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Estimating the Value of Achieving 'Good Ecological Status' under the Water Framework Directive in the Boyne River Catchment: A Mixed Multinomial Logit Approach

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Abstract: Following the implementation of the Water Framework Directive (WFD), integrated catchment management plans must be prepared for all river basins in order to achieve 'Good Ecological Status' (GES) in all EU waters. This concept is a broader measure of water quality than the chemical and biological measures which were previously dominant in EU water policy. The directive also calls for a consideration of the economic costs and benefits of improvements to the water bodies' ecological status in catchment management plans, along with the introduction of full social cost pricing for water use. In this paper, the Choice Experiment (CE) method of valuation is used to estimate the value of improvements in a number of components of ecological status in the Boyne river catchment in Ireland. The study determines what value the targeted population of the catchment place on the non-market economic benefits of moves towards GES. In addition, the effect of various factors of observed individual heterogeneity on choice is explored.

Keywords: Boyne River, Choice Experiment, Good Ecological Status, Water Framework Directive

1. Introduction

The Water Framework Directive (WFD) (2000/60) was adopted in October 2000 and establishes a framework for European Community action in the field of water policy (CEC 2000). The directive calls for integrated catchment management plans to be prepared in order to achieve Good Ecological Status (GES) in all EU waters by 2015. This concept is a broader measure of water quality than the chemical and biological measures which were dominant in European water policy before the WFD. Particularly, according to Article 2 (18), 'Good surface water status' is referred to the status achieved by a surface water body when both its ecological status and its chemical status meet certain agreed criteria for river health. As such, the directive aims, at a minimum, for 'good' and 'non-deteriorating' status for all European waters, and sets common approaches and goals for water management in the EU Member State (MS) countries.

The main steps involved in the implementation of the WFD include the setting of ecological standards, the identification of anthropogenic pressures and the adoption of corrective measures. In implementing these steps Member States are expected to take account of the principle of full recovery of costs of water services that will provide incentives for the efficient use of water by different users. Another important change in water management policy is that the measures to achieve the WFD objectives will be co-ordinated at the level of River Basin District (RBD) that correspond to large catchment basins incorporating smaller Hydrometric Area (HA) units. In Ireland's case there are seven such RBDs.

An important element of the directive from an economic perspective is that it calls for a consideration of the economic costs and benefits of improvements to ecological status in catchment management plans. Hence, benefits play an important role in the assessment of the proportionality of costs in the implementation of the WFD. The directive allows for the lower target of "Good Ecological Potential" for a particular water body if the costs of improvement to good ecological status are "dis-proportional" (Hanley and Black, 2006c). Also, the WFD requires that charges for water services should adopt the principle of full cost recovery in accordance with the polluter pay principle, thus providing incentives for improved water use efficiency. At the same time common methods to estimate these costs are yet to be determined and it is expected to be quite challenging in a number of Member States where water in the domestic and agricultural sectors is subsidised (Spain, Greece, Portugal) or where water pricing is almost completely absent (Ireland). Ireland is also somewhat behind in terms of measuring the economic value of achieving "good ecological status" under the WFD across catchments.

In general, measuring the benefits associated with a healthy water body as defined by the WFD is an important but difficult task of the river basin authorities and will involve them having to consider and evaluate costs and benefits of implementing the policy—including non-market environmental benefit values. In this context, the objective of this paper is to elicit the value of achieving GES in an Irish river catchment though the exploration of the preferences that the Irish public holds for river improvements. In particular, the paper identifies how Irish citizens make trade-offs between potential benefits from water quality improvements such as recreation, river life, bank erosion and water appearance by employing a choice experiment.

At this point, it should be noted that while some valuation studies for water resource benefits have been undertaken in Ireland (Curtis, 2002, 2003; Hynes & Hanley, 2006; Hynes et al. 2009) there is no comprehensive set of values. This study has therefore the potential to inform the policy debate on a number of levels by principally exploring the value for achieving GES under the WFD and assessing the implicit prices associated with a number of individual water characteristics including the ecological health and recreational usage. The determinants of choice with regard to individuals' heterogeneity are also explored.

The rest of the paper is organised as follows. In Section 2 an overview of the Directive's implementation in Ireland with regard to economics is presented as well as a literature review on studies that have taken place in the country. Section 3 provides an overview of the study area and section 4 a short description of the choice experiment methodology. Decisions related to survey design and data are discussed in section 5, while section 6 reports the results from the analysis of the data. The final section comments on the results and offers some conclusions.

2. Ireland's Implementation of the WFD

Currently Ireland is up to date with the requirements of the WFD's implementation timetable. In particular, Ireland undertook in 2004 a characterisation and analysis of all RBDs as required by Article 5. The report (ERBD, 2005) provided an analysis of the characteristics of RBDs and undertook a review of the impact of human activity on the status of waters, providing an economic analysis of water use in accordance with the requirements of Article 5 of the Directive. As referred to in its executive

summary, “the report serves as a comprehensive assessment of all waters (groundwater, rivers, lakes, transition and coastal waters), establishes a baseline and identifies priority actions for subsequent stages in the river basin planning cycle”.

As part of the 2005 National Summary Report for Ireland, a baseline economic analysis has been completed with a preliminary assessment of the value and costs associated with water resources in Ireland. In this context key information gaps were identified along with a proposed strategy to address them. The results presented in the final report ‘Economic Analysis of Water Use in Ireland’ (CDM 2004), provided the foundation for the economic component of the summary national characterisation report under Article 5 of the Directive. The methodology used for the estimation of water use benefits suggested an economic impact assessment of key water-using activities and valuations of abstractive and in-stream water resources in each RBD. In particular, for the in-stream valuations such as water based leisure activities, economic valuations that were based on national estimates of expenditures for using Ireland’s recreational fisheries, navigable waters, beaches, and other marine amenities available from research conducted by the Economic and Social Research Institute (Williams and Ryan, 2004). The study provided estimates of the partial value people who engage in water-based leisure activities in Ireland place on the water bodies that support these uses, as well as an economic impact assessment parameter—an output value—for the water-based leisure “sector”.

Goodbodys (2008) investigated the possibility of making use of values derived in other countries, in the absence of original studies in Ireland, and in particular benefit values from UK in order to estimate the non-market value associated with Irish water

bodies. They concluded that although "the benefit values mandated in the UK are the most appropriate ... the incremental changes in status that underpin the guidance do not map directly onto water status levels, as defined in the WFD" (Goodbody 2008, p.23).

It should be noted that the number of studies that have applied stated preference techniques in the context of valuing economic benefits that derive from the WFD is large and increasing across Europe (Kontogianni *et al.*, 2005; Brouwer 2006; Baker *et al.*, 2007; Spash *et al.*, 2009). A considerable number of these studies have applied the Choice Experiments (CE) method (Álvarez-Farizo *et al.*, 2007; Hanley *et al.*, 2007; Hanley *et al.*, 2006a, 2006b; Lago and Glenk, 2008; Kataria 2009; Kataria *et al.*, 2009; Brouwer *et al.*, 2010; Poirier and Fleuret, 2010), while Adamowicz *et al.* (1994) is the first study to apply CE to non-market valuation and in particular to sites of water based recreation.

The above CE studies vary in terms of the purpose of the study[1], the geographic scale (local, regional, national) and hence the affected population. They also vary in terms of the good, the baseline, the change in ecological status, the payment vehicle, the survey mode and the validity of the results. That makes comparisons difficult but nevertheless they provide an indication of related values and demonstrate how the idea of valuing benefits within the WFD may be approached, since there is no specific guideline from the EU on how to proceed in this regard.

[1] The purpose of the study may differ in the final use of the derived economic value. For example it may be used in Cost-Benefit Analysis context, to assess the importance of an issue, to set priorities within a sector, establish the basis for an environmental charge etc (eftec 2008).

In the case of Ireland, valuation studies with a focus on river quality improvements are limited. Those studies which are available focus on valuing water-based leisure activities. Hynes and Hanley (2006) estimated through Travel Cost Method (TCM) the mean WTP of the average kayaker using the Roughty River in Co. Kerry, in order to shed light on the conflict between commercial interests and recreational pursuits on Irish rivers. In Hynes *et al.* (2009) the authors examined the welfare loss to recreationalists from a reduction (50%) in the recreational rating of a river due to water diversion for agricultural use or the implementation of a hydro scheme. This study uses revealed preference data to estimate values for a range of river attributes relevant to kayaking. Another study is that of Curtis (2002) which applied the TCM to estimate the demand and economic value of salmon angling in Co. Donegal. In addition, in Curtis (2003) the demand for water-based leisure activity (sea angling, boating, swimming and other beach/sea/island day-trips) in Ireland was examined based on data from a nationally representative telephone survey.

There are also a number of other economic studies in Ireland that involve some form of economic appraisal of water based activity that do not however measure directly water related benefits. For example, Lawlor *et al.* (2007) conducted an economic evaluation of selected water investment projects in Ireland. The authors estimated 'required WTP' with respect to the local population. An apportionment of benefits was made between local and non-local beneficiaries, based on the relative importance or popularity of the water body in question. However, the study did not provide benefit values of use in the appraisal of water resource initiatives. Bullock *et al.* (2008) carried out an economic assessment of the value of biodiversity in Ireland and considered the economic and social benefits of biodiversity across a range of sectors,

including water. Consumer's surplus figures were produced for specialist and general users of rivers and lakes based on certain population assumptions. However, the findings were indicative only and not based on any primary valuation studies.

Despite the aforementioned studies that have explored aspects of water quality and valuation in Ireland, no major CE valuation exercise on water quality features has been conducted to date. Moreover, no studies have attempted to estimate the value of achieving good ecological status arising from the WFD for any Irish water body values for a range of water features for the general population of Ireland. This research seeks to fill this gap in the literature both in terms of how economic values generated from this study compare to economic valuations conducted in other regions but also in terms of the knowledge gap that exists on Irish residents' values for water. As a case study, we focus on the catchment of the River Boyne.

3. The Study Site: The Boyne Catchment

According to Environmental Protection Agency (EPA) approximately 50 percent of the land area of the State is drained by nine river systems. In Ireland there are seven RBDs, as presented in Figure 1, and the country is divided into 40 HAs each of which comprises a single large river catchment or a group of smaller catchments.

Figure 1 here

The River Boyne (Figure 2) belongs to the Eastern RBD. The Boyne system has a lowland catchment covering the fertile plains of Co. Meath, a significant area of Co. Westmeath and parts of Kildare, Offaly, Cavan and Louth. The river rises near

Edenderry, Co. Offaly and flows in a north-easterly direction for 70 miles before entering the Irish Sea at Drogheda. The Boyne is one of Ireland's premier game fisheries and both the main channel and the tributaries offer a wide range of angling, from spring salmon and grilse to sea trout and extensive brown trout fishing[2]. Agriculture is the predominant land use with 91 percent of the Boyne catchment, occupied by arable lands or pasture. The agricultural sector (arable and pasture) is estimated to generate the greatest total phosphorus load in the Boyne catchment (MCOS 2002). The rivers Boyne and Blackwater and the Boyne estuary[3] are registered Special Areas of Conservation (SAC) while the Boyne estuary is also a Special Protection Area (SPA). It is also noteworthy the historical significance of the River Boyne as a result of the famous Battle of Boyne in 1690.

Figure 2 here

The Three Rivers Project[4] has demonstrated that the Boyne river, along with the Suir and the Liffey, are regarded as "valuable, national and regional resources having major importance in terms of natural and cultural heritage, tourism, recreation and water abstraction for public and industrial uses" (MCOS 2002, p.9). In addition, following the Three Rivers Project, the Boyne was one of the rivers in which the national decline in water quality was deemed to be reflected. Therefore, the river can be considered as representative waterbody of Ireland where moderate improvements in water quality are likely to be needed to meet GES. This is also reflected in Figure

[2] www.IrishFisheries.com.
[3] http://www.npws.ie/en/.
[4] This Three River Project was a Government initiative, supported by the European Union Cohesion Fund, which started before WFD came into force and which had as objective to develop catchment-based water quality monitoring and management systems for the Boyne, Liffey and Suir river catchments (MCOS 2002)

2[5] which presents the map used in the survey to inform respondents about the geographical distribution of the river system and its current condition (2005 EPA Q-values). From this map it is apparent that only a small percentage of the river system is classified as being of good quality (about 19 percent).

4. Methodology

The methodology we use to estimate the value of improvements in river ecology is the choice experiment (CE) approach. The CE method is consistent with utility maximization and demand theory (Bateman *et al.*, 2002). In this framework environmental goods are valued in terms of their attributes, by applying probabilistic models to choices between different bundles of attributes. Individuals will choose to 'consume' the bundle of attributes presented in a choice card that gives them the highest utility. Respondents are asked to provide answers to a sequence of such choice cards. The alternatives/bundles are constructed according to experimental design theory which makes it possible to explore how an individual makes trades-offs in terms of a set of attributes whose levels differ across the choice options on the choice cards.

CEs have their roots in random utility theory (McFadden 1974; Ben-Akiva and Lerman 1985). The conditional logit model (CL) is the most commonly used structure for choice models but is often rather restrictive in practice as it relies on the assumption of independence of irrelevant alternatives (IIA). The mixed multinomial logit (MMNL) that is used in this study is a more flexible model that relaxes the IIA assumption and allows for preference heterogeneity. The standard indirect utility

[5] Map was designed using GIS data provided by EPA, Ireland.

function underlying the MMNL (as detailed in McFadden and Train (2000)) is given by the following:

$$\boldsymbol{U}_{ij} = \boldsymbol{V}_{ij} + \boldsymbol{\varepsilon}_{ij} = \boldsymbol{\beta}_i \boldsymbol{X}_{ij} + \boldsymbol{\varepsilon}_{ij} \quad (1)$$

where $\boldsymbol{U}_{ij}$ is the utility held by individual i for alternative j. Utility has two components; one part that is measurable denoted by $\boldsymbol{V}_{ij}$, and a stochastic element, $\boldsymbol{\varepsilon}_{ij}$, that captures the unobserved influences and which is assumed as having an IID extreme value distribution. In the MMNL context the vector $\boldsymbol{\beta}$, which is made up of the coefficients for a number of observed choice attributes and possibly individual characteristics $\boldsymbol{X}_{ij}$, follows a mixing distribution with density $f(\boldsymbol{\beta})$. This has the advantage of facilitating preference heterogeneity among the sample of respondents. This density represents the mean and covariance of $\boldsymbol{\beta}$ in the sample population:

$$\boldsymbol{U}_{ij} = \boldsymbol{\beta} \boldsymbol{X}_{ij} + f(\boldsymbol{\beta}) \boldsymbol{X}_{ij} + \boldsymbol{\varepsilon}_{ij} \quad (2)$$

In this framework, we can express the representative component of utility as follows:

$$\boldsymbol{V}_{ij} = \boldsymbol{\beta}_0 + \boldsymbol{\beta}_m \boldsymbol{M}_{ij} + \boldsymbol{\beta}_p \boldsymbol{P}_{ij} + \boldsymbol{\beta}_s \boldsymbol{S}_{ij} \quad (3)$$

where $\boldsymbol{\beta}_0$ is the alternative specific constant, $\boldsymbol{\beta}_m$ the vector of coefficients attached to the river quality attributes $\boldsymbol{M}$ that follows the normal distribution ($\boldsymbol{\beta}_m \sim N(\mu,\sigma^2)$), $\boldsymbol{\beta}_p$ the

price vector, and $\boldsymbol{\beta}_s$ the vector of coefficients related to the individual's socioeconomic characteristics $\boldsymbol{S}$. By making one of the attributes a price or cost term, marginal utility estimated using probabilistic choice models can be converted into willingness-to-pay estimates for changes in attribute levels (Hanley *et al.*, 2005) and welfare estimates obtained from combinations of attribute changes. In particular, marginal WTP (MWTP) can be derived using the following formula (Adamowicz *et al.*, 1994):

$$MWTP_m = -\frac{\boldsymbol{\beta}_m}{\boldsymbol{\beta}_p} \quad (4)$$

Thus, the MWTP for a change in attribute *m* is the ratio between it and the price attribute. In order to obtain a total economic value represented by the Compensating Surplus (CS) associated with river improvements, our calculations are based on the Compensating Variation (CV) log-sum formula, described by Hanemann (1984) for determining the expected welfare loss (or gain) associated with the policy scenarios:

$$CV = \frac{1}{\boldsymbol{\beta}_p}\left[\ln\left(\sum_{j=1}^{J}\exp(\boldsymbol{V}_j^{\boldsymbol{1}})\right) - \ln\left(\sum_{j=1}^{J}\exp(\boldsymbol{V}_j^{\boldsymbol{0}})\right)\right] \quad (5)$$

where $\boldsymbol{\beta}_p$ as explained before is the coefficient of the monetary attribute defined as the marginal utility of income, and $\boldsymbol{V}_j^{\boldsymbol{0}}$ and $\boldsymbol{V}_j^{\boldsymbol{1}}$ represent the deterministic part of the indirect utility function before and after the policy change.

Within the CE framework, the value of a good is derived by separately evaluating individuals' preferences for each of the attributes that characterize that good rather

than eliciting the preferences for the good as a whole. In this framework it is possible to explore how households within a catchment, value different improvements related to river's environmental condition that the WFD is supposed to deliver.

5. Survey Design and Data

The survey instrument employed in the study evolved through consecutive steps recommended for a CE (Hynes *et al*., 2011). These steps include the selection of attributes, the definition of attribute levels, the choice of the experimental design, the construction of the choice sets and the measurement of preferences. Input from experts, focus groups, cognitive interviews and pilot testing contributed to the survey development. The input of the focus groups was necessary to identify the aspects of the river's ecological status that are important to residents living within the catchment, and to understand expert opinion on water quality issues in the Boyne. The first focus group was organised with experts, namely river managers and ecologists who are directly involved in the establishment of the RBD and the River Basin Management Plans. These included the RBD Co-ordinator for the Boyne, the relevant consultancies that contribute to the development of the management plans, scientists from the EPA responsible for each HA and a Teagasc specialist on water matters.

The overall aim of the consultation with the experts was to help shape the agenda for later focus groups discussions, identify a preliminary set of attributes and also to extract background information for the HA to be used in the valuation scenario of the questionnaire.

The second focus group involved a sample from the local population. The suitability of visual tools (maps and show cards) and the capability of participants to answer the

choice sets were examined. In particular, the appropriate level of choice task complexity was explored. Focus groups also served to derive values for the price attribute through the use of an open-ended elicitation question. Finally, a pilot survey tested the questionnaire's efficiency and derived the priors to be used in the next step of experimental design's construction.

According to the directive, progress towards GES is monitored by a combination of biological and chemical indicators. As a result, one of the non-market benefits that were considered from the beginning for inclusion as an attribute in the choice options was the provision of improved ecosystems. The second attribute included was improved conditions for recreation in and around the water body. Finally, another feature that was considered was improved aesthetic appearance of the water environment in terms of water clarity, plant growth and odour. Feedback from focus groups suggested that the condition of river banks was another important element of the river's environmental quality and therefore it was included in the final group of attributes. Show cards of illustrations were employed to explain attributes and levels to the respondents. Both focus groups suggested an increase in annual tax payments as a payment mode for the next 10 years since domestic water service charges were not yet implemented at a national level at the time of survey implementation (such charges have been used as a payment vehicle in equivalent UK studies). As a result, four environmental river related attributes and an annual cost attribute were employed. The river attributes were all measured using three levels apart from River Banks and the annual Cost attribute. The following table (Table 1) presents the attributes and levels.

Table 1 here

The choice of attributes to be valued included a mixture of direct use values like recreation or aesthetic appearance and non-use values such as biodiversity (option value). Following the selection of attributes and levels the experimental design of the choice cards was generated. A Bayesian efficient choice design was employed. The design was derived using the D_b-error criterion which takes the determinant of the Asymptotic Variance-Covariance matrix as its design criterion to be optimised (Bliemer and Rose, 2006). Prior estimates from the pilot survey were used to create the efficient design. In addition, restrictions were placed on certain attribute level combinations in order to take account of possibly incompatible attribute interactions as perceived by respondents and suggested by experts. The design allowed for nonlinear effects in all attributes except the attribute River Banks Condition, while socio-economic variables were considered by interacting them with the constant term.

As Figure 3 shows, three options appeared in each choice card, two showing river improvements and a No Change, No Payment or status-quo alternative that was constant across all choice sets. Each respondent was asked to make choices from four choice cards. The questionnaire was composed of three additional sections. In the first section general attitudes and activities of respondents were explored, while the section that followed the choice cards asked follow-up questions that aimed to identify protesters, capture cognitive burden and psychometric factors. In the third and final section, people were asked to provide standard socio-economic information. A cheap talk script[6] was also included in the survey.

[6] A cheap talk script, initially suggested by Cummings and Taylor (1999), attempts to reduce the hypothetical bias that stems from the hypothetical nature of the experiments describing and discussing the propensity of respondents to exaggerate stated WTP (Carlsson et al., 2005). In particular, the cheap talk treatment contained the following text: "Finally, we would like to mention that some people say

Figure 3 here

A total of 252 households were interviewed during the autumn of 2010. A multi-staged quota controlled probability sampling procedure with randomly selected starting points was employed. Sixty percent of the sample was found to belong to the lower middle and skilled working class, 8 percent belongs to the middle class, 3 percent to the upper class while 10 percent are farmers. Furthermore, 52 percent were male, 61 percent were 35 years old and over, 39 percent had education higher than secondary and 50 percent were fully employed. Other interesting characteristics of the sample were that 78 percent of respondents stated that they were concerned about the environment, 16 percent were aware about a specific water related policy in the catchment and 37 percent found the general environmental quality (water and surroundings) of the Boyne river system unsatisfactory. Finally, the mean distance of households to the closest accessible tributary was 2 km.

6. Results

Violation of the IIA[7] property based on the Hausman-McFadden test[8] (Hausman and McFadden, 1984) suggested that estimating the model as a CL could generate misleading results. After considering different model diagnostics[9] (LL function, ρ^2,

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they are willing to pay more in surveys for these types of improvements in rivers quality than that they actually would pay if the situation were real. This is because when people actually have to part with their money, they take into account that there are other things they may want to spend their money on."

[7] According to that property, the ratio of choice probabilities between two alternatives in a choice set remains unaffected by the introduction or removal of other 'irrelevant' alternatives.

[8] A violation of the assumption occurs whenever the Hausman-McFadden IIA test value is strictly higher than the critical value for the χ^2 statistic which in our case was 16.92. Hence, acceptance of IIA was firmly rejected with the Hausman statistic being large and statistically significant at the 5 percent level.

[9] The ρ^2 is defined as: 1- (*LL ($\hat{\beta}$)) / LL (0))* where *LL ($\hat{\beta}$)* and *LL (0)* are the log-likelihoods for the estimated model and the model in which all parameters are set to zero respectively. The Bayesian information criterion (BIC) can be used to discriminate between un-nested models by also placing a

BIC and percentage of cases correctly predicted) and Likelihood Ratio (LR) tests of different models, the assessment regarding the best-fit model revealed that the MMNL was more flexible and superior to other models tested (CL and Nested MNL)[10]. In addition, the combination of including observed individual-specific characteristics (in order to capture observed heterogeneity) as well as unobserved sources of preference heterogeneity led to overall improvements in model fit. The LR-test statistic of 139.50 for the extended MMNL model with individual-specific interactions was higher than the χ^2 critical value of 22.36 (with 13 degrees of freedom at $\alpha = 0.05$) and as a result the extended model produced significantly higher LL function than the model with only river attributes and *status quo* effects[11].

Regarding the observed individual characteristics, as presented in Table 2, they included different groups of variables such as socio-economic (age, educational level, if full-time employed, if belonging to middle class, number of dependents) and psychometric (if respondent chose by only following her instinct, by thinking what family and friends would expect her to chose and perceived degree of cognitive burden related to choice tasks). Other variables were location (calculated distance from closest tributary) and knowledge and belief related (if respondent believed that

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penalty on the number of parameters. The BIC is defined as follows: $BIC = -LL(\hat{\beta}) + (P/2) \times ln(N)$, where P is the number of parameters and N is the number of respondents in the sample.

[10]In particular, an overall observation is that inspection of the χ^2 statistics suggested that the MMNL models (basic and extended) were superior to their CL and NMNL model equivalents, thereby providing evidence of preference heterogeneity across respondents for the river attributes. The predominance of the MMNL model was also deduced by comparing the model diagnostics of the MMNL models against those of the CL and the NMNL models for both basic and extended models. These findings are in accordance with the improvements observed in the ρ^2, BIC statistic and percentage of cases correctly predicted statistics. Hence, although there were additional parameters to be estimated, as measured by the peudo-R^2s, there appeared to be improvement in fit in the MMNL models compared to their simpler CL and NMNL counterparts. Moreover, the BIC statistics indicated that this improvement remained even after penalising for the loss of parsimony for the extended model. This implies the presence of considerable preference heterogeneity and vindicated the move away from the basic CL model and the simpler NMNL specifications.

[11]The statistical package NLOGIT (Version 4) was used to estimate the models (Greene 2002).

river's general environmental quality was unsatisfactory, if was not sure whether concerned about the environment and if respondent was aware about any water policy in Ireland). Finally, a dummy variable indicating whether respondent had refused to report an income band was also included.

Table 2 here

In order to explore the range of taste intensities held by the respondents as far as the non-cost attributes (river life, appearance, recreation and river banks) are concerned, these were specified as random with normal distributions considering the possibility that for each of these attributes, respondents may have a negative or positive preference for them. For example, for the river banks attribute some respondents may like riverbanks without vegetation that makes them more accessible, while other respondents may find natural looking banks more aesthetically appealing. Furthermore, we follow the relatively common practice in the literature and hold the cost coefficient fixed. Specifying the cost parameter β_p as fixed and considering formula (4) but with river quality parameters varying across people allows easy derivation of the distribution of WTP for any quality parameter, since it is distributed in the same way as the attribute's *m* parameter (Revelt and Train, 2000). At the same time potential identification problems associated with the choice of a distribution for the cost parameter are avoided. Parameter estimates were generated using 500 Halton draws (Greene, 2002). It should also be noted that the panel dimension of the data was considered in the estimation, in which case the probability of the sequence of all choices made by each respondent is considered.

Results from both basic and extended models are reported in Table 3 for reference. The first model includes only the river and cost attributes along with *status quo* effects. The second model includes these same variables and also incorporates aspects of observed heterogeneity by enriching the specification with respondents' various characteristics (socio-demographic, belief, psychometric and other variables) which are necessarily interacted with the *status quo* or No Change option[12]. Results show that all river attributes apart from Recreation _S were positive and statistically significant. Cost was negative and significant while *status quo* effects were absent. As far as unobserved heterogeneity is concerned, standard deviations of all river attributes were statistically significant at conventional levels, indicating statistically different preferences for these attributes across respondents. Overall the model was statistically significant with a χ^2 value of 638.163, against a χ^2 critical value of 42.55 (with 29 degrees of freedom at $\alpha = 0.05$).

Table 3 here

It is interesting to note that the coefficients for the River Life_M and River Life_G attribute are not different from each other. This would appear to suggest that respondents were indifferent (or could not distinguish any real difference) between the Good and Moderate levels for the river life attribute and derived almost the same utility from this attribute regardless of level. This result may also suggest that preferences between the river life levels Poor and Moderate and between Poor and Good were linearly related. A Wald test for possible linear restrictions indicated that

[12] Since attributes of the individual remain the same across all alternatives the effect of individual characteristics are not identifiable in the probability of choosing specific alternatives and thus cannot enter directly into the model on their own, as they would drop out from the estimation. They can only enter the model if they are specified in a manner that creates differences in utility over alternatives, in the same way that attributes of the good under evaluation generally vary across alternatives.

the null hypothesis of equal coefficients could not be rejected[13] (at 95% confidence level). It is possible that the ecological conditions variable could have been coded using just two levels (poor versus high or moderate). Finally, it should be noted that similar to the above result a choice experiment by Brouwer et al. (2010) that also included a river basin's hydrogeographical units and levels of water quality improvement in the experimental design also found no significant difference between moderate and good water quality levels.

With the exception of age and education, the socio-economic, psychometric and attitudinal interaction regressors were all found to be significant determinants of choice. In line with *a priori* expectations, respondents who were fully employed, who had knowledge of previous or current water policy in Ireland, who were unsatisfied about the environmental conditions of the local river and who were closer to river's tributaries were significantly less likely to select the No Change alternative. On the other hand, respondents with more dependents, belonging to the middle class and experiencing less cognitive difficulty were also significantly less likely to choose the No Change alternative. In contrast, respondents who refused to report their income, who were not sure if they were concerned about the environment, who trusted their instinct in making-up their minds and who were concerned about what their circle of friends or relatives expected them to chose, were significantly more likely to choose the No Change alternative. The positive and significant sing of the last two variables is of particular interest. Although these issues are not expanded in the current paper and need further investigation, the extended model highlights the significant role of psychometric variables which is often ignored in a choice modelling context and

[13] Testing H_0: River Life _G = River Life _M, Wald Statistic was 2.598 and probability from χ^2 with 1 degree of freedom 0.106. Regarding H_0: Appearance _A= Appearance _S, Wald Statistic was 6.940 and probability from χ^2 with 1 degree of freedom 0.008.

provides evidence on deviation from a behavior according to which people only choose by fully consulting their own preferences in a rational manner.

Table 4 reports the implicit prices of the river attributes (i.e., based on estimates of the mean) along with their 5 percent confidence intervals estimated using the Krinsky and Robb (1986) procedure using 1,000 draws. Table 4 also reports the mean amount of money individuals are willing to pay for the specified improvement given in the table. Most of these prices are statistically significant. According to the results, the river life attribute (and in particular improvement from Poor to Moderate) represents the highest WTP, followed by improvement in Appearance ('No improvement' to 'A lot of improvement'), River Banks and improvement in Recreation ('limited activities' to 'all the possible activities').

Table 4 here

The results of this analysis are also presented using plots for the conditional WTP distributions as shown in Figure 4. The kernel-smoothed distributions of the individual-specific WTP estimates conditional on observed choices (Hensher and Greene, 2003) illustrate that for the river attribute *Appearance,* theoretical expectation of decreasing marginal utility is reflected in the magnitude of individual-specific WTP estimates. However, from the distributions of River Life attribute evidence of monotonicity of the two levels of action is observed. It is also clear that the attributes most valued are River Life and Appearance and the attribute least valued is Recreation.

Figure 4 here

Compensating Surplus (CS) estimates for the catchment were calculated according to formula (5). However, for the MMNL model it was required to account for the heterogeneity, meaning that the expected measure of CV had to be integrated over the distributions of taste in the population. Hence, the integral of the estimated distributions for the taste is also approximated by simulation from 1,000 draws, following the Krinsky and Robb (1986) procedure. The indirect utilities of respondents were calculated using the coefficients of significant variables and the sample means of the socioeconomic variables. CS estimates for four different policy scenarios were then estimated as presented in Table 5.

Table 5 here

To find the CS associated with each of the scenarios presented in table 5 the difference between the welfare measures under the *status quo* and the alternative management scenarios were calculated. The results indicate that the CS for the change from the *status quo* to the different scenarios increased as greater improvements in river conditions in the catchment were considered. The greatest mean CS for the Boyne was €48.12 under Scenario 2. Scenario 1 (High impact management scenario) produced estimates of less magnitude for the Boyne due to the smaller coefficient of River Life _G compared to River Life _M.

7. Discussion and Conclusions

In this study, we applied a choice experiment design to determine what values the public places on improvements to a watercourse in Ireland as envisaged under the WFD. Four attributes were selected to represent improvements under the directive. These were river ecology, aesthetics, potential for recreation and condition of river banks. Respondents living in different parts of the river basin were asked to value the characteristics simultaneously and make trade-offs in terms of the levels of each characteristic.

We found significant marginal values attached to improvements in the river attributes. Results showed that the recreation attribute was valued lower than the river ecology, appearance and bankside conditions attributes. From a policy perspective, both the estimated implicit prices of the attributes and the CS estimates demonstrated that the households in the Boyne do not just have preferences for quality improvements to acceptable levels but they also prioritise these improvements. The relative magnitude of the implicit prices implies that respondents demonstrate higher interest in some of the attributes compared to others. In particular respondents would appear to be willing to pay more for improvements in river ecology and the prevention of bank erosion than for small improvements in appearance or more recreational opportunities.

The CS scenario results also show that improvements in river life, appearance, recreation and bankside conditions are related to much higher estimates than improvements that concern only river life and water appearance. Hence, although river life is valued more, improvements in all characteristics contribute to higher CS estimates. In this context, it is important for river managers to realise public's preferences, when setting catchment policy for a specific river and for decision

making to be more targeted towards these preferences. In addition, the results provide evidence of the magnitude of benefits derived by catchment's households that could inform decisions related to the implementation of 'polluter pays' and cost recovery principles. Finally, these values could be included in a Cost-Benefit context in order to identify potential 'derogations' in the case of the Boyne. With regard to this concept, Article 4 of WFD states that exemptions are possible if the cost of reaching the GES is disproportionate[14].

Model results also indicated that accounting for both observed and unobserved individual heterogeneity produced a better fitting model. In particular, awareness of water related policies, perception on degradation of the river's environment and families with dependents are more likely to agree for improvements taking place instead of preserving the current situation. Households located in close proximity to the river are also less likely to opt for the No Change scenario. In addition, from a methodological point of view there is evidence that less (perceived) cognitive burden involved in the CE task results in a higher probability of respondents choosing a non-*status quo* option. Overall, CEs do seem promising in providing estimates for ecology related improvements under the WFD, especially for non-marketed characteristics. In particular, the main advantage of CEs is that they can incorporate variations in both environmental quality and socio-economic characteristics across sites, which would seem *a priori* to be the biggest drivers of differences in value.

In order to achieve maximum economic efficiency (where marginal social benefits are equal to marginal social costs) or at the very least to try and move towards achieving

[14] Costs are considered as disproportionate if they exceed the monetised benefits of achieving GES in a water body.

it for water resources it is necessary to establish the full value of achieving GES of these water resources, and to incorporate this into private and public decision making processes (Birol et al., 2006). While we have attempted to do this for one river catchment body in this paper further research is needed in order to examine the value of achieving GES across all water bodies in Ireland. Ireland is somewhat behind in terms of measuring the economic value of achieving "good ecological status" under the WFD across catchments. Therefore, an interesting avenue for future research would be to use the model estimates derived in this paper in conjunction with benefit transfer techniques to place a value of achieving GES in a series of alternative water bodies in Ireland based on a classification of their attributes and the socio-economic characteristics of their catchment populations.

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Tables

Table 1: ***Attributes and Levels in CE***

Attribute	**Description**	**Levels**
River Life: fish, insects, plants	Composition and abundance of biological elements (fish, plants, invertebrates, mammals and birds)	Three levels: 1. Poor 2. Moderate 3. Good
Condition of River Banks	Level of erosion and presence of vegetation (scrubs, trees) and animals (mammals and birds)	Two levels: 1. Visible erosion that needs repairs 2. Natural looking banks
Water Appearance	Clarity, plant growth, visible pollution, noticeable smell	Three levels: 1. No improvement 2. Some improvement 3. A lot of improvement
Recreational Activities	Number of activities available	Three levels: 1. No fishing and swimming 2. No swimming 3. All available (walking, boating, fishing, swimming)
Cost	Annual household taxation for 10 years.	Six levels: €0, 5, 10, 20, 40, 80

Table 2: ***Definition of Variables Included in Discrete Choice Model***

Variable name	Description
River Life _G	River Life (fish, insects, plants): Good relative to Poor
River Life _M	River Life (fish, insects, plants): Moderate relative to Poor
Appearance _A	Water Appearance: A lot of improvement
Appearance _S	Water Appearance: Some improvement
Recreation _A	Recreational Activities: Walking, Boating, Fishing, Swimming
Recreation _S	Recreational Activities: Walking, Boating, Fishing
River Banks	Condition of River Banks: Natural looking banks relative to Visible erosion that needs repairs
Cost	Household's annual tax payments for the next 10 years (€/year)
SQ	*Status quo* (No Change alternative)
Age	Respondent's age scale 1 to 6, where 1=15 to 17 and 6=over 65
Hdegree	1 if education is higher than secondary school, 0 otherwise
Depnt	Number of dependents in the household
Fullempl	1 if respondent is full-time employed, 0 otherwise
Middlecl	1 if chief income earner belongs to middle class, 0 otherwise
NoIncome	1 if respondent reported her income, 0 otherwise
Waterpolicy	1 if respondent is aware of any specific water related policy taking place in Ireland at the moment or in the past, 0 otherwise
Nsconserned	1 if respondent is not sure thinking of him/herself as being concerned about the environment, 0 otherwise
Unsatisfqual	1 if respondent describes river's general environmental quality (water & surroundings) unsatisfactory, 0 otherwise
Instinct	1 if respondent chose by only following her instinct, 0 otherwise
Socialcon	1 if respondent chose according to what family/friends would expect/like her to chose, 0 otherwise
Cognitive	Total score of cognitive ability, measured on a 1 to 7 likert scale, according to perceived degree of difficulty concentrating on the task, remembering the necessary information, thinking clearly and logically and choosing the best option. The smaller the score the higher the degree of difficulty.
Dist1km	1 if distance of respondent's townland is less than 1 km from closest tributary, 0 otherwise

Table 3: ***Model Results***

	Model 1		**Model 2**	
	est.	*t*-ratio	est.	*t*-ratio
River Life _G	1.663	(2.594)***	1.180	(2.890)***
River Life _M	2.580	(3.622)***	1.754	(4.743)***
Appearance _A	2.282	(3.145)***	1.649	(3.627)***
Appearance _S	0.993	(1.711)*	0.671	(1.801)*
Recreation _A	1.641	(2.151)**	1.000	(2.263)**
Recreation _S	0.523	(1.157)	0.250	(0.793)
River Banks	2.433	(2.879)***	1.292	(3.518)***
Cost	-0.070	(-3.468)***	-0.044	(-4.932)***
SQ	-0.720	(-1.028)	2.315	(1.177)
AgeSQ			0.070	(0.327)
HdegreeSQ			0.930	(1.523)
DepntSQ			-0.409	(-1.723)*
FullemplSQ			-1.699	(-2.900)***
MiddleclSQ			-1.438	(-2.581)**
NoIncomeSQ			1.526	(1.693)*
Dist1kmSQ			-2.355	(-3.295)***
WaterpolicySQ			-2.218	(-2.192)**
NsconsernedSQ			3.734	(2.733)***
UnsatisfqualSQ			-2.041	(-3.129)***
InstinctSQ			1.489	(2.514)**
SocialconSQ			1.922	(3. 140)***
CognitiveSQ			-0.128	(-2.367)**
St. Dev. of parameters				
River Life _G	3.536	(2.030)**	1.580	(1.737)*
River Life _M	2.635	(3.023)***	0.986	(2.115)**
Appearance _A	3.307	(3.175)***	1.606	(3.469)***
Appearance _S	3.502	(3.239)***	2.183	(4.148)***
Recreation _A	2.738	(1.440)	1.658	(2.553)**
Recreation _S	2.373	(2.452)**	1.222	(2.563)***
River Banks	3.895	(3.306)***	2.679	(5.068)***
LL	-648.361		-577.386	
χ^2	557.734		638.163	
ρ^2	0.30		0.35	
BIC	691.176		654.498	
Correctly predicted	48%		52%	
Observations	844		816	
# of respondents	211		204	

(*) indicates significant at 10%; (**) indicates significant at 5%; (***) indicates significant at 1%.

Table 4: ***Implicit Prices and Confidence Intervals for Boyne River***

River Life _G	26.57 (9.54, 44.28)
River Life _M	39.62 (27.14, 54.98)
Appearance _A	38.71 (15.73, 69.88)
Appearance _S	16.00 (-0.23, 38.20)
Recreation _A	23.56 (3.02, 49.40)
Recreation _S	0.00*
River Banks	30.07 (13.83, 53.14)

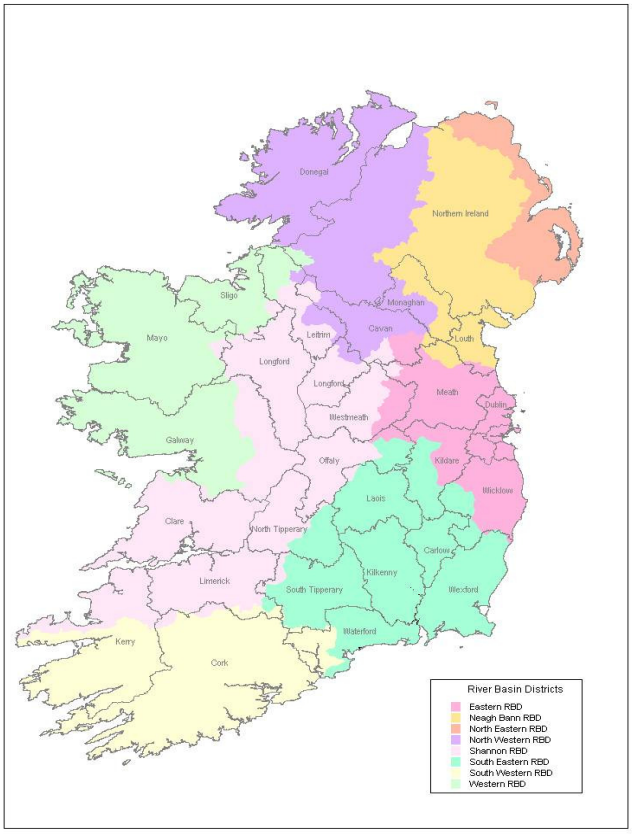
*WTP estimate was not found to be significantly different to zero at α= 0.05 and is expressed as zero

Table 5: ***Scenario Descriptions and Associated CS Values (€/household/year)***

	Scenario 1 High impact management	**Scenario 2** Medium impact management 1	**Scenario 3** Medium impact management 2	**Scenario 4** Medium impact management 2
River Life: fish, insects, plants	Good	Moderate	Moderate	Good
Water Appearance	A lot of improvement	A lot of improvement	A lot of improvement	A lot of improvement
Recreational Activities	Walking Boating Fishing Swimming	Walking Boating Fishing Swimming	Walking Boating Fishing Swimming	Walking Boating ~~Fishing~~ ~~Swimming~~
Condition of River Banks	Natural looking banks	Natural looking banks	Visible erosion that needs repairs	Natural looking banks
Compensating Surplus	32.70 (-55.26,114.68)	48.12 (-43.43,131.53)	21.79 (-46.91, 84.12)	8.67 (-79.65,84.24)

Figures

Figure 1: ***River Basin Districts (RBDs) in Ireland***



(*Source:* http://www.wfdireland.ie/images/RBD04.jpg)

Figure 2: ***Boyne Hydrometric Area (HA)***

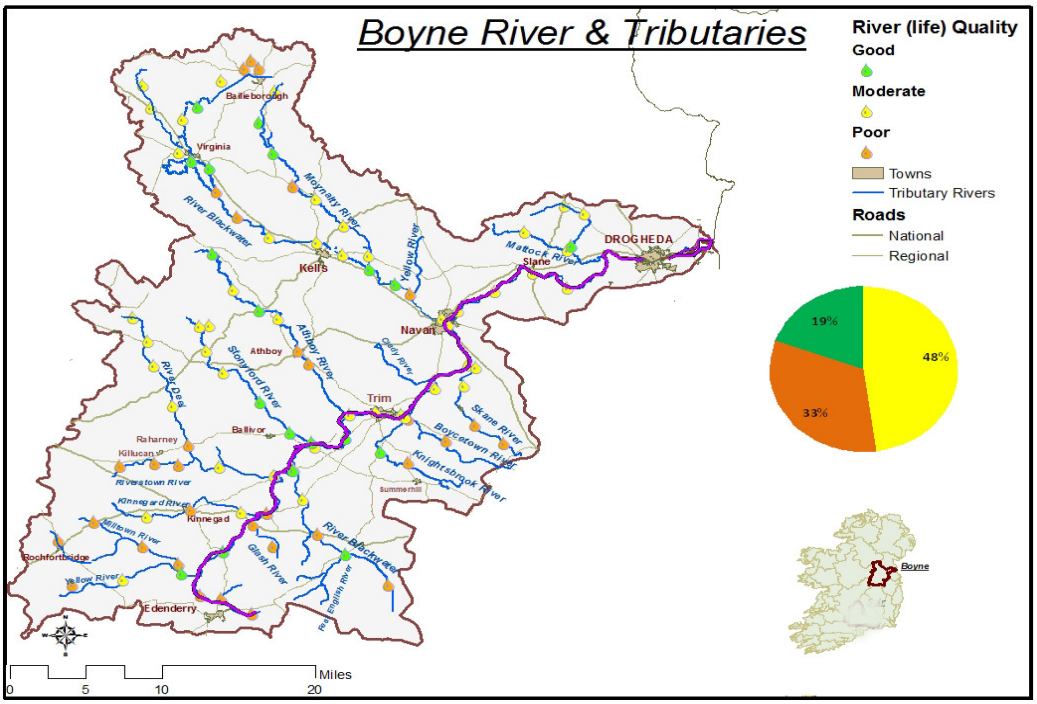
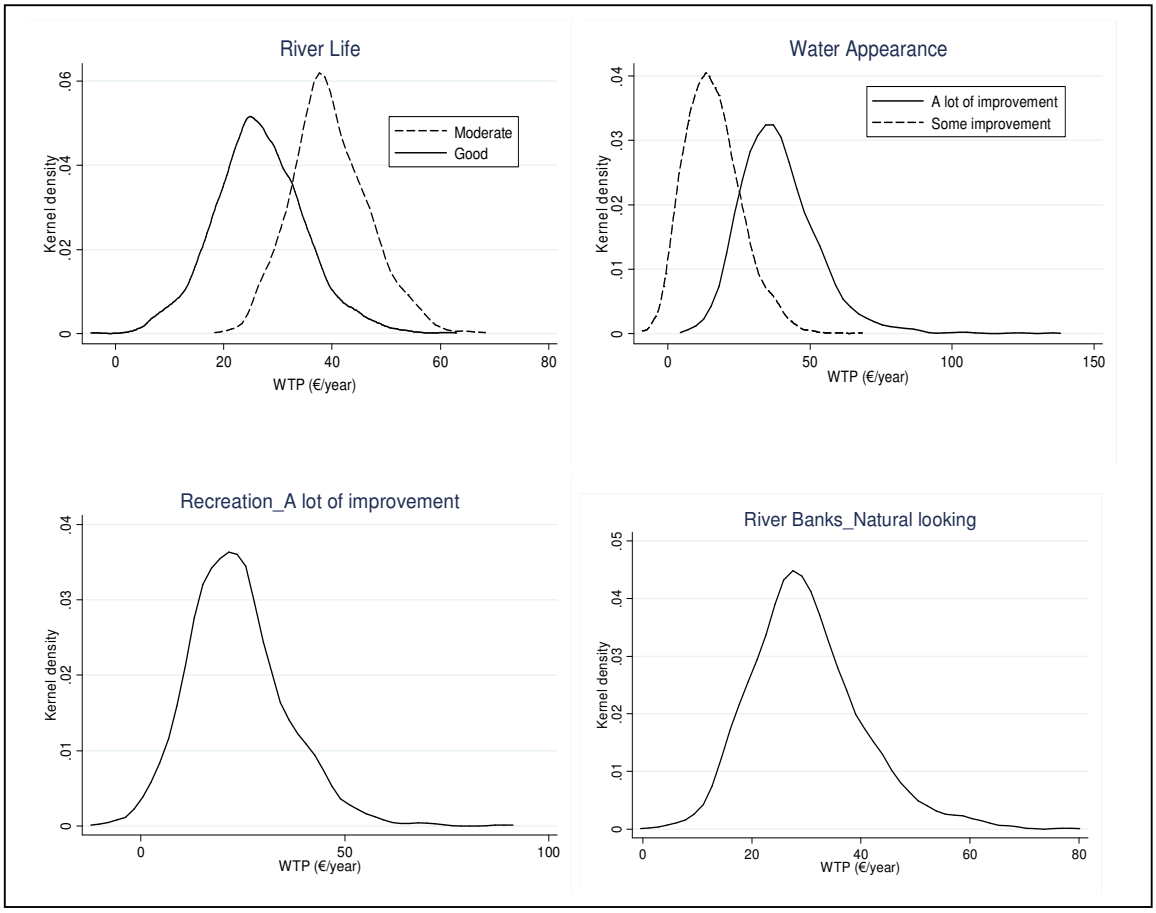


Figure 3: ***Example of a Choice Card Concerning the Boyne River***

	No Change	**Option A**	**Option B**
River Life: fish, insects, plants	Poor	Moderate	Good
Water Appearance	No improvement	Some improvement	A lot of improvement
Recreational Activities	Walking Boating ~~Fishing~~ ~~Swimming~~	Walking Boating Fishing ~~Swimming~~	Walking Boating Fishing Swimming
Condition of River Banks	Visible erosion that needs repairs	Natural looking banks	Visible erosion that needs repairs
Increase in annual tax payments by household for next 10 years	€0	€5	€80
Which do you like best?			

Figure 4: ***WTP Distributions for the Attributes of River Improvements***

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