

ESTIMATING PREFERENCES FOR WATER QUALITY IMPROVEMENTS USING A CITIZENS' JURY AND CHOICE MODELLING: A CASE STUDY ON THE BREMER RIVER CATCHMENT, SOUTH EAST QUEENSLAND

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J. Robinson, B. Clouston & J. Suh

Abstract:

This paper describes a study undertaken on the Bremer River catchment in 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. A choice modelling survey was conducted prior to and at the conclusion of the citizens' jury. The jury accepted that more resources should be devoted to improving water quality in the catchment, making a number of pertinent recommendations about how and where additional resources should be directed. In addition, the jury indicated that, in terms of willingness to pay, riparian vegetation was an important ecosystem attribute. Although the preliminary and final models derived for the choice modelling exercise indicate that the models were not equivalent, there was no statistical difference in the implicit prices between the two models. Nevertheless, the confidence interval of the implicit prices narrowed following the provision of information in the citizens' jury and there was an improvement in the statistical reliability of the model.

1. INTRODUCTION

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 the catchment and if so under what terms. In this regard, information about the willingness of the community to pay is required to determine the extent to which resources should be directed to water quality improvements.

Environmental management requires information to be provided by scientists to verify the scope and magnitude of perceived resource degradation. However, this information is not necessarily sufficient for government agencies to take action to avoid, reduce or minimise degradation risks. 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.

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 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 and mechanisms to deter polluters; to assess the worth of environmental assets; and finally, to simply stimulate awareness of environmental issues.

The valuation technique identified as particularly appropriate for this study is choice modelling (Robinson, 2001). In brief, the choice modelling approach estimates a demand function for water quality improvements and 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 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. For example, Blamey *et al.*, (2000) acknowledged two important shortcomings that could lead to biased results, by undertaking valuations when the respondents have limited information and, distinguishing between respondents who respond as citizens and those who respond as consumers. To address these shortcomings, Blamey *et al.*, (2000) support the “need for methods of public participation with stronger emphasis on information and deliberation” (p. 7). They suggested 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). Rolfe *et al.*, (2002) suggested that stated preference valuations may be biased due to framing effects such that the context for stating preferences differs from the setting that would occur under normal decision processes. Within the citizens’ jury framework, opportunities are available for framing the good or service within a policy context and reducing possible bias.

The remainder of this paper is divided into six sections. The next section provides a description of the Bremer River catchment, outlining the research question to be addressed. Section three 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. Section 4 outlines the development of the choice modelling survey as a valuation instrument for this study. Section five provides a comparison of the estimated logit models, prior to and proceeding the citizens' jury. The sixth section provides information on the implicit prices derived from the models and presents the WTP for a number of hypothetical scenarios. The concluding section outlines the major findings from the study and identifies a number of limitations of this study.

2. THE RESOURCE PROBLEM IN THE BREMER RIVER CATCHMENT

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 approximately 15 km upstream from the junction of the Bremer and Brisbane Rivers. 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 throughout the catchment (Chaloupka *et al.*, 2001).

A review of ABS statistics reveals 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 and point-source discharge accounts for only 40% of the discharge to the waterways. The remainder is storm water, agricultural runoff and unlicensed discharge.

A recent study on water quality in the Bremer River (Stratton, 2001) indicated 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 sediment and carries substantial amounts of floating debris including discarded rubbish.

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

The question that decision-makers in the Bremer catchment need to address is the level of improvement in water quality that would be affordable and best meet the needs of the community. Thus the community needs to be able to indicate if more resources should be

devoted to managing water quality and, in relation to that, what the community is willing to pay for an improvement in water quality and subsequent improvements in ecosystem services. More importantly, it needs to be determined how the community would like additional resources to be used in the catchment. This information is required also by authorities throughout south east Queensland charged with improving the quality of water in the river systems.

3. CITIZENS' JURY AND RESPONSE TO THE CHARGE

The citizens' jury is a deliberative form of public participation which can be used to involve the community in informed decision-making. The Jefferson Centre (Minneapolis) has conducted citizens' jury projects since 1974 at the local, state and national levels. The citizens' jury is based on the model used in Western-style criminal court proceedings. This approach is an effective way to involve citizens in developing a thoughtful and well-informed solution to a public problem or issue. 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. Citizens' juries address a number of the problems associated with environmental valuation techniques that rely on community surveys where attitudes, beliefs and preferences are often based on limited levels of information and with little deliberation (Blamey *et al.*, 2000).

Closely related to public participation in valuation of the environment is the use of expert opinion. The integrity of the expert opinion needs to be established as this could seriously impact on the degree of credibility and reliability of the information supporting the valuation. In addition, respondents should be given the opportunity to ask questions of the experts to enable them to respond to the charge (an opportunity not traditionally provided in Western-style courts of law).

To address the water quality issues in the Bremer River catchment, a citizens' 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 jury was selected as a quota sample¹ of the affected population. The participants were required to respond to a specific question about water quality improvements (hereafter termed 'the charge') as well as to complete a survey to value water quality improvements. By exposing respondents to intensive scientific information provided by a number of experts modelling and monitoring the condition of the Bremer River, it was possible to use the available information on the catchment as well as to facilitate a discursive approach to the valuation exercise. Respondents (jurors) were provided with the opportunity to gain an in-depth understanding about the issues associated with water quality improvements in the Bremer, rather than being presented with limited information which is often the case with survey-based valuation techniques. The outcome from the citizens' jury is regarded as an 'informed' response to the charge and an informed and considered estimate of the willingness of the community to pay.

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 from responses to the advertisement to stand on the jury. Jurors' ages ranged between 16 years and 69 years and they came from a range of income and education levels; for the most part, their prior involvement in community groups with an interest in the environment was limited. Members of the jury

¹ A quota sample was adopted for this study based on the population profile of the Bremer catchment.

were not people normally involved in public sector decision-making. They were not involved in community organizations or local action groups that might have a vested interest in the outcome or, and more importantly, likely to use the outcomes from the jury process for rent seeking activities.

The jury was convened for two full days. Jurors were resident at a conference centre and were paid a nominal fee for their participation. The program for jurors included presentations from expert witnesses, group discussion periods and time for questions from jurors directed towards witnesses. Jurors were provided also with the opportunity for informal discussion with expert witnesses. In short, jurors were encouraged and provided with the opportunity to seek all of the information they required to help them to respond to the charge.

Selection of the expert witnesses was an important consideration. Time constraints permitted only six witnesses to be called. 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. They were chosen from a relatively large number of people whose information was based on scientific research regarded by their peers as reliable and credible.

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 doing so, they stipulated a number of caveats to their acceptance. These were:

- that additional information about discharge to the river is 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 to increase their awareness that relatively minor actions can adversely affect water quality is imperative. Knowledge should be directed towards increasing individual responsibility for water quality in the catchment.
- that there is a need to determine the opportunity cost of expenditure on water quality improvements, particularly in relation to other demands on the funds of the local authority.
- that an audit is required to identify the existing financial and research resources available to state and local authorities as well as catchment community and research organizations.
- that there is a need to achieve environmental improvements at least cost. It was emphasised that improvements in the condition of the environment might be achieved without financial outlay for additional 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 cooperative research centers (CRC).

Continuing 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 to work towards the ultimate 2020 goal consistent with the South East Queensland Water Quality Management Strategy. Further, it was suggested that a program to monitor water quality improvements be put in place. Approval for continuation of funding should be made in five yearly increments contingent on meeting the identified sub-goals. In relation to the direction of funding, jurors identified the need for market-based incentives to be introduced for landowners to take up the required land management tasks to improve water quality in the catchment.

4. DEVELOPMENT OF THE CHOICE MODELLING QUESTIONNAIRE

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

The design of the choice sets is an important component of choice modelling exercises. This includes selection of attributes and levels, the options to be presented and the experimental design. Jurors responding to the survey were presented with choice sets, each containing a ‘do-nothing’ or *status quo* option and two alternatives, as presented in Table 1. They were

requested to indicate the option within each choice set that they preferred. Each option within a choice set was presented as a series of levels of specific attributes, where one attribute was the cost of implementation to the householder. The levels of the attributes describing the options were designed to vary in accordance with an experimental design that allows estimates of the relative importance of each attribute describing the options to be calculated.

Table 1 An example of a choice set presented to respondents

Attribute	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	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Focus groups or community discussion groups are recognised as providing a valuable opportunity to identify and determine the appropriateness of the attributes to be included in the choice sets as well as to test the survey design. For this study, the opinion of scientific experts as well as the community was sought.

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. For the purpose of this study, three ecosystem attributes the community would like to see improved were selected. The appropriate levels that these could be offered to survey respondents and the plausibility of the financial attribute and its acceptance by respondents, particularly with respect to the payment vehicle, was assessed through a focus group of eight people who were members of the Rural Consultative Committee supported by the local council.

The selected attributes were, riparian vegetation and aquatic vegetation (as described previously) as well as visual appearance which was defined for this study as an absence of floating rubbish, oil, grease and substances from effluent and stormwater runoff that produces an undesirable muddy colour, taste or foaming. Standard attributes such as swimability or recreational fishing are not meaningful in this area because the number of people taking up these options is minimal, primarily due to the availability of close substitutes (Robinson, 2001). The monetary attribute was described to jurors as an additional levy per year on council rates, the proceeds of which would be quarantined for managing water quality in the catchment.

The *status quo* 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; and
- \$0 levy on council rates per year

The assignment of attribute levels to options for valuation of water quality in the Bremer River catchment was designed to be consistent with an orthogonal experimental design.² A fractional factorial (i.e. a sub-set of the available attribute level combinations making up the full factorial) was identified so that the main effects could be estimated. Four attributes (including the levy) 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 the citizens'

² Orthogonality ensures the separate importance of all attributes can be estimated through the choice model.

jury approach to conduct the survey restricted the number of attributes and levels of attributes that could be included in the choice sets. It was considered that a questionnaire comprised of 27 choice sets was 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. The questionnaires were the same for all jurors and for the preliminary and final survey. 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 answering surveys 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. Preliminary questions were designed to frame the survey within a wider picture of public expenditure. As well, attitudinal questions and questions about respondent's socio-economic characteristics were included.

5. COMPARISON OF ESTIMATED LOGIT MODELS, PRIOR TO AND PROCEEDING THE CITIZENS' JURY

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 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 model, as described by 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 attributes included as variables determining utility in the nested logit model were RIPARIAN VEGETATION, AQUATIC VEGETATION, and APPEARANCE. The levy attribute was included as the variable DOLLAR. In addition, an alternative specific constant was included in the utility functions for options B and C.

The logit models that best fit the two datasets are presented in Table 2. As revealed in Table 2, the statistical reliability of the final model is better than that of the preliminary model. The R^2 of the final model is higher than that of the preliminary model (0.276 as against 0.149). This suggests that the final model is more reliable for policy formation.

The results from the nested logit model were used to test for the equivalence of the models of jurors' preferences prior to and following the proceedings of the citizens' jury. The influence of attitudes and the socioeconomic characteristics of jurors on choice of option was also examined. Of particular importance for these results was the change in the significance of EDUCATION as a socioeconomic variable in the models prior to and following the citizens' jury.

Equivalence test of the two models

The equivalence test of the two models to determine the equivalence of the models prior to and at the conclusion of the citizens' jury followed the work of Swait and Louviere (1993) and Morrison *et al.*, (1998). Following 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:

$$H_0: \beta_p = \lambda\beta_f \quad (1)$$

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

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

The test statistic is:

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

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. Here, $LR = -2[-886.3687 - (-483.3844 + -378.5327)] = 48.9032$. The log-likelihood values are presented in Table 2.

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, and it is concluded that the models are different from each other.

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

Table 2 Estimated coefficients of nested logit models

Variable	Preliminary model	Final model	Joint estimation (scaled)
C ₁	0.3596 (0.00)		-0.0341 (-0.122)
C ₂		-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) **
<i>Summary Statistics</i>			
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.
 ** 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 variables were included in the model, including education level (EDUCATION) and the employment status of jurors (WORK). As it is not possible to include the socioeconomic and attitudinal variables directly in the utility functions, because they are invariant across the options in a choice set, it is 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 WORK were interacted with the variable DOLLARS.⁴ However, the incorporation of the interaction terms did not consistently

⁴ All variables were initially included as interactions with both the attribute variables and the alternative specific constants and were discarded if they were non-significant.

improve the statistical reliability of the preliminary and final models. For example, Table 3 shows the results of the inclusion of the variables EDUCATION and WORK interacted with DOLLARS. While this specification proved the best fit for the preliminary model, EDUCATION was no longer significant at the 5% level for the final model.

Table 3 Nested logit models including interaction of EDUCATION and WORK with DOLLARS

Variable	Preliminary model	Final model
C_1	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)*
<i>Inclusive Values</i>		
Do-nothing	0.2126 (0.000)	0.3811 (0.000)
Do-something	0.5237 (3.125)**	0.5779 (3.046) **
<i>Summary Statistics</i>		
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.

** significant at the 1% level.

* significant at the 5% level.

Inclusion of the variable EDUCATION interacted with DOLLARS produced a statistical improvement (in terms of the adjusted R^2) in the reliability of the preliminary model but not for the final model. This result is important because whereas the EDUCATION coefficient was significant for the preliminary model it was no longer significant for the final model when all respondents had been provided with more detailed information with respect to the attributes. That is, it could be concluded that the level of education was no longer relevant as respondents based their choices on the information provided through the jury. The results for this model which included EDUCATION interacted with DOLLARS are provided in Table 4.

Table 4 Nested logit models including interaction of EDUCATION with DOLLARS

Variable	Preliminary model	Final model
C ₁	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)
<i>Inclusive Values</i>		
Do-nothing	-0.0.0059 (0.000)	-0.3741 (0.000)
Do-something	0.4380 (2.731)**	0.1927 (0.980)
<i>Summary Statistics</i>		
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.

** significant at the 1% level.

* significant at the 5% level.

6. VALUATION OF WATER QUALITY IMPROVEMENTS

The coefficients estimated from the logit models for the preliminary and final surveys, as presented in Table 2, were used to estimate the implicit prices for percentage changes in individual attributes. Further, the results of these logit models enabled the estimation of WTP for a number of distinct scenarios for improving water quality. The estimates presented in Tables 2 and 5 are used to obtain these welfare measures.

6.1 Estimation of implicit prices for individual attributes

To derive the implicit prices for individual attributes, the coefficient of each variable is divided by the coefficient of the DOLLAR variable (the levy attribute). Implicit prices provide a point estimate of the value of a one unit change in the level of an attribute. They are marginal values in the sense that they represent the value of a small change in one of the attributes. The implicit price for each attribute is based on the assumptions that all other attributes are held constant except for the attribute for which the implicit price is being

calculated, and that the marginal utility of each attribute remains at the same level. Thus, implicit prices represent the amount, on average, that an individual is willing to pay for an additional unit of the attribute. That is, implicit prices are an indication of the worth of environmental improvements for the average individual. These implicit prices do not take into account 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 a 1% increase in the area under riparian vegetation or a 1% change in length of stream with aquatic vegetation. The information is useful also in identifying the relative importance people place on the various attributes and can assist policy-makers to devise management regimes that best meet the preferences of the community. The implicit prices for the preliminary and final surveys are presented in Table 5. 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.

Table 5 Implicit prices and confidence intervals of the attributes for the preliminary and final models

	Riparian vegetation	Aquatic vegetation	Appearance
Preliminary model	\$1.37 (\$0.93, \$1.81)	\$1.27 (\$0.84, \$1.71)	\$0.61 (\$0.29, \$1.00)
Final model	\$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: Numbers in parenthesis are lower and upper 95% confidence bounds.

Estimates of the implicit prices for the attributes differ between the preliminary and final surveys. For example, the implicit price for RIPARIAN VEGETATION increased such that a 1% improvement in this attribute rose by \$0.10 per 1% change and the estimated implicit price for AQUATIC VEGETATION fell by \$0.19 per 1% change after receiving information through the citizens' jury. The implicit prices also demonstrate that APPEARANCE was the least important of the attributes presented. The value for APPEARANCE dropped from an

initial value of \$0.61 to a final value of \$0.37 per 1% change. Changes in the implicit prices is likely to be a reflection of the information presented through the citizens' jury.

The equality of implicit prices for the preliminary and final models was tested for statistical similarity. Implicit prices and 95% confidence intervals for the two models are reported in Table 5. 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 unreliable test of equality of means and may result in Type II errors.

An alternative test can be carried out with 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:

$$H_0: IP_{ip} = IP_{if} \quad (4)$$

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 marginal rates of substitution.⁵ 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 for $(IP_{ip} - IP_{if})$, presented in the last row of Table 5, indicate whether the gap between IP_{ip} and IP_{if} is statistically significant. With a two-tailed hypothesis test, H_0 is rejected at the 5%

⁵ Additional discussion and an example of an application of this approach is provided by Suh (2001).

significance level if the absolute value of the t -statistic is greater than the critical value 1.96. As indicated in Table 5, the H_0 cannot be rejected for any of the attributes.

Although there was no statistical difference in the implicit prices estimated by the preliminary and final models, it is noted from Table 5 that the confidence intervals narrowed for the final survey. This could be an indication that respondents' preferences became more similar following the provision of information in the citizens' jury. This implies that as the standard errors of the implicit prices from the final survey were smaller than those estimated from the preliminary survey, the results would be more reliable for policy makers.

6.2 Estimation of willingness-to-pay for hypothetical scenarios

The results presented in Tables 2 and 5 enable an estimation of the WTP for a number of scenarios for improving water quality. Estimation of the overall WTP for a change from the current to an alternative situation represents the change in consumer surplus. Thus, the consumer surplus can be estimated by:

$$CS = -\frac{1}{b_M}(V_C - V_N) \quad (5)$$

where b_M is the coefficient of DOLLARS; V_C represent the utility of the current situation, and V_N represents the utility of the new option (Hanemann, 1984; Morrison *et al.*, 1999).

Table 6 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 take into account the costs of achieving the improvements. Nevertheless, the WTP for the scenarios provides

information for decision-makers on the worth of the improvements which can be weighed against the costs.

Table 6 Willingness to Pay to improve water quality in the Bremer River from the current situation derived from the final survey

Scenario	Riparian Vegetation (% of total length of river)	Aquatic vegetation (% of total length of river)	Appearance (% of total length of river)	Willingness to pay (\$)
Do-nothing (current)	30	5	55	0
Minimal Improvement	45	5	60	21
Moderate Improvement	50	10	65	36
Substantial improvement	75	20	75	87

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

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

The estimated benefit to the jurors, who are representative of households in the catchment, of a hypothetical moderate improvement is \$36 per household per annum. This is the amount that they would be willing to pay per year to achieve the improvement from the current situation. It is clear from Table 6 that there is considerable scope for benefit for citizens from an improvement in the water quality of the Bremer River.

7. DISCUSSION OF RESULTS AND 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 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 decision-making.

The caveats jurors stipulated in response to the charge are particularly meaningful for decision-makers. 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 high quality of information they received from the expert witnesses and a positive response to the experience of sitting on the jury.

A valuable role for the proceedings of the jury, with respect to valuation of the environment, was framing the valuation of water quality in the catchment in the context of how authorities are currently directing expenditure and the opportunity cost associated with changes to expenditure. One of the recommendations from the jury was to determine the extent to which more resources devoted to the environment would affect resources available to meet other needs. In brief, the citizens' jury increased the level of awareness of respondents about 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 to improve water quality that would best meet the preferences of the citizens in the Bremer River catchment. The results of the survey also provide information on the benefits of improving water quality for a number of distinct hypothetical scenarios. This information allows decision-makers to balance these estimated benefits with the costs and feasibility of achieving specific outcomes.

A key finding from the citizens' jury approach to conducting a choice modelling valuation of water quality improvements is 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 affects contingent valuation results.

The statistical reliability of the final model is better than that of the preliminary model, given that the R^2 increased from 0.149 to 0.276. This suggests that the information provided to jurors during the citizens' jury was helpful to formulate the choices of respondents. The findings from the final model are therefore more reliable for policy-makers.

One of the limitations associated with this approach includes the limited number of attributes that were included in the choice sets. As the number of attributes increases, so 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 excessive number of choice sets. If the survey had been conducted on the population of the Bremer catchment 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 due to logistical problems associated with assembling the expert witnesses. 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 as to be better able to accommodate these options, an opportunity not necessarily available to respondents in mail-out surveys.

Another limitation of this approach is the difficulty of selecting a jury that could confidently be described as a stratified random sample of the relevant population. 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. The timing (over a weekend) and duration of the jury proceedings may have deterred others, such as those with family commitments, from participating. Ordinarily, approximately 14 jurors would have been an appropriate number, but 23 jurors sat on the jury for this study. The number was increased to establish statistically meaningful results from the valuation survey.

Finally, conducting the valuation survey through a citizens' jury means that although it would be misleading to extrapolate the results to the population as a whole due to the small number of respondents, 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 to assist in policy formation.

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