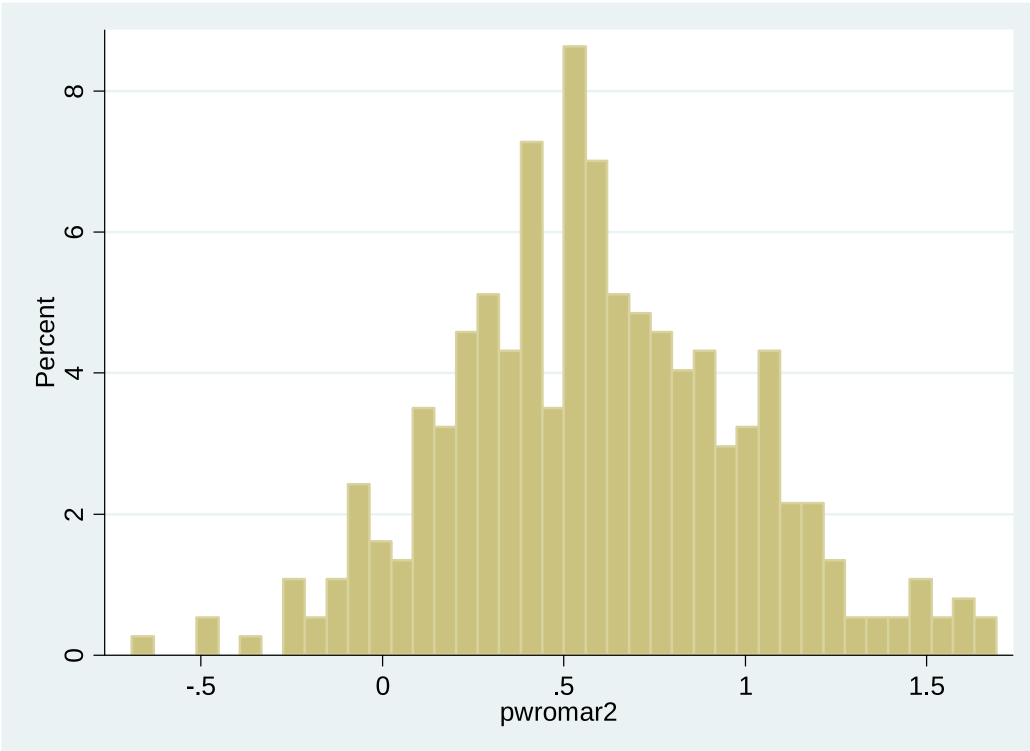

Figure 2b Distribution of individual part-worths for source: ROMAR

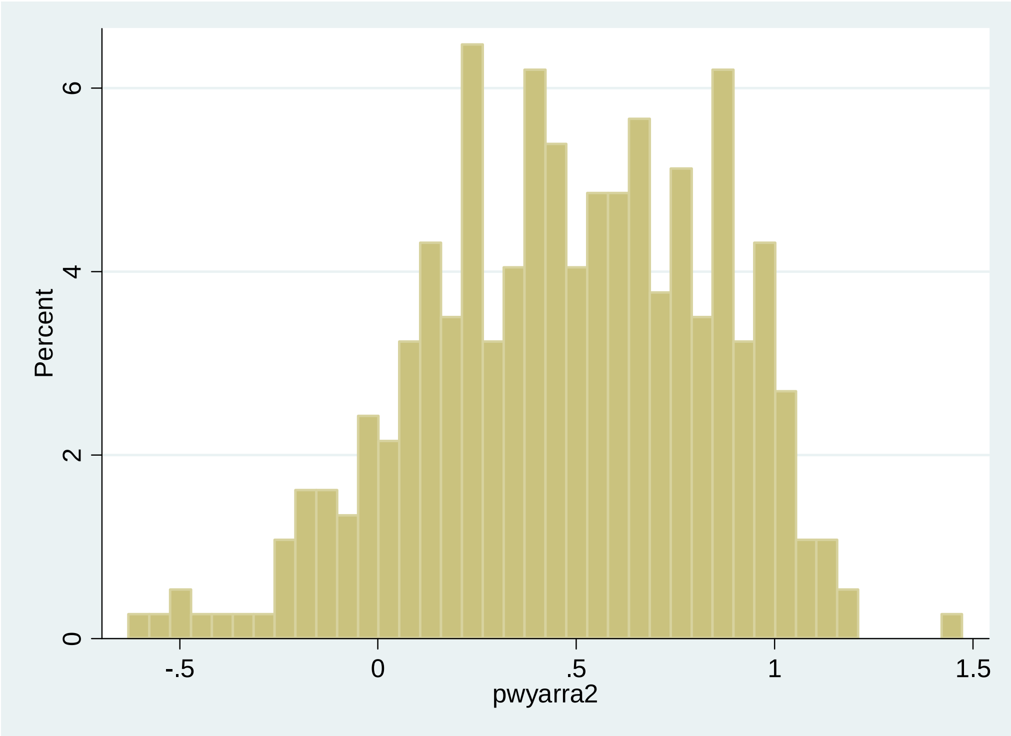

Figure 2c Distribution of individual part-worths for source: Yarragadee