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Testing for value stability with a meta-analysis of choice experiments: River health in Australia

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Abstract

While meta-analysis is typically used to identify value estimates for benefit transfer, applications also provide insights into the potential influence of design, study and methodological factors on results of non-market valuation experiments. In this paper, a meta-analysis of sixteen separate choice modelling studies in Australia with 130 individual value estimates relating to river health are reported. The studies involved different measures and scales of river health, so consistency was generated by transforming implicit prices from each study into a common standard of WTP per kilometer of river in good health. Tobit models have been used to identify the relationships between the dependent variable (WTP/km) and a number of variables.

The results demonstrate that values are sensitive to marginal effects, with lower WTP/km for larger catchments, and higher WTP/km when river health is in decline. Values are also lower when river health has been defined by a subset of benefit types, such as recreation uses, vegetation health, fish health or bird populations. While there is evidence that the framing of the choice sets and descriptions of attributes have systematic impacts on values, there is very little evidence that choice dimensions, collection methods, sample sizes, response rates, statistical methods or publication status have influenced value estimates. Tests of apparent author effects show that these become insignificant when other explanatory variables are included in the models.

Key Words: non-market valuation, choice modelling, meta analysis, river health

1. Introduction

Benefit transfer of environmental values is attractive because it means that results from a small number of targeted studies may potentially be transferred to other sites of interest, providing a cost effective means of extending economic analysis (Brookshire and Neil 1992; Brouwer 2000; Rolfe and Bennett 2006; Rosenberger and Stanley 2006; Johnston and Rosenberger 2010). However, there are a number of questions about the validity and accuracy of benefit transfer applications, with concerns that large transfer errors may limit the usefulness of results (Rosenberger and Stanley 2006; Rolfe 2006; Johnston and Rosenberger 2010). The transfer of value functions (e.g. from choice experiments (CE)) are considered a superior approach than single point transfers (such as from Contingent Valuation experiments), given the emphasis of CE on different environmental and policy characteristics captured through attributes and policy scenarios and the potential for both site and population adjustments to be made (Morrison et al., 2002; Rolfe 2006; Rosenberger and Stanley 2006; Johnston and Rosenberger 2010).

The accuracy of benefit transfer can be further improved by pooling data from a number of studies to allow systematic analysis (Rosenberger and Loomis 2000; Bateman and Jones 2003). Meta-analysis is the statistical analysis of the summary findings of empirical studies (Glass et al. 1981; Bateman and Jones 2003; Bergstrom and Taylor 2006, Nelson and Kennedy 2009) and has been applied to a number of non-market valuation studies including wetlands (Brouwer et al. 1999; Woodward and Wui 2001; Brander et al. 2006), water quality (Johnston et al 2003; van Houtven et al. 2007), and aquatic resources (Johnston and Besedin 2009). Three key advantages of adopting a meta-analysis approach to BT is that (a) more studies can be incorporated, (b) methodological differences are relatively easy to control, and (c) subsequent value functions are easily adjusted for potential target sites (Rosenberger and Loomis 2000).

Applications of meta-analysis can also provide insights into the potential influence of design, study and methodological factors on results of non-market valuation experiments. While split-sample experiments and other controlled designs continue to be used to identify how different application influence results, meta-analysis offers opportunities for systematic analysis of how variation in both internal and external study features may impact on value estimates. However this type of analysis is limited because most meta-analysis studies incorporate results from different stated preference and revealed preference techniques (Bateman and Jones 2003; Nelson and Kennedy 2009; Johnston and Rosenberger 2010), leading to criticisms that values may not be commensurable (Bergstrom and Taylor 2006). A key limitation of such diverse pooling of values is that methodological influences on values may not be distinguishable. For example, there is evidence with choice experiments that values may be influenced by design dimensions (Caussade et al. 2005; Hensher 2006).

The research reported in this paper involved a meta-analysis of only CE studies, the first that the authors have been able to identify[1]. The main purpose of the study was to identify if a number of methodological and case study characteristics have a significant influence on values, pinpointing areas where analysts should exercise more caution in both experiment

[1] Other MA studies such as Johnson et al. (2005) incorporate CE studies along with results from other non-market valuation techniques.

designs and the subsequent BT process. A secondary goal was to demonstrate the development of a transferable set of value estimates for an environmental case study of water and wetland values in Australia. The paper is organized as follows. In Section 2, an overview is provided of the available CE literature related to healthy waterways. A discussion of the key factors that might influence river protection values is provided in section 3, and results of the meta-analysis provided in section 4. Final conclusions follow in section 5.

2. Case studies and WTP variables

While interest in meta-analysis has been driven by the potential to improve the accuracy of value transfers, a number of challenges exist in performing a successful analysis (Johnston and Rosenberger 2010). A key problem is that most benefit transfer studies lack a strong theoretical foundation to guide the multiple subjective judgements that are often required (Smith and Pattanayak 2002, Bergstrom and Taylor 2006). Other problems include the difficulties of ensuring commensurability across data sets, the variation in methods and approaches because the experiments are not controlled, limited data sets and inadequate methods of analysis (Smith and Pattanayak 2002, Johnston and Rosenberger 2010). In this section the case studies, the issues involved in pooling the data and the key tests that could be performed from the data are reviewed.

To generate a theoretically consistent base for the data pooling and analysis, only value estimates from CE studies were chosen. Marginal tradeoffs in terms of implicit prices (also known as part-worths) were chosen as the dependent variable because these avoided scale parameter issues in comparing results, and allowed only values for selected attributes to be reported. Using compensating surplus estimates as the dependent variable was not identified as practical because of the difficulty in establishing future protection scenarios that were consistent across case studies and the variation in attributes between case studies. However, where only unit changes in single attributes are involved, then estimates of compensating surplus collapse to implicit prices. As implicit prices are regularly used to conduct benefit transfer tests (e.g. Morrison et al. 2002; Colombo et al. 2007), there is no theoretical barrier to their use in pooling study results.

Case studies chosen for the meta-analysis involved non-market values of river protection in Australia. The case studies were chosen because the environmental issues were reasonably consistent across case study areas, and a large number of choice models were available from a series of studies conducted over a 10 year period from 2000 to 2010 (Table 1). The meta-analysis involved 149 individual value estimates from nineteen separate choice modelling studies across five states and territories (Table 1). Selection of the case studies involved several key issues, particularly around the identification, definition, description and estimation of the dependent variable.

Table 1: Overview of studies included in the meta-analysis

	Authors	Study year	River catchment	State	Implicit price (WTP)
1	Van Bueren and Bennett (2004)	2000	All waterways (not specified)	National, QLD, WA	$/hh/year per 10 km restored waterway for fishing or swimming
2	Morrison and Bennett (2004)	2000	Bega, Clarence, Georges, Gwydir, Murrumbidgee	NSW	$/hh/year and one-time-off per % of river covered with healthy native vegetation / per fish species / for fishable/swimmable water quality whole river / per waterbird & other fauna species
3	Morrison and Bennett (2006)	2000	NSW rivers	NSW	$/hh/year and one-time-off per % of river covered with healthy native vegetation / per fish species / for fishable/swimmable water quality whole river / per waterbird & other fauna species
4	Rolfe et al. (2002)	2000	Fitzroy, Dawson Comet-Nogoa- Mackenzie	QLD	$/hh/year per km of waterways in the catchment remaining in good health
5	Rolfe and Windle (2003)	2001	Fitzroy	QLD	$/hh/year per km of waterways in the catchment remaining in good health
6	Windle and Rolfe (2004)	2003	Fitzroy	QLD	$/hh/year and one-time-off per km of waterways remaining in good health
7	Windle and Rolfe (2006)	2005	SE Queensland, Fitzroy Murray-Darling Mackay Whitsunday Great Barrier Reef	QLD	$/hh/year per % of waterways in good health
8	Kragt et al. (2007)	2006	Goulburn	NSW	$/hh one-time-off per % native fish species and population level / for % of river length with healthy native vegetation / per native waterbird and animal species /
9	Bennett et al. (2008a)	2006	Moorabool, Gellibrand, Goulburn	NSW and VIC	$/hh one-time-off per % native fish species and population level / for % of river length with healthy native vegetation / per native waterbird and animal species /
10	Bennett et al (2008b)	2006	Murray River	NSW and VIC	$/hh/year per % of pre-European fish numbers / % of healthy flooded vegetation (river red gums)
11	Rolfe and Bennett (2009)	2002	Fitzroy	QLD	$/hh/year per km of waterways in the catchment remaining in good health
12	Kragt and Bennett (2009a)	2008	George	TAS	$/hh/year per km of river length with healthy native vegetation
13	Kragt and Bennett (2009b)	2008	George	TAS	$/hh/year per km of river length with healthy native vegetation
14	Kragt and Bennett (2010)	2009	George	TAS	$/hh/year per km of river length with healthy native vegetation
15	Mazur and Bennett (2009)	2008	Lachlan, Namoi, Hawkesbury-Nepean	NSW	$/hh/year per km of healthy waterways
16	Mazur and Bennett (2010)	2008	Hawkesbury-Nepean	NSW	$/hh/year per km of healthy waterways
17	Hatton MacDonald and Morrison (2010)	2010	Murray	NSW/VIC/SA	$/hh/year per % of healthy vegetation along the River Murray
18	Morrison et al (2010)	2010	Murray	NSW/VIC/SA	$/hh/year per % of healthy vegetation along the River Murray

ACT = Australian Capital Territory, QLD = Queensland, WA = Western Australia, NSW = New South Wales, VIC = Victoria, TAS = Tasmania

Identification

Identification of the dependent variable focused on identifying an environmental good that was relevant across a large number of case studies. 'Improvements in river health' was suitable for this purpose because more than twenty choice experiments could be indentified in Australia that were relevant to this goal. These studies were drawn from a range of published and grey literature sources. Each of the published studies was available publicly in some format, and each provided implicit prices and enough study details to populate the meta-analysis.

Definition

Definition of the variable proved problematic, as many studies involved slightly different aspects of environmental health. Many researchers defined the environmental good in similar terms such as 'waterways in the catchment remaining in good health', 'waterways in good health' and 'healthy waterways' (Table 1). Other terms used that may be considered as very consistent with or indicators of healthy rivers included 'river length with healthy native vegetation', 'healthy flooded vegetation', 'waterways for fishing or swimming', 'population level of native fish species', and 'population level of native waterbird and native animal species'. While recreation opportunities, vegetation, fish and waterbird populations may be indicators of healthy river conditions, they may only reflect sub-sets of values for the environmental good. As a consequence, extension of the meta-analysis to encompass varying indicators of healthy rivers may associated with scope issues. To address this in the study, dummy variables were identified for definitions that may be more narrowly scoped.

Some studies were identified where the environmental good of interest related to river health, but where the environmental good was more broadly defined than river systems. For example Morrison and Bennett (2002) and Windle and Rolfe (2004) report protection values for wetlands and estuaries respectively, where protection values are largely dependent on healthy river systems and adequate water flows. However, the need to apportion values between the wetlands/estuaries and the healthy river system makes these types of studies problematic for the meta-analysis. In this application, case studies that are scoped more widely than healthy river systems have been excluded from the analysis.

Description

Substantial variation was identified in the way that changes in the environmental good were described. Where the good was defined in terms of river health, the key approaches were to identify changes in terms of absolute values (kilometers of waterways in good health) or percentage values (percentage of waterways in good health). The same variation occurred across the indicator variants of river health description, where variables such as vegetation, fish and birds were described in both absolute and percentage terms across studies. For the meta-analysis, absolute values were chosen as the consistent descriptive standard. Implicit prices from studies where changes were described in percentage terms were converted to values per kilometer using the length of the river system as the base[2].

Some studies of river health in Australia have involved the description of environmental changes in more qualitative terms, such as 'poor, moderate, good and very good'

[2] Many studies included this information as part of the framing to survey respondents. Where the information was not included in studies, the data was sourced from Norris et al. (2001).

environmental health of waterways (Brouwer et al. 2010), or ‘1 star, 3 star and 4 star’ quality of the river for recreational fishing (Zander et al. 2010). The difficulties with the use of these descriptive measures are that there are rarely conversions back to quantitative changes available, and that respondents may have interpreted the amounts represented by each qualitative measure in different ways. Because of these difficulties, studies have been excluded where the description of the environmental good of interest does not allow estimates of quantitative changes.

Estimation

Value estimates from the selected studies were not directly comparable because differences in attribute description, payment streams, and study year. Three key steps were required to transform values from the individual case studies into a consistent estimate of WTP per kilometer of waterways in good health. To address description differences, values for percentage changes were transformed into absolute values by multiplying percentage changes by river length. To address variations in payment streams, all WTP estimates were converted to lump sum amounts. About 50% of the value estimates in the study were for lump sum values, while the remainder used annual payment streams for between 3 and 20 years. While there is evidence that choices are sensitive to temporal differences (Kim and Haab 2003; Taylor et al. 2003; Swait et al. 2004), little information exists to identify an appropriate discount rate. To allow sensitivity testing, present values for payment streams were estimated using a selection of discount rates between 5% and 30%.

As the studies had been collected over a ten year period between 2000 and 2010, WTP estimates needed to be converted to real values in a consistent year. To achieve this, the Consumer Price Index for Australia was used to bring all payment estimates into 2010 dollar equivalents. The resulting values are shown below in Figure 1, with six extreme values from Morrison and Bennett (2004) associated with recreation use omitted from the analysis.

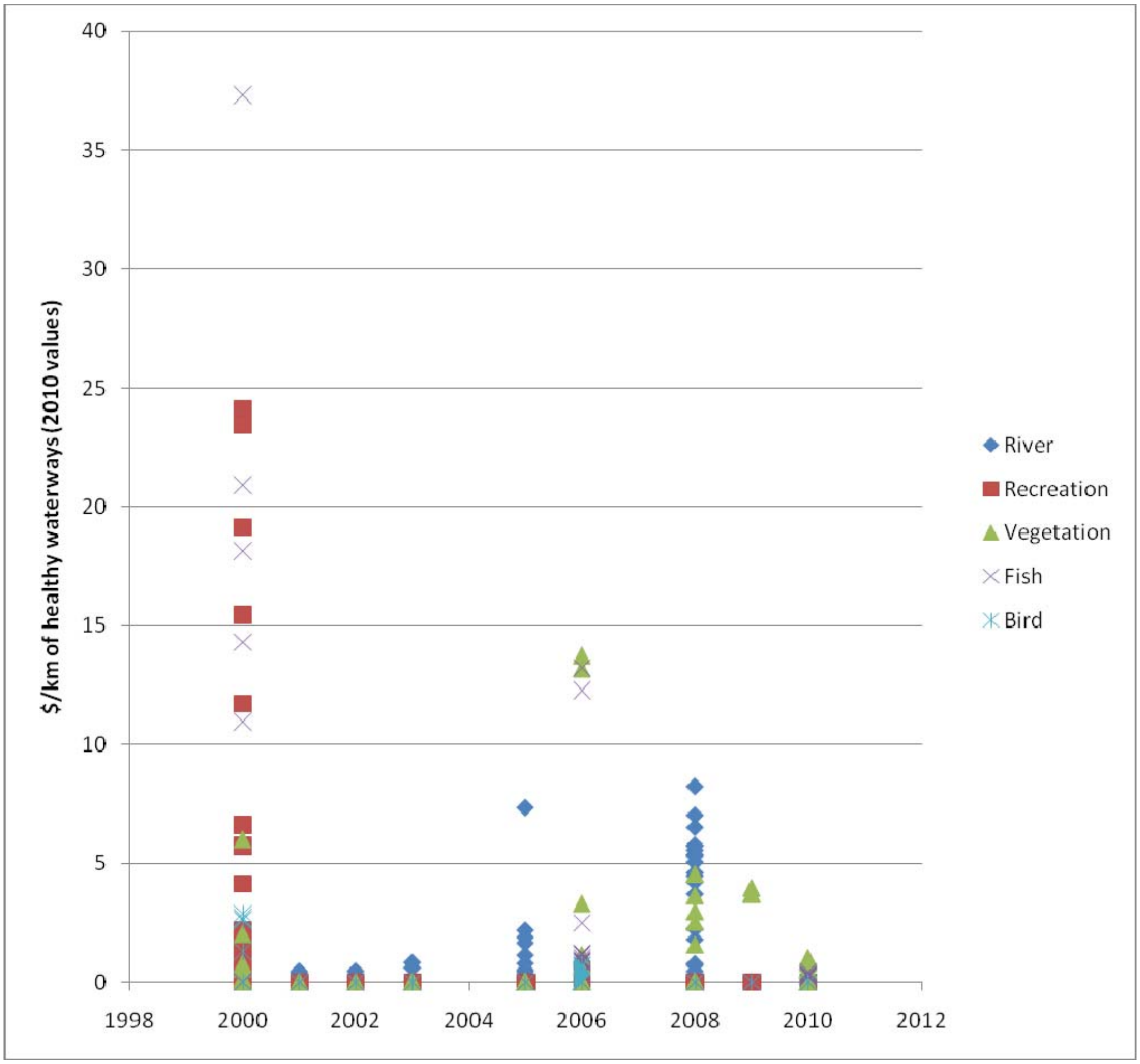
3. Explanatory variables

The graphical analysis presented in Figure 1 demonstrates that there is substantial variation in WTP per kilometer of waterways in good health. While the mean of values is $3.13/hh/km, the standard deviation is 5.47. However, there are a number of methodological, framing and design variations between the CM experiments that may have some influence on value estimates. These are reviewed below.

Amenity specification

Specification of the amenity to be valued varied in two key ways. Variations in definition, as explained earlier, meant that different amenity scopes may have been involved across case studies. Some scopes, such as for vegetation and waterbirds, are likely to comprise of largely non-use values, while other scopes, such as for recreation, are likely to be focused on use values. These values are likely to be components of total use values, and hence will be subsets of values for healthy waterways as a whole. Amenity specification is also likely to vary with catchment characteristics, where factors such as size (river length), location (State) and type (inland versus coastal) may influence how respondents view the tradeoffs. Many studies could be identified in two key catchments: the Murray Darling river system draining parts of Queensland, New South Wales, Victoria and South Australia, and the Fitzroy River system in central Queensland.

Figure 1: Scatter plot of WTP per Km of Healthy Waterways (2010 values)



Population differences

Values may vary across populations and with population characteristics. There is some evidence from individual case studies that values differ according to whether the population sample comes from inside or outside catchments (van Bueren and Bennett 2004; Morrison and Bennett 2004; Kragt et al. 2007; Bennett et al. 2008a; Bennett et al. 2008b), and when state capital versus local populations are sampled (Rolfe et al. 2002; Morrison and Bennett 2004; Kragt et al. 2007; Bennett et al. 2008a; Bennett et al. 2008b; Mazur and Bennett 2009).

There is also consistent evidence across the studies that key socio-demographic characteristics such as age, gender and household income influence WTP amounts.

Framing of the tradeoffs

Several differences were identified between the studies in terms of the way that the tradeoffs were framed to choice respondents. All the experiments were consistent in terms of presenting a status quo or constant base option plus two or more improvement options together with a cost attribute. Most studies presented the information in absolute terms (kilometers of healthy waterways under different policy options), but one study (van Bueren and Bennett 2004) framed the information as marginal changes, and one study (Windle and Rolfe 2006) presented both absolute and marginal levels together.

Differences in WTP per kilometer of improvement may also be driven by marginal effects. The total length of river systems that were assessed varied from 209,118 kilometers (Australian total) to 44 kilometers (Moorabool River), while the percentages in good condition ranged from a low of about 5% for the Clarence River (Morrison and Bennett 2004) and the Goulburn River to 65% for the Georges River (Kragt and Bennett 2009). It is possible that respondents considered this information when indentifying their values per each one kilometer improvement.

There were differences in the way that condition trends were depicted, with the future base lower than current condition in 57% of experiments and equal to current condition in the remainder. Concerns about losses, in a form of endowment effect, may mean that choice behavior is different between the framing scenarios. There were also differences in the total range of improvement levels offered, from a low of 2% of total river length (Mazur and Bennett 2009, 2010) to a high of 100% of total river (Morrison and Bennett 2004). Where the proportion amounts of level changes are higher, respondents may find improvement options more attractive.

Framing of payment mechanisms

A number of different payment mechanisms have been applied in the different studies, with most using some form of local rates or levies to identify how payment would be collected. Some studies present a mix of payment vehicles, where respondents were informed that the higher costs would be generated by a mix of higher taxes, rates, charges and consumer costs. About half of the studies involved annual costs over a number of years, with 20 year time frames being the most common.

Data collection

There was some variation in survey collection techniques, with 53% of samples collected through mail surveys, and 47% collected through drop-off/pick-up techniques. The mean sample size was 378 respondents (standard deviation = 587), while the mean response rate was 41.5% (standard deviation =17.4%). Response rates were significantly lower with mail surveys, with average response rates of 33.3% for mail surveys and 48.8% for other collection methods.

Presentation of levels

Differences were also identified between studies in the way that levels were presented in the choice sets. Tradeoffs were only described in absolute numbers (i.e. kilometers of waterways) in 36% of experiments, in only percentage terms in 10% of experiments, and with the use of symbols in 38% of surveys. Other formats included the joint use of absolute numbers and percentage terms (15% of surveys) and the joint use of absolute numbers and symbols (6% of surveys).

Choice set dimensions

There was limited variation in the dimensions of choice sets used in the experiments. All experiments used three alternatives (including one as a base), apart from one experiment which had five choice alternatives. The latter was also the only labeled experiment. Five attributes were used in 82% of experiments, with 4 attributes used in the remainder. Five choice sets per questionnaire were applied in 72% of experiments, with 6 choice sets in 18% and 8 choice sets in 9%.

Analysis of results

The statistical models used in the data analysis were generally confined to three main approaches when only models used to predict results were considered. Conditional logit models were employed for 38% of studies, Nested logit models for 52% of studies, and Random Parameters Logit models were used for 9% of studies. Reported model fits in terms of adjusted rho-square values ranged from a low of 0.034 to a high of 0.41. Forty-one percent of the studies had been published in refereed journal articles or book chapters, while the remainder in the grey literature as conference papers and research reports.

4. Results

The analysis of relationships between the implicit prices (WTP per kilometer of healthy waterways) and the potential explanatory variables are shown in two ways. First, simple univariate analyses are shown which focus on identifying how average implicit prices vary for different groupings of the data. Second, multivariate analysis is applied to identify the relationship between the dependent variable and these different groups of explanatory variables. Fixed effect tobit regression functions have been applied for this purpose given the censored nature of the data (positive WTP values only) and heteroscedasticity (intra-study effects due to similar design). The meta-model used to predict the marginal rate of substitution between income and a healthy waterways attribute (implicit price) can be described more generally as follows:

$$MWTP_i = \beta_j X_{ij} = \beta_1 X_{i1} + \beta_2 X_{i2} + \beta_3 X_{i3} + \varepsilon_i \qquad (1)$$

where $MWTP_i$ is the vector containing the implicit price found in study *i* and X_{ij} represents the design matrix for the covariates, consisting of amenity characteristics (measured through the vector β_1), population characteristics (measured through the vector β_2), and study and methodology characteristics (measured through the vector β_3), with the latter capturing variations in tradeoff framing, payment mechanisms, data collection, level description, choice set design, and data analysis. In this meta-analysis study, 130 observations were retrieved from the sixteen studies presented in the previous section.

4.1. Univariate results

The results from the univariate analysis are summarized in Table 2, showing average implicit prices for subsets of the data defined by different environmental attributes, catchments, and other study characteristics. Where independent variables are metric rather than grouping variables, the coefficient of correlation between the variable and implicit prices are reported. Tests for significance have been performed between different groups using independent samples t-tests and correlation tests.

Results are presented for the full data set with the implicit prices calculated from temporal payment streams at a 15% discount rate. Respondents making choices where costs (and benefits) occur over long time periods are likely to have higher effective discount rates than government bonds or bank interest rates because of uncertainty about scenario outcomes and and the incidence of payment burdens in the longer term. The selection of 15% as a discount rate reflects that it is likely to be at the lower end of potential rates. Sensitivity tests around the discount rate levels did not generate any significant changes in results.

The results for the amenity specification tests show that WTP values for recreation, vegetation and fish focused river health values are higher than only river health values were assessed. These results suggest that there may be some form of amenity mis-specification involved, as values for component assets would normally be expected to be lower than values for the whole asset. The relatively high values for recreation focused waterways relative to environmental asset specifications suggest that a large component of protection values relate to use values. Values are lower for experiments valuing improved river health in the Murray Darling or Queensland.

The population subgroups show that values are much larger for studies conducted for local or within-catchment populations, and lower for studies assessing values from capital city populations. The positive correlation coefficients for male, age and income variables show that values tend to increase with larger levels of those variables. Results of the framing comparisons show that values tend to be much lower when results are only framed as marginal changes rather than in absolute amounts. Values are higher when the future base is lower than current conditions, indicating that river health is declining rather than stable. The correlation tests show that values tend to be higher when current condition of rivers is better, and when potential improvements (represented by the range of levels in the choice sets) is proportionally larger.

Payment mechanisms are an important influence on implicit prices, with lump sum payments generating higher implicit prices and regular payment streams (present value at 10% discount rate) generating lower implicit prices. The use of rates or levies generates higher values, perhaps because respondents perceive advantages in the use of a provision rule that would extend payment requirements across populations. In contrast, the use of mixed payment mechanisms (where respondents are told that they would pay higher costs through a combination of different mechanisms) were associated with lower WTP values. Correlation tests revealed a negative relationship with values and years since 2000.

Table 2. Implicit prices by different good, site and study characteristic subsets

	Number of studies	Average WTP[1]	Standard deviation of WTP	Correlation coefficient	Significant difference to sample (95% test)
All studies	149	3.13	5.47		
Amenity specification					
River health	51	2.10	2.44		Yes
Recreation	18	6.54	8.43		Yes
Vegetation	40	3.51	6.10		No
Native Fish	30	4.75	8.61		No
Waterbirds	10	1.49	1.10		Yes
River length	149			-0.13	No
Murray Darling	49	3.56	5.95		No
Queensland	34	0.78	1.28		Yes
Year of study				-0.22	Yes
Population differences					
Local catchment populations	54	4.49	6.94		Yes
State capitals	37	1.96	3.22		Yes
Percent male				0.19	Yes
Age				0.27	Yes
Income				0.13	No
Framing of tradeoffs					
Framed as absolute changes	132	3.38	5.74		Yes
Framed as marginal changes	6	0.76	6.31		Not assessed
Future base lower than current	76	4.02	6.08		Yes
Current percent in good condition	149			-0.31	Yes
Level range as % of river length	149			0.19	Yes
Year of benefit not specified	45	5.45	8.52		Yes
Payment mechanisms					
Annual payments	85	1.43	2.07		Yes
Rate or levy	66	4.23	7.30		Yes
Mixed mechanisms	55	1.99	2.38		Yes
Data collection					
Mail survey	70	4.56	7.42		Yes
Sample size	149			0.09	No
Response rate	149			0.06	No
Presentation of levels					
Absolute levels only	52	4.00	6.50		No
Percent levels only	32	0.63	1.05		Yes
Symbol levels	45	4.33	6.50		No
Mixed formats	26	1.85	1.78		Yes
Choice set dimensions					
Number of choice cards	149			-0.06	No
Number of alternatives	149			-0.09	No
Labelled alternatives	8	0.99	7.91		Not assessed
Number of attributes	149			0.05	No
Analysis of results					
Conditional logit	61	1.65	2.19		Yes
Nested logit	63	4.99	7.71		Yes
Random parameters logit	18	2.68	1.84		No
Adjusted rho-square				0.21	Yes
Refereed publication	48	6.31	8.42		Yes

Note 1: WTP defined as dollars per household per kilometer of river in good health at 15% discount rates

Tests of data collection methods showed that mail surveys tended to generate higher values. However, the use of mail surveys was higher correlated with annual payment mechanisms (r = -0.69) and response rates (r = -0.54), as well as other design factors. Correlation tests showed that values for river health were positively related to increasing sample sizes and response rates.

Information communication in choice sets through the way that levels are presented appears to have a large influence on results. Values are higher when levels are presented as symbols, and lower when levels are presented as absolute values or percentage values, or in mixed formats. Correlation tests with choice set dimensions show that increasing the number of choice sets and choice alternatives is associated with lower values, while increasing the number of attributes is associated with higher values.

The groupings associated with statistical analysis methods indicate that nested logit models are associated with higher values, and condition logit and RPL models with lower values. There are higher values associated with refereed publications, and the correlation tests show some positive association between values and model fits. There appear to be some author effects, with Morrison associated with higher values and Rolfe with lower values.

4.2. Multivariate results

In this section a multivariate regression model is reported where the combined effect of the independent variables are analysed. The implicit prices are modelled using Tobit regression in order to account for the limited dependent nature of the response variable and the high degree of censoring at zero (see section 3). Equation (1) can in that case be rewritten as follows (e.g. Greene, 1993):

$$MWTP_i^* = \beta_j X_{ij} + \varepsilon_i \;;\; \varepsilon \sim N(0,\sigma^2) \tag{2}$$

$$MWTP_i = \begin{cases} MWTP_i^* & \text{if } MWTP_i^* > 0 \\ 0 & \text{otherwise} \end{cases} \tag{3}$$

where $MWTP_i^*$ is the unobserved (latent) dependent variable and $MWTP_i$ the observed implicit price. As before, X_{ij} denotes the matrix of covariates and the error term ε_i is assumed to be normal distributed with zero mean and variance σ^2. The estimates for the regression coefficients β_j are obtained through maximum likelihood (ML) techniques. The dependent variable used is the log of the WTP per kilometre of river health. The results of the modelling are shown in Table 3.

The model results show that amenity specification was a highly significant indicator of values, with attributes focused around recreation uses showing significantly higher values, and attributes focused around waterbirds showing significantly lower values. This may be because values associated with recreation combined both use and non-use preferences, while values for waterbirds were only for a subset of non-use values.

Some systematic population differences were identified. Values were higher where populations in local catchments were sampled and with higher ages and income levels. As well, values were lower with increasing proportions of male respondents.

The way that tradeoffs were framed was also identified as being significant influence on values. Having declining conditions (as shown by a lower future base) increased WTP, while small marginal improvements (level range relative to river length) were associated with lower WTP. The case studies where the years to and years of environmental improvement were not specified are associated with higher WTP. However, the current condition of a river system (amount in good condition) was not identified as a significant influence.

As expected, the use of compulsory rates or levies for payment mechanisms was significant in lowering values. However WTP through annual payment mechanisms were identified as significantly lower than WTP through lump sum payments. This indicates that the discount rate used in this analysis (15%) to convert period payments to lump sum amounts is too high to drive equivalence. However, these differences in WTP remain even when discount rates as low as 5% are used. This result is contrary to expectations, suggesting that further work is necessary to understand how respondents view payment vehicles.

Data collection issues did not have a large influence on WTP. There was some evidence that mail survey techniques led to lower values, although this may be driven by some underlying correlations in the data set. Sample sizes and survey response rates were not identified as significant influences. This indicates that the studies reviewed in the meta-analysis have conformed to best practice standards.

Only some factors relating to the design and analysis of the choice experiments could be identified as significant. The description of levels in either percentage or symbol terms appears to depress values, although this may be related to other correlations in the data set. Increasing the number of choice sets and the number of attributes in an experiment appears to reduce WTP estimates, perhaps indicating some level of complexity or fatigue effects may exist. In contrast, the number of alternatives was not significant, although the variation was only between three and five alternatives across the data set. There was little evidence that more sophisticated analysis was influencing value estimates. The use of conditional logit models was not significant compared to more advanced model formulations, while the coefficient for model fit statistics (normally improved with more advanced models) was also non-significant.

Table 3: Tobit regression Model explaining WTP for river health

Dependent variable = Log of $/km	**Coefficient**	**St. Error**
Constant	22.677***	6.266
Sigma	0.057***	0.075
Amenity specifications		
Recreation	4.446***	1.282
Waterbirds	-2.006***	0.644
Year of study (from 2000)	-0.494**	0.205
Population differences		
Local catchments	0.619**	0.269
Percent male	-0.061***	0.023
Age	0.064*	0.036
Income ($000)	.025***	.008
Framing of tradeoffs		
Future base lower than current	0.933***	0.244
Current percent in good condition	0.009	0.008
Level range as % of river length	-0.027***	0.010
Years of benefit not specified	1.464*	0.758
Payment mechanism		
Annual payments	-6.422***	1.928
Rate/levy payment vehicle	-5.997***	1.795
Data collection		
Mail survey	-3.160**	1.603
Sample size	0.000	0.001
Response rate	-0.005	0.016
Presentation of levels		
Levels in percentages	-1.902***	0.532
Levels as symbols	-2.280*	1.246
Choice set dimensions		
Number of choice sets	-1.164**	0.487
Number of alternatives	-0.222	0.332
Number of attributes	-1.386*	0.813
Analysis of results		
Conditional logit models	-0.253	0.373
Adjusted Rho Square statistic	-1.944	1.482
Number of observations		147
Log-likelihood		-109.322
AIC		1.828
BIC		2.336

$^{*}p<0.10$; $^{**}p<0.05$; $^{***}p<0.01$.

5. Conclusions

The results of this study show substantial variation in the WTP of households for river health in Australia, although there is some indication that values are declining and have exhibited less variation over time (Figure 1). There is some evidence of amenity mis-specification, where values for river health are lower than for components such as fish and healthy vegetation. This indicates that those values may not be strong substitutes for healthy waterways.

The results of both the bi-variate and multi-variate analysis demonstrate that several different factors appear to have a systematic effect on estimates of WTP. While the affects of amenity specification and population variables are largely consistent with expectations, there are a number of other issues identified. Values are sensitive to the way that tradeoffs are framed, where the relative size of marginal changes are important. Values also appear to be sensitive to the way that the payment mechanism is structured.

There is more limited evidence that values are sensitive to a number of design issues around the collection of data, representation of levels, choice set dimensions or the analysis of results. There is some evidence that mail surveys generate lower WTP, and that some form of complexity or fatigue effects may be associated with experiments that have more choice sets and more choice alternatives.

These results provide some indication that choice experiments in Australia are generally well-designed, with little evidence that different collection, design or analysis factors are having major impacts on values. However, issues of amenity specification, tradeoff framing and payment mechanisms are more problematic, and suggests that much more attention is needed on these issues.

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