

**ESTIMATING CONSUMER PREFERENCES FOR WATER QUALITY
IMPROVEMENTS USING A CITIZENS' JURY AND CHOICE MODELLING:
A case study on the Bremer River catchment, South East Queensland¹**

J.Robinson^{a,b}, B.Clouston^b and J.Suh^{a,c}

^a School of Economics, The University of Queensland

^b CRC for Coastal Zone, Estuary and Waterway Management

^c School of Economics and School of Natural and Rural Systems Management, The
University of Queensland

Email: Jackie.Robinson@nrm.qld.gov.au

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Abstract

An improvement in the water quality of the river systems flowing into Moreton Bay has been identified as a desirable goal for the management of the waterways of South East Queensland. To this end, the Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management (Coastal CRC) has undertaken numerous studies to monitor and model water quality in the rivers flowing into the Brisbane River and Moreton Bay. It is timely for this information to be disseminated to the community to establish if more resources should be devoted to improving water quality in catchment areas and under what terms. In addition, to determine the extent to which resources should be directed to water quality improvements, information about the willingness of the community to pay is required. This paper describes a study undertaken on the Bremer River catchment located within South East Queensland. The study informed members of the community about water quality issues in the catchment through a citizens' jury and then solicited their opinion about whether more resources should be devoted towards improving water quality and how much they thought the community should pay.

1. INTRODUCTION

Environmental management requires information to be provided by scientists to verify the extent and magnitude of perceived resource degradation. However, this information is not necessarily sufficient for government agencies to take action to avoid, reduce or minimise the degradation risks. Information is required that would determine if the expected benefits from taking action are at least equal to the costs. There is a real danger that if no quantitative measure of the value of environmental resources is available, then it could be perceived that they have little or no value to society and can therefore be exploited.

Identification and reconciliation of the trade-offs between the negative externalities created by urban and industry developments and protection of recreational areas, important natural habitat areas, biodiversity as well as areas of natural beauty is important. In a situation where there are competing potential users and uses of a scarce resource, the issue of optimal allocation arises. Where there is a competitive market functioning, the price mechanism will ensure an economically efficient allocation. Where markets do not exist or there is a failure of the market to value environmental resources, there is a need for techniques that estimate a value for these resources. Resource managers are likely to require information about the economic value of environmental resources in coastal areas to assist with identifying the appropriate use to which coastal and estuary resources should be put; to provide justification for management to protect environmental resources; to provide a basis for "polluter pays principles" to deter polluters; to assess the worth of environmental assets and finally to simply stimulate awareness of environmental issues.

Report outline

This report firstly provides a description of the Bremer River catchment, outlining the research question to be addressed. It then describes the application of the citizens' jury

approach as a participative tool for informed decision-making for the Bremer River catchment. The findings of the jury are presented also. The third section of this report describes and presents the findings from the choice modelling approach to valuing water quality improvements in the catchment. The concluding section outlines the major findings from the study and points out a number of limitations.

2. THE BREMER CASE STUDY

The Bremer River is a tidally influenced freshwater system that flows into the Brisbane River and then into Moreton Bay in South East Queensland. Ipswich is a major provincial centre for the Bremer River catchment located at ca 15 km upstream on the Bremer River. The Bremer River has been subject to a long history of chronic nutrient enrichment due to agricultural runoff and discharge from wastewater treatment plants and abattoirs located along the waterway distributed through the catchment (Chaloupka *et al.*, 2001).

A review of ABS statistics shows that the economy of the Bremer River catchment is growing, putting increasing pressure on the condition of environmental resources in the catchment. Between 1986 and 2000 the estimated resident population in the Bremer River catchment increased by approximately 16.8% to a little over 134,000 people. Between 1986 and 1996, employment in the catchment increased by 11.7% with over 17.5% of the total employment in the catchment in 1996 located in manufacturing industries. These industries are dominated by a number of abattoirs that discharge, with a license, treated effluent into the Bremer River. Licensed, point sourced, discharge accounts for only 40% of the discharge to the waterways. The remainder is sourced from storm water, agricultural runoff and unlicensed discharge.

A recent study on water quality in the Bremer River (Stratton, 2001) indicates that the water quality has deteriorated from an autotrophic condition (where the production of oxygen within the system meets the demand), to a heterotrophic system where the consumption of oxygen in the system is greater than production and has resulted in a loss of ecosystem services. If nothing is done to manage runoff or wastewater discharged directly or indirectly into the river, the 'do nothing' scenario, then it is likely that the river will continue to deteriorate and become increasingly heterotrophic. The appearance of the water quality in the Bremer, particularly in the Ipswich city precinct is extremely poor. Even without reference to the scientific reports on the water quality, the river is deep brown with mud and carries substantial amounts of floating debris that includes discarded rubbish.

Estimates of the costs to improve the quality of the water, including upgrading of sewerage treatment plants, improvement in the quality of wastewater discharged into the rivers by industry as well the cost of restoring or rehabilitating riparian vegetation, is generally available. Not all of these costs will be absorbed by industry or from the general revenue of local councils. The community will, either directly through local rates, or indirectly through reduced industry activity in an area, be asked to make a financial contribution to an improvement in water quality.

The question that decision-makers need to address is the level of improvement in water quality that would be affordable and best meet the needs of the community. In brief, the community needs to determine if more resources should be devoted to managing water

quality and, in relation to that, what is the community willing to pay for an improvement in water quality and for the ecosystem services an improvement will provide subsequently? In addition, and more importantly, it needs to be determined how the community would like additional resources to be used in the catchment. This information is required by authorities throughout South East Queensland charged with improving the quality of water in the river systems.

To address these issues in the Bremer River catchment, a citizen's jury was conducted to establish whether more resources should be devoted to improving water quality in the catchment and to determine citizens' preferences for management scenarios to improve water quality in the catchment. The jurors participating in the citizens' jury were required to respond to a charge as well as to complete a survey to value water quality improvements. By exposing respondents to intensive information provided by a number of experts modelling and monitoring the condition of the Bremer River, it was possible to use all of the available information on the catchment as well as facilitate a discursive approach to the valuation exercise. Respondents were provided with the opportunity to gain knowledge about the issues associated with water quality improvements in the Bremer, rather than simply being made aware, which is often the objective of survey-based valuation techniques. The outcome from the citizens' jury process is regarded as an 'informed' response to the charge and an informed and considered estimate of the willingness of the community to pay. In addition, by selecting jurors as a quota sample of the population in the Bremer River catchment, the number of respondents was reduced to a relatively small number.

3. CITIZENS' JURY AND RESPONSE TO THE CHARGE

Stakeholder participation in resource management, and this includes valuation of environmental resources, is an increasingly acceptable way to empower communities to be involved in decision-making. Citizens' jury is a deliberative form of public participation. This approach is an effective way to involve citizens in developing a thoughtful, well-informed solution to a public problem or issue. The Citizens' jury is based on the model used in Western-style criminal court proceedings. The great advantage of the Citizens jury process is that it yields citizen input from a group that is both informed and representative of the public. The Jefferson Centre (Minneapolis) has conducted Citizens jury projects since 1974 at the local, state and national levels. Citizens' juries are argued to go somewhat towards addressing environmental valuation techniques that rely on community surveys where attitudes, beliefs and preferences are often based on limited levels of information and with very little deliberation (Blamey *et al.*, 2000).

Closely related to public participation in valuation of the environment is the use of expert opinion. Although the knowledge base of survey respondents has been identified as a problem for stated preference approaches to valuation reliant on surveys, expert opinion, adopted as an alternative to population surveys, will only be as good as the information informing the experts and the skill of the experts. With respect to environmental valuation, the integrity of the expert opinion needs to be established as it could seriously impact on the degree of credibility and reliability of the valuation (Blamey, 1998). In addition, respondents should be given the opportunity to ask questions of the experts about the scientific viability of the environmental resources being considered.

If the estimated value for environmental improvement is to be transferred to other policy sites to assist management, then a citizens' jury has the capacity to provide the framework for meaningful community involvement. By selecting a jury as a quota sample of the affected population and informing the jury that their decisions would count and provide the direction for environmental management, it is possible to considerably reduce the biases inherent in general survey work. In addition, by calling in experts to provide 'evidence' to the jury and allowing discussion and feedback to take place between the jury and the experts, greater use is likely to be made of the available information.

The jury selected for the Bremer study was recruited through an advertisement in the local newspaper. The advertisement called for an expression of interest to participate in a citizens' jury "to be held on a matter of public importance". In brief, there was no indication at the time of recruitment that the issue to be addressed was one of water quality in the Bremer River catchment. There were 12 males and 11 females selected to stand on the jury. Jurors ranged between 16 years and 69 years of age, came from a range of income and education levels and, for the most part, their involvement in community groups with an interest in the environment was limited.

The jury was convened for two full days. Jurors were resident at a conference centre and were paid for their participation. The program for jurors included presentations from expert witnesses, group discussion periods and subsequent questions from jurors directed towards witnesses. Jurors were provided with the opportunity for informal discussion with expert witnesses over extended morning and afternoon tea breaks as well as over lunch. In short, jurors were encouraged and provided with the opportunity to seek all the information they required to help them to respond to the charge.

Selection of the expert witnesses was an important consideration. For the Bremer study, time constraints permitted only six witnesses to be called. They were chosen from a relatively large number of people working on water quality improvements in the catchment whose information was scientifically valid and whose opinion was regarded as reliable and credible. In short, although persons were identified who had an opinion to express about water quality management in the catchment, their opinion was regarded as eccentric and could not be substantiated by any scientific evidence. In a court of law, such people would have had an opportunity to express their opinion and for the defence or prosecuting barristers to expose deficiencies in their statements. The citizens' jury held for the Bremer study did not have that facility, only the jurors were given the opportunity to question witnesses. Witnesses included state and local government personnel involved in projects associated with improvements in water quality in the Bremer River catchment or in South East Queensland generally, scientists involved in research projects on water quality issues as well as representatives of industry, both manufacturing and agriculture, located in the catchment. Expert witnesses, their affiliation and a description of their presentation is provided in Table 1.

Table 1 Expert witness, their affiliation and description of presentation

Witness	Affiliation	Presentation
Jim Fewings	EPA	Introduction to SEQld waterways, current condition, science and current initiatives
Milani Chaloupka	Coastal CRC	The attributes of a healthy aquatic ecosystem. Why we need a healthy aquatic ecosystem. What ecosystem goods and services would be available with a healthy river.
Peter Pollard	Griffith University and Coastal CRC	Description of scientific modelling of Bremer and identification of sources of sediment and nutrient discharge
Geoff Faulkner	Ipswich City Council	Initiatives of Ipswich CC to repair and conserve riparian vegetation. Issues involved in repairing or restoring riparian areas, eg costs, cooperation of landowners
Neal House	AMH	What does this industry contribute to the local economy? What is this industry currently doing to assist the clean-up of the river?
Morris McInnes	Agricultural producer	What does the industry contribute to the local economy? What are farmers currently doing to assist the clean-up of the river? What are the constraints?

The charge

The charge given to the jury convened to consider water quality in the Bremer River catchment was:

Should the whole community (government, industry and individual citizens) be devoting more resources to improving water quality in the Bremer River catchment?

Jury response to the charge

Jury members agreed to the charge, or modifications to the charge, in principle. However, in so doing, they stipulated a number of caveats to their acceptance of the charge. These were:

- that additional information about discharge to the river was required. It was recommended that an audit be undertaken of diffuse sources of waste to the Bremer including unlicensed discharge from industry, storm water and from agricultural run-off
- that education of the whole community was imperative. Knowledge should be directed towards increasing individual responsibility for water quality in the catchment. In particular, education should be directed towards increasing awareness that relatively minor actions can impact on water quality.
- that there was a need to determine the extent to which more resources devoted to the environment would impact on other needs in society (opportunity cost of expenditure on water quality improvements).
- that an audit is required to identify the existing resources available to state and local authorities as well as catchment community organisations and research organisations including the Coastal CRC
- that there is a need to look for environmental improvements at least cost. It was emphasised that improvements in the condition of the environment might be achieved without an outlay of additional resources. This means that monetary outlays from the community are not the sole source of resources. It was considered that human resources provided voluntarily could make a valuable contribution.

Jurors were unanimous in accepting that the findings from the jury were to be made available to relevant state government agencies, the Ipswich City Council, Bremer River Catchment community groups and relevant CRCs.

On-going communication between scientists and the community was identified as a necessary requirement for successful implementation of water quality management policies. It was considered that more opportunities should be provided for partnerships to be developed between scientists working in the area and the community, addressing questions relevant to catchment management.

Jurors expressed concern about how additional resources, particularly those of a monetary nature sourced from local authority levies, were to be used. It was suggested that sub-goals be identified as stepping-stones to work towards the ultimate 2020 goal consistent with the South East Queensland Water Quality Management Strategy. For the community to see that the funding was achieving its goals it was suggested that a monitoring program be put in place with feedback to the community and that approval for continuation of funding be made in five yearly increments.

Also in relation to the direction of funding, jurors identified the need to make freehold landowners 'want' to fix the problem. That is, there needed to be an incentive for landowners to take up the required on-farm management tasks to improve water quality in the catchment. It was considered that existing funding initiatives (although good) only do part of the job.

In addition to the charge, jurors were requested to complete a survey to estimate the willingness of the community to pay for improvements in water quality.

4. VALUATION OF WATER QUALITY IMPROVEMENTS

The valuation technique identified as particularly appropriate for this study (see Robinson, 2001) is choice modelling. This technique was adopted for this study because it offers the opportunity to adopt the results for environmental value transfer or benefit transfer (BT) to other sites. In brief, the choice modelling approach estimates a demand function for water quality improvements as well as estimates of part-worths (that is, implicit prices), where the parts are comprised of attributes of water quality. By using repeated experiments and statistical analysis of the data, the researcher is able to estimate the influence of the different attributes on choices and hence utility. By including price as one of the attributes, willingness to pay (WTP) can be indirectly estimated from the choices made.

Although choice modelling surveys provide valuable information about the value of specific attributes of a resource, they suffer from many of the criticisms that have been levelled at stated preference surveys generally. These criticisms include bias in the quality and quantity of information supplied to respondents, on the welfare measure used (willingness to pay or willingness to accept compensation), and on the acceptability of the payment vehicle to respondents (Blamey, 1998).

Blamey *et al.*, (2000) have acknowledged two important shortcomings of stated preference techniques for environmental valuation that could lead to biased results. The first is undertaking valuations when the respondents have limited information. The

second is distinguishing between respondents who respond as citizens and respondents who respond as consumers. To address these shortcomings, Blamey *et al.*, support the “need for methods of public participation with stronger emphasis on information and deliberation” (p.7). They suggest that referenda-type surveys be replaced with citizens’ juries, where citizens act in the position of jurors representing the interests of others and are therefore assumed, “*ceteris paribus*, to feel greater responsibility to make a well-informed and deliberated decision than referendum voters” (p.13).

Respondents to a choice modelling survey are typically presented with several choice sets each containing a ‘do nothing’ or status quo option and a number of options or alternatives (see Table 2). Respondents are required to indicate the option within each choice set they prefer. Each option within a choice set is presented as a series of levels of specific attributes, where one attribute is the cost of implementation to the householder. The levels of the attributes describing the options are varied according to an experimental design that allows estimates of the relative importance of each attribute describing the options to be calculated.

Table 2 An example of a choice set presented to respondents

Attributes	Option A (current situation)	Option B	Option C
Length of river with riparian vegetation	30%	75%	45%
Length of river with aquatic vegetation	5%	50%	35%
Length of river with good or very good appearance	55%	70%	70%
Additional levy on Council rates (per year)	\$0	\$60	\$40

Please tick the box under the option you prefer

Focus groups or community discussion groups are recognised as a vital part of the determination of the attributes that should be included in the choice sets as well as to trial the survey design. For this study, the opinion of the community as well as scientific experts was sought. Community consultation identified the ecosystem attributes the community would like to see improved and the appropriate levels that these could be offered. Plausibility of the financial attribute and its acceptance by respondents, particularly with respect to the payment vehicle, was assessed through the focus group.

Scientific experts have identified the attributes of a healthy freshwater ecosystem habitat to include an abundance of submerged aquatic vegetation (SAV) comprised of macrophytes (aquatic plants), an abundance of emergent aquatic vegetation (EAV) comprised of grasses, sedges and reeds, as well as riparian vegetation, sandy beaches and clear water. The advantage of adopting bundles of these attributes of a healthy aquatic ecosystem for the choice sets representing different management options or regimes is that these attributes are readily identifiable and transferable to other sites. This is particularly important as the context for the Bremer study is to be able to use the information for the valuation of other sites. Standard attributes such as swimability or recreational fishing are not meaningful for many of the freshwater rivers in South East Queensland because there are numerous close substitutes available to households (Robinson, 2001).

The attributes that were included in the choice modelling survey on the Bremer River were selected by examining scientific reports that had been compiled on the current condition of the Bremer River and in collaboration with scientists working in the field. The monetary attribute was described to jurors as an additional levy per year on council rates. As everyone in the Bremer River catchment contributes, in some way, to the problems in the river it was thought that a levy was a suitable vehicle for collecting payment from all residents.

The current condition of the river was described as having:

- 30% of the total length of the streams and rivers in the catchment with riparian vegetation in moderate or better condition
- 5% of the total length of the streams and rivers in the catchment with aquatic vegetation in moderate condition
- 55% of the total length of the river with good or very good visual appearance
- \$0 levy on council rates per year as the levy would be additional to any other levies presently in place

The assignment of attribute levels to options or alternatives for valuation of water quality in the Bremer River catchment was designed to be consistent with an orthogonal experimental design². A fractional factorial (a selection of the available attribute level combinations making up the full factorial) was identified so that the main effects could be estimated. Four attributes were set at four levels across three options. Each choice set presented to respondents consisted of the status quo and two generic options. The adoption of a citizens' jury approach to conduct the survey restricted the number of attributes and levels of attributes that could be included in the choice sets. More specifically, as the number of attributes and levels of attributes increases, so too does the number of choice sets required to determine the main effects. It was considered that 27 choice sets were the upper limit for tolerance by individual respondents.

To determine the extent to which information has an impact on responses from respondents, jurors were requested to complete the choice modelling survey prior to the jury proceedings as well as at the conclusion of the proceedings. To complete the survey prior to the citizens' jury proceedings, jurors were provided with a written description about the water quality problems in the catchment and a description of each attribute. This information was consistent with the level of information ordinarily provided to survey respondents responding via other avenues of survey delivery such as postal survey. Each juror was presented with a booklet containing the background information and 27 choice sets. Questions were included designed to frame the survey within a bigger picture of public expenditure. As well, attitudinal questions and questions about respondent's socio-economic characteristics. The questionnaires, including the choice sets, were the same for all jurors and for the preliminary and final survey.

Modelling and analysis of the results

The statistical model adopted to estimate the relationship between jurors choices and the attributes of the options presented to the jurors was that the probability that a given option will be chosen is assumed to be a function of the expected utility, V , derived

² Orthogonality ensures there are no correlations between the attributes so that the separate importance of all attributes can be estimated through the choice model.

from the option in question and each of the other options in the choice set. The option offering the highest expected utility has the highest choice probability. For the purposes of this study, a nested logit (NL) model (McFadden, 1986) was adopted because it was determined that this model more closely represented the structure of the decision that jurors were likely to make.

The structure of the basic model is:

$$\begin{aligned} V_1 &= b_1 \text{dollars} + b_2 \text{riparian vegetation} + b_3 \text{aquatic vegetation} + b_4 \text{appearance} \\ V_2 &= C1 + b_1 \text{dollars} + b_2 \text{riparian vegetation} + b_3 \text{aquatic vegetation} + \\ & b_4 \text{appearance} \\ V_3 &= C1 + b_1 \text{dollars} + b_2 \text{riparian vegetation} + b_3 \text{aquatic vegetation} + \\ & b_4 \text{appearance} \end{aligned}$$

Where the variable C1 is the alternative specific constant for options 2 and 3.

The logit models that are best fitted to the two datasets are presented in Table 3. The statistical reliability of the final model is significantly better than that of the preliminary model. The R^2 of the final model is much higher than that of the preliminary model (0.276 and 0.149 respectively). The results from the final model are therefore more reliable for policy-makers.

Analysis of results from the NL model was used for this study to provide four sets of results. The first set of results show the equivalence of the models of jurors' preferences prior to and following the proceedings of the citizens' jury. The results show changes in the level of statistical reliability of the models. The second set of results indicated if the attitudes and socioeconomic characteristics of jurors influenced choice of option. Of particular importance for these results was the significance of education as a socioeconomic variable in the models prior to and following the citizens' jury. The third set of results provides estimates of the implicit prices for a percentage change in individual attributes. The fourth set shows the equivalence of the implicit prices estimated from the model of juror preferences prior to and following the proceedings of the jury. The last set of results provides an estimation of a monetary value for a number of hypothetical scenarios comprised of varying bundles of attributes.

Equivalence of models

Following the work of Swait and Louviere (1993) and Morrison *et al* (1998) a statistical test was conducted to determine the equivalence of the models prior to and at the conclusion of the citizens' jury. Following the work of Swait and Louviere (1993), it is possible to test the hypothesis that the two data sets are equal, except for differences in variance. The hypothesis to be tested is:

$$\begin{aligned} H_0: \beta_p &= \lambda \beta_f \\ H_1 \beta_p &\neq \lambda \beta_f \end{aligned}$$

Where β_p and β_f are the taste parameter vectors³ corresponding to the preliminary and final datasets, and λ represents the ratio of scale factors. The scale parameter (λ) is inversely related to the variance, but is confounded by the vector of utility parameters

³ The taste parameter vectors refer to the coefficients estimated from the logit models for an array of attributes.

(Swait and Louviere, 1993). The equivalence of the overall models is tested after allowing for differences in variance. It is not possible to estimate the scale parameter directly, however a method has been devised to identify the ratio of the scale parameter between two data sets. Morrison *et al.*, (1998) suggest that the ratio can be estimated by stacking the two datasets and conducting a one-dimensional grid search using different values for the scale parameter. When the log-likelihood of the nested logit model, using the stacked data, is maximized, the correct value of the scale parameter is found.

The Swait and Louviere (1993) test was used to determine whether the H_0 should be rejected.

The test statistic is:

$$LR = -2[L_{\lambda} - (L_p + L_f)] \quad [1]$$

where L_{λ} is the log-likelihood calculated using the combined data set that has been rescaled, L_p is the log-likelihood using the preliminary data set and L_f is the log-likelihood calculated using the final data set. This test statistic is asymptotically chi-squared distributed with $k-1$ degrees of freedom, where k is the number of attributes that are forced to be the same across data sets.

The log-likelihood values are presented in Table 3. Using the test statistic [1]:

$$-2[-886.3687 - (-483.3844 + -378.5327)] = 48.9032$$

The critical value of the χ^2 statistic at the 5% significance level is 7.81 with 3 degrees of freedom. The hypothesis of equality of the models is rejected. In short, this means that the models are statistically different from each other.

Table 3 Estimated coefficients of nested logit models

Variables	Preliminary	Final	Joint estimation (scaled)
C1	0.3596 (0.00)		-0.0341 (-0.122)
C2		-0.1667 (0.000)	0.546 (1.809)
Dollars	-0.0343 (-7.529) **	-0.0560 (-9.755) **	-0.0501 (-12.602) **
Riparian Vegetation	0.0470 (7.690) **	0.0825 (10.033) **	0.0657 (11.638) **
Aquatic Vegetation	0.0436 (7.824) **	0.0602 (8.697) **	0.0526 (10.286) **
Appearance	0.0209 (3.468) **	0.0208 (3.264) **	0.0207 (4.376) **
Summary Statistics			
Log-likelihood	-483.3844	-378.5327	-886.3687
Restricted log-likelihood (no coefficients)	-825.5338	-840.0944	-2225.365
χ^2	684.3078	923.1234	2677.993
R^2	0.1494	0.2768	0.6017
Optimal scale factor			0.80
No. of Observations	621	621	1242

Note: the numbers in parentheses are t -statistics

** denotes significant at the 1% level

Significance of socioeconomic and attitudinal interactions

To test if attitudes and socioeconomic characteristics influenced the choice of option, a number of these variables were included in the model, including education level and whether jurors were employed (work). It is not possible to include the socioeconomic and attitudinal variables directly in the utility functions, as they are invariant across the alternatives or options in a choice set. It is therefore necessary to estimate them interactively, either with one of the attributes from the choice set, or with the alternative specific constant (C1). The interactions with the attributes show how the variables modify the effect of attributes on the probability of choice (Morrison *et al.*, 1998).

The socioeconomic variables of education and employment (work) were interacted with the attribute dollars⁴. However, the incorporation of the interaction terms did not consistently improve the statistical reliability of the preliminary and final models. For example, Table 4 shows the results of the inclusion of the variables education and work interacted with dollars. While this model proved the best fit for the preliminary model, education was no longer significant at the 5% level in the final model.

Table 4 Nested logit models including interaction of education and work with dollars

Variable	Preliminary	Final
C1	0.6913 (0.000)	0.6447 (0.000)
Dollars	-0.0951 (-6.517) **	-0.0754 (-5.401) **
Riparian vegetation	0.0455 (6.851) **	0.0786 (9.637) **
Aquatic vegetation	0.0417 (6.696)**	0.0570 (8.313)**
Appearance	0.0183 (3.131) **	0.0201 (3.234) **
Dollars*education	0.0336 (4.229) **	0.0074 (0.892)
Dollars*work	0.0212 (2.683)**	-0.002 (2.246)*
Inclusive Values		
Do nothing	0.2126 (0.000)	0.3811 (0.000)
Do something	0.5237 (3.125)**	0.5779 (3.046) **
Summary Statistics		
Log-likelihood	-473.6354	-377.2674
χ^2	703.8057	925.6540
R^2	0.1665	0.2792
R^2 adjusted	0.1604	0.2739

Note: the numbers in parentheses are *t*-statistics

** denotes significant at the 1% level

* denotes significant at the 5% level

Interacting education with dollars provided a statistical improvement in the reliability of the preliminary model but not for the final model. This result is important as it suggests that education was a significant indication of choice prior to the citizens' jury. However, following the jury when all respondents had been provided with more detailed information with respect to the attributes, education was no longer significant. That is, the level of educational was no longer relevant as respondents based their choices on the information provided through the jury. The results for the model which included education interacted with dollars are provided in Table 5.

⁴ All variables were initially interacted with both the attribute variables and the alternative specific constants and were discarded if they were insignificant.

Table 5 Nested logit models including interaction of education with dollars

Variable	Preliminary	Final
C1	0.3540 (0.000)	0.2298 (0.000)
Dollars	-0.0861 (5.861) **	-0.0551 (-3.358) **
Riparian vegetation	0.0458 (7.480) **	0.0826 (9.280) **
Aquatic vegetation	0.0421 (7.472)**	0.0603 (3.415)
Appearance	0.0188 (3.188) **	0.2081 (3.415) **
Dollars*education	0.0327 (3.777)**	-0.0007 (-0.063)
Inclusive Values		
Do nothing	-0.00059 (0.000)	-0.3741 (0.000)
Do something	0.4380 (2.731)**	0.1927 (0.980)
Summary Statistics		
Log-likelihood	-477.1454	-378.5307
χ^2	696.7857	923.1274
R^2	0.1603	0.2758
R^2 adjusted	0.1549	0.2721

Note: the numbers in parentheses are *t*-statistics

** denotes significant at the 1% level

* denotes significant at the 5% level

Estimation of implicit prices

Extrapolating the coefficients estimated from the logit models for the preliminary and final surveys, as presented in Table 3, one can estimate the implicit prices for percentage changes in individual attributes. To derive the implicit prices, the coefficients of each attribute is divided by the coefficient of the dollar variable. Implicit prices provide a point estimate of the value of a unit change in an attribute. They are marginal values in the sense that they represent the value of a small change in one of the attributes dealt with in the questionnaire. The implicit price for each attribute is based on the *ceteris paribus* assumption, that all other attributes are held constant except for the attribute for which the implicit price is being calculated. Thus, implicit prices represent the amount, on average, that an individual is willing to pay for an additional unit of the attribute to be achieved. That is, implicit prices are an indication of the worth of environmental improvements for the individual. These implicit prices do not reflect the costs of achieving the environmental change. Implicit prices are useful for management decisions where information is required about the value of marginal changes in environmental quality, such as an increase in area under riparian vegetation or a percentage change in length of stream with aquatic vegetation. The information is useful also in identifying the relative importance people place on the different attributes. The implicit prices for the attributes are presented in Tables 6 and 7 for the preliminary and final surveys respectively.

Table 6 Implicit Prices– Preliminary Survey

Attribute	Implicit price
Increase by 1% the total length of the streams and rivers in the catchment with riparian vegetation in moderate or better condition	\$1.37
Increase by 1% the total length of the streams and rivers in the catchment with aquatic vegetation in moderate condition	\$1.27
Increase by 1% the total length of the river with good or very good visual appearance	\$0.61

Table 7 Implicit Prices–Final Survey

Attribute	Implicit price
Increase by 1% the total length of the streams and rivers in the catchment with riparian vegetation in moderate or better condition	\$1.47
Increase by 1% the total length of the streams and rivers in the catchment with aquatic vegetation in moderate condition	\$1.08
Increase by 1% the total length of the river with good or very good visual appearance	\$0.37

The implicit prices represent the estimated WTP for a 1% increase in one of the attributes. The highest WTP was for an increase of 1% of riparian vegetation with a value of \$1.37 for the preliminary survey and \$1.47 for the final survey. Thus, if the condition was to change from the present where there is 30% of the total length of the streams and rivers in the catchment with riparian vegetation in moderate or better condition to a situation where there is 60% of the total length of the streams and rivers in the catchment with riparian vegetation in moderate or better condition then, for the preliminary survey, the WTP would be \$41.10 (30 x \$1.37). For the final survey the estimated WTP to pay to increase riparian vegetation from 30% to 60% would be \$44.10.

Similar calculations can be made for the attributes of aquatic vegetation and visual appearance. The estimated WTP to increase aquatic vegetation along the length of river from its present state of 5% to say 50% would equal \$56.15 (for the initial survey). The implicit price of aquatic vegetation fell by \$0.19 per 1% change after receiving information through the citizens' jury. This is likely to be a reflection of the information provided by expert witnesses who stressed the importance of riparian vegetation. The implicit price of a 1% improvement in this attribute rose by \$0.10 per 1% change. The implicit prices also demonstrate that visual appearance was the least important of the attributes presented. The value for visual appearance dropped from an initial value of \$0.61 to a final value of \$0.37 per 1% change. This again reflects the information presented through the citizens' jury.

Equality of implicit price estimates

The fourth test focused on the equality of implicit prices for the preliminary and final models. If the information provided in the citizens' jury altered the importance of attributes, then implicit prices may also have altered.

Implicit prices and 95% confidence intervals for the two models are shown in Table 8. Each of three implicit prices has overlapping confidence intervals which indicates a degree of similarity. However, Morrison *et al.*, (1998) suggest that overlapping confidence levels provide an inaccurate test of equality of means and hence type II errors are more likely to occur.

An alternative test can be obtained from the combined data set where the coefficients of all variables are allowed to differ. With the stacked data set it is possible to test whether differences in implicit prices of attributes across surveys are different from zero. The hypothesis to be tested is:

$$H_0: IP_{ip} = IP_{if}$$

$$H_1: IP_{ip} \neq IP_{if}$$

Where IP_i is the implicit price of the non-monetary attribute i , and p and f represent the preliminary and final models respectively.

The equality of implicit prices can be tested by obtaining the standard errors of each implicit price. The standard errors were estimated using a *LIMDEP* (Greene, 1998) procedure called “WALD”, which automates the procedure of estimating standard errors for non-linear functions such as the marginal rates of substitution (Suh, 2001). To provide estimates of the standard errors for $(IP_{ip} - IP_{if})$, the WALD command was applied to the stacked data set. The t -statistics $(IP_{ip} - IP_{if})$, presented in the last row of Table 8, indicate whether the gap between IP_{ip} and IP_{if} is statistically significant (Suh, 2001). With a two-tailed hypothesis test, H_0 is rejected at the 5% significance level if the absolute value of the t -statistic is greater than the critical value 1.96 for an infinite sample size. As indicated in Table 8, the H_0 cannot be rejected for any of the attributes. Even though equivalence of the two models was rejected, the implicit prices can be statistically equivalent.

Table 8 Implicit prices and confidence intervals for the preliminary and final models

	Riparian Vegetation	Aquatic Vegetation	Appearance
Preliminary	\$1.37 (\$0.93, \$1.81)	\$1.27 (\$0.84, \$1.71)	\$0.61 (\$0.29, \$1.00)
Final	\$1.47 (\$1.15, \$1.79)	\$1.08 (\$0.79, \$1.36)	\$0.37 (\$0.14, \$0.60)
t-ratio	-0.473	0.706	0.935

Note: the numbers in parenthesis are the confidence intervals.

Although there was no statistical difference in the implicit prices estimated by the preliminary and final models, it is noted from Table 8 that the confidence intervals narrowed for the final survey. This may indicate that respondents’ preferences became more similar following the provision of information in the citizens’ jury. In other words, as the standard errors of the implicit prices from the final survey were smaller than those estimated from the preliminary survey, the results can be considered more reliable for policy makers.

Estimation of WTP for hypothetical scenarios

The fifth set of results enables an estimation of the WTP for a number of different scenarios for improving water quality. To estimate the overall willingness to pay for a change from the current to an alternative situation represents the consumer surplus. Thus, the consumer surplus can be estimated by:

$$CS = -\frac{1}{b_M}(V_C - V_N) \quad [2]$$

where b_M is the marginal utility of dollars; V_C represent the utility of the current situation, and V_N represents the utility of the new option.

Table 9 presents four hypothetical scenarios ranging from the current condition to an optimal outcome. Again, these values represent the estimated benefits in monetary

terms to the jurors of an improvement in water quality in the Bremer River. They do not reflect the costs of achieving the improvements. Nevertheless, the willingness to pay for the differing scenarios provides information for decision-makers on the worth of the improvements which can be weighed against the costs.

Table 9 Willingness to Pay to Improve Water Quality in the Bremer River (from the Current Situation)

SCENARIO	Riparian Vegetation (% of total length of river)	Aquatic Vegetation (% of total length of river)	Appearance (% of total length of river)	Willingness to Pay (\$)
1 Do Nothing (Current)	30	5	55	0
2 Minimal Improvement	45	5	60	21
3 Moderate Improvement	50	10	65	36
4 Substantial improvement	75	20	75	87

Note: Estimates derived from the final survey.

For example, a moderate improvement in the health of the Bremer River is given as:

- 50% of the total length of the streams and rivers in the catchment with riparian vegetation in moderate or better condition (20% increase)
- 10% of the total length of the streams and rivers in the catchment with aquatic vegetation in moderate condition (5% increase)
- 65% of the total length of the river with good or very good visual appearance (10% increase).

The estimated benefit to the jurors, who are representative of households in the catchment, of a moderate improvement is \$36 per annum. This is the amount that they would be willing to pay per year to achieve the improvement from the current situation. The other scenarios can be interpreted in a similar way. It is clear from Table 9 that there are considerable estimated benefits for citizens from an improvement in the water quality of the Bremer River.

5. CONCLUDING COMMENTS

The citizens' jury held on water quality in the Bremer River catchment has provided valuable information to decision makers. Communication of scientific research to the community to enable informed contribution to decision-making is one of the research objectives of the Coastal CRC. The citizens' jury is one tool in a whole toolkit of approaches to discursive communication. For this study, the citizens' jury was used to disseminate valuable information to a group of people from the Bremer River catchment. For the most part, these people were not ordinarily involved in community organizations. In short, they were ordinary citizens of the area.

The caveats or conditions jurors stipulated in response to the charge were, in many ways, more meaningful for decision-makers than acceptance or rejection of the charge. Of particular interest is the emphasis the jury placed on directing additional resources

towards education of the community about water quality issues. This can be interpreted as a positive response to the quality of information they received from the expert witnesses.

A valuable role for the proceedings of the jury with respect to valuation of the environment was in framing the valuation of water quality in the catchment in the context of how authorities were currently directing expenditure and the opportunity cost associated with changes to expenditure. Rolfe *et al.*, (2002) have suggested that the framing effects associated with non-market valuation studies may be widespread, a situation that might bias WTP estimates upward. One of the recommendations from the jury was to determine the extent to which more resources devoted to the environment would impact on other needs in society. In brief, the citizens' jury made respondents aware of the context for the valuation and in particular about the substitute goods and trade-offs implicit in their choice of option.

Choice modelling exercises held in conjunction with a citizens' jury have the capacity to provide reliable and useful information for policy makers. From the estimation of implicit prices it appears that citizens place greatest importance on improvements in riparian vegetation as a means to improve water quality in the Bremer River than the other attributes provided in this study. This information provides decision-makers with a basis on which they could develop management actions, most important to the citizens in the Bremer River catchment, to improve water quality. The results of the survey also provide information on the benefits of improving water quality for four different scenarios. This allows decision-makers to balance these estimated benefits with the costs and feasibility of achieving these outcomes.

A key finding from the citizens' jury approach to conducting a choice modelling valuation of water quality improvements was that the socioeconomic variable, education, was no longer statistically significant following the citizens' jury process. This finding is important considering that there is *a priori* expectation that the education factor produces significant effects on contingent valuation results.

In addition, the statistical reliability of the final model is significantly better than that of the preliminary model, given that the R^2 of the final model is much higher than that of the preliminary model (0.276 and 0.149 respectively). This means that the information provided to jurors during the citizens' jury was helpful to formulate the choices of respondents. The results from the final model are therefore more reliable for policy-makers and of greater relevance for choice modelling applications for other studies and for environmental value transfer to other policy sites.

One of the limitations associated with this approach includes the constraints imposed on the number of attributes that were included in the choice sets. As the number of attributes increases, so too does the number of choice sets provided to individual respondents. It would have been helpful if additional attributes related to use values for the river could have been included, but this would have resulted in an exorbitant number of choice sets. If the survey had been conducted on the population of the Bremer as a whole, then a blocked factorial would have been appropriate. Multiple citizens' juries conducted on the same issue with the same expert witnesses was an alternative that was not considered. Related to the number of choice sets is the management of implausible or dominant options. Within the citizens' jury, jurors could be alerted to the possibility

of these occurring so that they were better able to accommodate these options, an opportunity not necessarily available to respondents for mail-out surveys.

Another limitation of this approach is the difficulty of selecting a jury that is a true stratified random sample of the relevant population. Ordinarily, approximately 14 jurors would have been an appropriate number but for this study, 23 jurors sat on the jury. The number was increased to establish statistically meaningful results from the valuation survey. It would have been particularly difficult to select a jury that could confidently be described as a stratified random sample. Quota sampling was adopted as an alternative approach but this might have resulted in a degree of bias as those who responded to the advertisement were those who received the local newspaper and who were able to reside at the conference center. This may have deterred others, those with family commitments, from participating.

Finally, conducting the valuation survey through a citizens' jury, with limited respondents, means that although it would be misleading to extrapolate the results to the population as a whole, it is possible to make inferences about how the population might value water quality improvements. In short, the information provided from a citizens' jury should not be used in situations where compensation issues are involved, but it would be appropriate for policy formation.

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